ECOSYSTEM RESTORATION

नयाँ सोच र सिर्जना, प्राकृतिक प्रणालीको पुनर्स्थापना

The Journal of

AGRICULTURE AND ENVIRONMENT

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Telephone: *00977-1-4211915*
Fax: *00977-1-4211839*
Web: *www.moald.gov.np*
Email: *info@moald.gov.np,*
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EDITORIAL

The World Environment Day (June 5), UN Environment-led global event, which takes place on June 5, every year and is celebrated all over the world involving all categories of people. "ECOSYSTEM RESTORATION" is the UNEP theme for the World Environment Day 2021.

The day is being celebrated through several events and relevant environmental campaigns. Food Security and Food Technology Division in the Ministry of Agriculture and Livestock Development has been publishing the Journal of Agriculture and Environment on the auspicious occasion of the World Environment Day every year. The division now has brought the journal's new issue, Vol.22, in the hand of readers. The journal essentially includes technical and review articles, and the volume has major coverage of climate change, plant breeding, agricultural biodiversity, agriculture product marketing, socio-economic aspects, prevailing climate change issues and impact experienced in Nepal. The Editor-in-Chief acknowledges the valuable contributions from authors, reviewers, editors and the editorial management team, and hopes that the readers find the issue informative and knowledgeable. The Editorial Board will be pleased to receive valuable suggestions and feedback to improve in forthcoming issues.

Editor-in-Chief

TABLE OF CONTENTS

S. No.	ARTICLES	PAGE No.
1	FROM THE FIELD TO DINING TABLE: PESTICIDES RESIDUES Y.D.GC and B.R.Palikhe	1
2	EMIGRATION AND FEMINIZATION IN NEPALESE AGRICULTURE: IMPLICATIONS FOR FOOD SECURITY A.Pandey, K. Tripathi and S. Devkota	17
3	EFFECTS OF DIFFERENT BIO-RATIONAL COMPOUNDS ON MORTALITY OF DIAMOND BACK MOTH (*Plutella xylostella* L.) LARVA UNDER LABORATORY CONDITION A.M. Bhattarai and S.Tiwari	31
4	AREA-WIDE CONTROL PROGRAM IN MANAGEMENT OF CHINESE CITRUS FLY, BACTROCERA MINAX (ENDERLEIN) (DIPTERA: TEPHRITIDAE), IN CITRUS ORCHARDS, SINDHULI, NEPAL D. Adhikari, R.B. Thapa, S.L. Joshi and J.J. Du	41
5	VARIETAL SCREENING OF RICE GENOTYPES FOR THE RICE WEEVIL, *Sitophilus oryzae* (Linnaeus) (Curculionidae: Coleoptera) AT LABORATORY CONDITION M.K. Pal, S. Tiwari, R. Regmi and F. Md. Ali	51
6	EFFECTS OF SOWING DATES ON GRAIN YIELD AND OIL CONTENT OF RAPESEED (*Brassica campestris var* L. *toria*) VARIETIES IN MIDDLE TERAI REGION, NAWALPARASI, NEPAL M.P. Khatiwada, N.K. Chaudhary, S.K. Sah and J.P. Dutta	61
7	SOCIO-ECONOMIC EFFECTS OF ORGANIC CERTIFICATION OF NEPALESE ORTHODOX TEA P. Mishra and R.R. Kattel	71
8	CHARACTERIZATION AND DIVERSITY ASSESSMENT OF NEPALESE GARLIC (*Allium sativum* L.) LANDRACES P. Thapa, R. P. Manali, A. Karkee, K. H. Ghimire, B. K. Joshi and K. K. Mishra	80
9	EVALUATION OF DIFFERENT BARLEY GENOTYPES FOR THEIR PHENOLOGICAL TRAITS, YIELD AND YIELD ATTRIBUTES IN THE WESTERN MID-HILL OF NEPAL R. Acharya, B. Adhikari, S. Bharati, H. Paudel, S. Subedi and B. Acharya	94

S. No.	ARTICLES	PAGE No.
10	SPECIALTY RICE VARIETIES AND LANDRACES S.S.Karkee	105
11	AN OVERVIEW OF CHEMICAL PESTICIDE IMPORT IN NEPAL D. Khanal, S. K. Neupane, S.Poudel and M. Shrestha	121
12	GENETIC VARIABILITY STUDY OF LOCAL RICE GENOTYPES P. Panth, A. Dahal and K. Upadhyay	135
13	EVALUATION OF BREAD WHEAT GENOTYPES FOR STRIPE RUST RESISTANCE P.B. Magar, S. Baidya, D.B. Thapa, M. Subedi, R. Basnet and K.R. Pant	146
14	FARMERS' KNOWLEDGE ON INSECT PESTS OF CITRUS (*Citrus reticulata*) AND THEIR MANAGEMENT IN GULMI DISTRICT OF NEPAL S. Chhetri, S. Bhatta, N. Kafle, B. Dahal and P.S. Subedi	156
15	ASSESSMENT AND MANAGEMENT OF TOMATO DISEASES UNDER PLASTIC HOUSE CONDITIONS IN LAMJUNG S.K. Neuapne, G.B. K.C., S.M. Shrestha and A. C. Neupane	179
16	MORPHOMETRICS AND LIFE CYCLE STUDY OF CABBAGE BUTTERFLY, *Pieris brassicae nepalensis* (DOUBLEDAY) IN ILAM, NEPAL A. Subedi and S.Tiwari	188
17	SAFE FOOD PRODUCTION REGIMES AND POTENTIALITY OF INTEGRATED MULTI-LEVEL FOOD CERTIFICATION SYSTEM IN NEPAL J. Pandit, Y.K. Karki, D. Gauchan and B.Paudel	196
18	MAINSTREAMING THE CONSERVATION AGRICULTURE IN NEPAL T.B. Karki and R. Acharya	213
19	ASSESSMENT OF DESIRED CORE COMPETENCIES AND ITS ACQUISITION BARRIERS OF AGRICULTURAL EXTENSION ADVISORS IN NEPAL R.K.Mehta, O.P. Singh, U.P. Sigdel and N.R. Joshi	226

GUIDELINES TOAUTHORS: MANUSCRIPT PREPARATION AND SUBMISSION

The Journal of *Agriculture and Environment* is devoted to the cause of advancing understanding on the Environmental aspects of Agriculture through literature review, theoretical analysis, research and practical experiences. Besides research and review papers, the journal may arrange spaces for case study, methodological approach, book review, report on seminar and meeting, short communication and letter to editor. Guidelines to authors on preparation and submission of manuscript follow.

1. The manuscript must be an original work written in English and not published elsewhere.
2. The title should be short and specific, but it should reflect the contents in the manuscript.
3. The abstract should be in italics 9-point font size, not exceeding 150 words, should concisely state major objective, methodology, findings and conclusion. It should not include diagram, footnote, equation or any parenthetical reference.
4. Key-words in alphabetical order should not exceed ten standard words.
5. Main text of the technical manuscripts should include introduction, objective, theoretical framework, methodology, results and discussions, conclusions and references.
6. The manuscript should not exceed 4500 words in total. It should be in MS-word with pages set on A4 size, the top and left margins at 3cm and the right and bottom margins at 2.5cm. The text format should be on Trebuchet MS font of, unless otherwise specified, 10-point size.
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   For a year book/report/periodical: UNESCO, 1986. Statistical year book. Paris: UNESCO Press. National Pay Commission, 1992.A report on the pay structure for civil servants. Kathmandu: Aradhana Press.

   For a newspaper: Sunuwar, D.K., 2008. Ecosan toilets bring multiple benefit. The Kathmandu Post, Vol. XVI (167), Aug 3, 2008:p.3(col.3).

   For thesis/dissertation: Pokhrel, D. M., 2005. Citrus marketing system in the mountains of Nepal: a study based on market structure, conduct and performance analyses. PhD dissertation submitted to School of Environment, Resources and Development, Asian Institute of Technology, Thailand.

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FROM THE FIELD TO DINING TABLE: PESTICIDES RESIDUES

Y.D. GC[1] and B.R. Palikhe[2]

ABSTRACT

This review article aims to present an overview of pesticide residue, focusing from the field to dining table and on the impact on health. This study also shows *that an information campaign regarding pesticide use and food safety for farmers and consumers. The methodology is based on previous research, relevant studies, published and unpublished sources and authors' own experiences. The work is only a review-based study. Food is a more basic need of man than shelter and clothing. The public is concerned about the presence of pesticide residues in foods. Pesticide residues in foods, farmers' exposure to pesticides, and environmental pollution are serious concerns in Nepal. Risks from pesticides are high because of the lack of knowledge of farmers, limited training and awareness on the safe production of food crops, the absence of an effective code of practices, alternatives to chemical pesticide and inadequate residue monitoring Increasing awareness regarding good nutrition through quality food is creating a rise in the demand for vegetables and fruits and other crops. Despite great demand for safe vegetables, the supply of vegetables labeled as safe or organic is still limited. As growers are in a hurry to sell their produce, they do not wait or abide by the waiting period. As a result, the pesticide residues, left to variable extent in the food materials after harvesting, are beyond the control of consumer and have deleterious effect on human health. The consumer must think twice before eating veggies and biting into that fruits. Pesticides in the field do show up on our dinner plates or onto our kitchen tables. These pesticides often end up on dinner table. Consumers are not aware of food safety. The concentration of pesticide residues in the vegetable crops from the IPM field was considerably lower, suggesting a greater ability of IPM systems to reduce the dietary risks from exposure to pesticides. However, this is an alarming situation.*

Keywords: Consumer, farmer, human health risk, pesticide residues, vegetables

INTRODUCTION

PESTICIDE USE SITUATION

Currently, the health hazard caused by pesticides are very important topics for Nepal as the Government is trying to promote a good *health* for its people, who have frequently encountered problems caused by pesticide consumption. Nepal is importing a huge quantity of pesticides every year. Pesticides are one of the major inputs used for increasing agricultural productivity of crops. A recent study shows that the national consumption of pesticide in Nepal is 396g a.i./ha, which is higher than the previous record of

1 Senior Agricuture Officer, FAO, Regional Office, Bangkok

2 Kathmandu Metropolitan City, Kathmandu

142g a.i./ha (IUCN, 1995) but is lower than world average 0.500a.i. kg per ha. On the ecological basis, the highest average pesticide used in the Terai region of Nepal i.e. 0.995 a.i. kg/ha followed by valley (0.470 a.i. kg/ha), hill (0.314 a.i. kg/ha) and lowest in the high hill (0.085 a.i. kg/ha) (PPD, 2015). The problem of safe application of pesticides attracts major attention now due to concerns about their health and environmental impacts (Vumillia, 2019). These developments are clearly supported by the Basel, Rotterdam and Stockholm Conventions and many other intergovernmental treaties and documents (WHO, 2020).

Nepal Government has put the mandatory requirement of the phtosanitary certificate at the custom points while importing the goods however, there is no stringent requirement of the traceability report yet. Based on the reports with frequency of *chemical* pesticide use suggests that, pesticide use in Nepal is heavily concentrated in a few locations. Pesticide use however is much more intensive in areas that have greater access to markets, such as the Terai and the districts adjacent to the Kathmandu and Valley. The use of pesticides is more common on fruits and vegetable crops (PRMS, 2015) not only to save them from pests and disease but also to protect their market values. Abuse and misuse of pesticides is common in Nepal. The overuse, abuse or misuse of pesticides can have serious consequences in crop. The current practice adopted in pesticides control in Nepal appears not enough in line with food safety. This has created a promising threat in food safety and human health (Koirala *et al.,* 2008). Large scale poisonings by pesticide contaminated food are unusual but not unknown in Nepal. And an agriculture officer shies away from the question by stating that "the data on residue levels are too sporadic to draw national conclusions".

These problems can arise from misuse of the pesticides or over-reliance on them, particularly if the users are not aware of these potential problems. Often such fruits and vegetables products are brought to the market for sale within a short period of time after use of pesticides on them (PPD, 2015). As such, fruits and vegetable products have more chances of having excessive pesticide residues than what is permissible under the law. Pesticide residues are a major concern in fresh vegetables and their products for domestic consumption and export. Pesticides are not as extensively used in Nepal as in other countries in Asia in terms of the ratio of active ingredients used per hectare of crop land. There is considerable evidence that farmers have overused and misused pesticides especially in vegetable-growing areas. About 89% pesticides are used in vegetables (Dahal, 1995). Increasing use of pesticides on vegetables is a growing environmental problem and food safety threat in Nepal where vegetable farming is becoming more intensive and a widespread. Because of an open and porous border with India, there is a *considerable*, but unknown quantity of trade between farmers close to the

border. Hence, illicit/illegal import of pesticides issue needs to be addressed in multilateral approach with neighboring countries to prevent potential infiltration of banned/ unregistered pesticides (Bhandari *et al.*, 2019).

PESTICIDE RESIDUES

Pesticide residue is defined by the World Health Organization as "any substance or mixture of substances in food for man or animals resulting from *the* use of a pesticide and includes any specified derivatives, such as degradation and conversion products, metabolites, reaction products, and impurities that are considered to be of toxicological significance. The residues are being accumulated from agriculture activities and Malaria control applications.

Pesticide residue refers to the pesticides that may remain on or in food after they are applied to food crops. It includes any derivatives of a pesticide such as their metabolites, conversion products, reaction products and impurities considered to be of any toxicological significance (FAO, 2013). People are potentially exposed to pesticides orally from pesticide residues in foods such as vegetables, fruits and milk. In developing countries like Nepal many crops are grown which are uncommon in developed countries and for which residue data is lacking. The detection of pesticide residues exceeding allowable limits in food crops is considered one of the long standing problems in Nepal despite various actions taken by the government to overcome it. No systemic and regular study has been carried out in Nepal to analyze the pesticide residues in vegetables and fruits. It goes without saying, international, regional and national authorities have the responsibilities to guarantee safe food, free from pesticide residues and put in place traceability systems for both raw and processed food. Sharma, 2016 reported, residues of some pesticides using Gas Chromatography MS detected the highest concentration of Cypermethrin in tomato and brinjal. The study further revealed, the concentration of Deltamethrin was highest in cowpea followed by cauliflower, tomato and brinjal whereas the concentration of Carbandazim and Mancozeb were also the highest in tomato followed by bottle guard and chilli indicating MRL value more than 39% in the studied samples.

WAITING PERIOD

Where applicable, the product label will specify the period which must elapse between the last treatment/application and harvesting of the crop. This period must be strictly observed, in order to ensure that pesticide residues on the crop are within acceptable limits. The pre-harvest interval (*PHI*) is the wait time between a pesticide application and when a crop can be harvested. Less waiting period indicates that there is a higher risk of presence of pesticides residue in crops, which poses higher health risk to crop growers as well as consumers.

Being a member of WTO, Nepal must comply with the SPS requirements. Residues levels in food consumed must, of course, be acceptable toxicologically. Therefore, an estimate is required of a level of pesticide residue intake below which the risk to health is too small to be of concern. This level of intake is normally referred to as the Acceptable Daily Intake (ADI), which is the amount of a pesticide which can be consumed every day over an individual's lifetime. The ADI value is expressed in terms of milligrams of the residue ingested per kilogram of body weight. Assuming humans would consume the pesticides, the higher the hazard ratio the greater the hazard. Maximum residue limits (MRLs) are the maximum pesticide residues limit in food considered safe to human as set by the Codex Alimentarius Commission (Codex) and the joint Food and Agriculture Organization/World Health Organization meeting on pesticide residues (JMPR). The JMPR aims to protect consumer's health and ensures fair practices in international food trade (FAO, 2013). The MRLs are always set far below levels considered to be safe for humans. MRLs can be used as guidance. MRL setting can be the responsibility of one or more authorities in a country and normally involves the health, agriculture and environmental agencies. MRLs are generally published in open literature or websites of the regulatory bodies for public usage.

RAPID BIOASSAY OF PESTICIDE RESIDUE

The Government of Nepal has already set up the Rapid Bioassay of Pesticide Residue Laboratory (RBPR) on the premises of Kalimati (Kathmandu) Fruits and Vegetables Market in 18 June, 2014 under the supervision of Plant Protection Directorate (now Plant Quarantine and Pesticide Management Centre).The Government has established some more such laboratories at Kakarvitta (Jhapa), Nawalpur (Sarlahi), Pokhara (Kaski), Butwal (Rupandehi), Nepalgunj (Banke) and Attaria (Kailali), The RBPR technology being *used* in Nepal was developed in Taiwan. It is an acetylchoninesterase (AChE) test used for detecting two categories of neurotoxin insecticides, organophosphate and carbamate. This method provides toxicological indication on plant samples (vegetables and fruits) with residue of Organophosphate and Carbamateinsecticides. The major reason for adopting RBPR is that organophosphates-based pesticides are widely used in Nepal. Until a few years ago, around 80 percent of the pesticides used in Nepal would be organophosphates-based. This has come down to around 60 percent over the past four years. RBPR is quick and cost effective technique to monitor pesticide residues and the quick results helps in avoiding shipment of contaminated products and in turn protecting consumers from consumption of such pesticides contaminated products. Fruits and vegetables are also highly perishable in nature; therefore, RBPR being rapid technique is more useful for monitoring pesticide residues on these products. A reliable and highly

sensitive determination of multi-pesticide residues can be achieved by chromatography techniques coupled with MS, tandem MS (MS/MS), triple quadruple MS, or high-resolution MS (Q-TOF).

RESIDUE LEVELS IN FRUITS AND VEGETABLES

The levels of pesticide residue in fruits and vegetables have been closely monitored in Nepal for the past 6 years. An analytical method is the series of procedures from receipt of a sample to the production of the final result. A study was conducted to determine the pesticide residues in different vegetables. Residues of 23 pesticides were analyzed in the three main vegetable crops grown in Southern *Nepal*: 27 egg plant, 27 chili and 32 tomato samples representing (i) conventional (N = 67) and ii) integrated pest management (IPM) fields (N = 19). The study revealed that pesticide residues were found in 93% of the eggplant samples and in all of the chili and tomato samples. Multiple residues were also observed in 56% of the eggplant samples, 96% of chili samples and all of the tomato samples (Science Direct Topics, 2020). The analytic concentrations are in the range mg/kg to mg/kg. The range (µg/kg) of total detected pesticide residues in eggplants, chilies and tomatoes was 1.71–231, 4.97–507, 13.1–3465, respectively. The most frequently detected pesticides in these vegetables were carbendazim (Fungicide) and chloropyrifos (Insecticide). Pesticide residues in 4% of the eggplant, 44% of the tomato and 19% of the chili samples exceeded the EU MRLs. The concentration of pesticide residues in the vegetable crops from the IPM field was considerably lower, suggesting a greater ability of IPM systems to reduce the dietary risks from exposure to pesticides (Bhandari *et al.*, 2019).

Pesticides residue tests of fruits and vegetables conducted by the government in various parts of the country between July 16, 2017 and May 14, 2018 have revealed that out of 3,677 samples 33 were found inedible due to high concentrations of pesticides. Likewise 93 samples of *fruits* and vegetables were quarantined. Out of the 507 samples tested at the Pokhara lab, 19 were inedible while 23 samples were quarantined, (Bhandari, 2019) most cases, the quarantined samples can be consumed after a few days (PPD 2018). Vegetables with AChE inhibition below 35 percent pesticide residue will be categorized as acceptable (Green) and safe´ for consumption purpose. Vegetables with pesticide residue of 35-45 percent will be acceptable only if they are consumed after 4-5 days (Yellow). Vegetables with more than 45 percent pesticide residue are harmful not only to human being but also animals. Such vegetables with more than 45 percent pesticide residue should not be consumed and need to immediately dump such vegetables regardless of their quantity (Red). RBPR does not calculate amount of pesticide neither it gives type of pesticides. It gives only inhibition percentage from which the result is withdrawn.

Residues analysis of 75 samples of 13 vegetables indicated that 58%t of the vegetable samples contained no detectable level (NDL) of the monitored pesticides, 38% samples resulted in trace level of the pesticides residue or below the minimum residue level (MRL), while 4% samples *showed* above MRL (EU Standard) (Sharma, 2015). However, this is an alarming situation. So there is an urgent need to analyze the marketable produce and to generate awareness among farmers and consumers.

TRAVELING ON/IN FOODS FROM FIELDS TO THE DINNER TABLES

This article focuses on pesticide residues, or the pesticides found on the surface of fruits and vegetables when they are purchased as groceries. Vegetable production in Nepal is now significantly dependent on pesticides, either on large scale production or smallholder production systems. The deep concern of society about environmental pollution, especially pesticide residues in food crops and products, has been growing in recent years. Fruit and vegetable production, easily are undertaken by unskilled and untrained farmers (WHO, 2003). Chemical contaminants in raw fruits and vegetables may be added during agricultural *production*, post-harvest handling and other unit operations. Much of the problem too has come about because of misuse of pesticides by farmers. Farmers are known to spray certain pesticide on cauliflower to give it an extra white appearance. Okra is dipped in chemical (copper sulphate) to make it look greener. Several farmers violate the rule that no spraying should be done a week before harvest to prevent high pesticide residues in vegetables. That has seen residue levels shoot up to dangerous levels in such vegetables as okra, tomatoes, cabbage and cauliflower. The highest level of use was on brinjal (3.34 a.i. kg/ha), which was much higher than on any of the other arable crops. The tomato crops were next highest in level of use (1.95 a.i. kg/ha), potato (1.03 a.i. kg/ha) and Cole crop (0.70 percent a.i. kg/ha) (Bhandari *et al.*, 2019).

The specter of pesticides traveling on/in foods from fields to the dinner tables has concerned the public. Farmers use higher amounts of pesticides than recommended doses because of ignorance, lack of training, experience, awareness etc. Farmers believe that production will be more if they apply more of pesticides. For that reason they use excess pesticides. It has been suggested by various studies that fruits and vegetables may contain residues of pesticides. Among all crops, comparatively more pesticides are applied for vegetables crops. The pesticide residue is expected to come from field to kitchen/dining table. The transmittal of pesticide residues is also expected through the food chain to the farm family and urban consumers. Milk and milk products sometimes are found contaminated with insecticides from feed and fodder which remain associated with its fat portion. Theoretically, it will never reach zero concentration, and therefore there will always be pesticide residue o/in food. Ever more pesticides, many illegal, are being used in

Nepal, Yet the tainted or contaminated produce keeps ending up on dinner tables, setting off alarm bells about serious health risks. In reality we (consumers) are also ingesting poisons that can accumulate in our bodies and make us very sick. We all ingest lots of chemicals, one way or another. We breathe them, we drink them, and we eat them. It makes us uncomfortable to think that while we are eating fruits and vegetables. Next time you're shopping at the fruit and vegetable market or grocery store, you may want to think twice about the fruits and veggies you plan to buy. The bigger sizes of vegetables and fruits in the market may look attractive, but people should also think twice before purchasing them. Otherwise, chemicals pesticides in the field do show up on our dinner plates or onto our kitchen tables.

Fruit and vegetables are an important part of a balanced diet. Doctors and nutritionists always advise us to eat plenty of green leafy vegetables, fruits and salads. Fruit and vegetables are an important part of diet as they contain vitamins, essential micronutrients, fiber, vegetable proteins and bio-functional components. We are told to eat two pieces of fruit and vegetables every day, but are they safe to eat? Most of the fruits and some of the vegetables are consumed directly without cooking. But most of these vegetables contain residues of pesticides that are widely used in Nepalese agriculture. However, the use of pesticides during production in the crop field often leads to the presence of pesticide residues in fruits and vegetables after harvest. Hence, the issue of pesticide residues assumes much greater importance for this food items. There are many ways that people are exposed to or come in contact with pesticides every day. One of the ways is eating such fruits and vegetables with pesticides on them. We are not only slowly poisoning ourselves but jeopardizing our future generations too. One of the most common routes of pesticide exposure to consumers is via food consumption. It is important for the consumer to understand the intake of pesticide residues. All agricultural produce marketed and consumed must not contain pesticide residue levels higher than the MRLs. Food safety is defined as the assurance that the food will not cause harm to the consumer when it is prepared and/or eaten according to its intended use.

Randomized security checks of pesticide residues in the field will help increase farmers' motivation to use less toxic pesticides and apply them in a standardized way. For this reason, it is urgent to develop programs related to the monitoring of pesticide residues in food to secure consumers. This calls for a comprehensive and integrated **farm-to- dining table** approach in which the producer, processor, transporter, vendor, and consumer all play a vital role in ensuring food safety and quality.

EFFECTS OF PESTICIDE RESIDUES

The presence of pesticide residues is a concern for consumers because pesticides are known to have potential harmful effects to other non-targeted organisms than pests and diseases. Worldwide, people are unwillingly exposed to pesticide residues through food. The persistent use of pesticides leaves behind toxic residues on food crops. These pesticides upon ingestion exert adverse effects on human health, in addition to disturbing ecosystem. Dietary exposure is the function of pesticide residues level in food and rate of consumption of that food. Human health effects associated with pesticide residues exposure include headache, skin irritation, itching, dizziness, restlessness, neurotoxicity, breathing difficulties, unconsciousness, and chronic poisoning-related diseases such as cancer and death incidences. There are two types of health effects—one is acute or immediate and the other is chronic or takes place over longer periods of time.1 in 10 people fall ill every year from eating contaminated food and 420,000 die each year as a result. Children under-5 is at particularly high risk. 125,000 young children die from food borne diseases every year (WHO, 2020).

It is suggested that different processing operations can be effectively applied on fruits and vegetables to minimize the risk of pesticides on human health. However, pesticide use also has created concerns regarding its effect on the environment and the potentially toxic or carcinogenic residues remaining in the food chain. The main concern of the public is the possibility of adverse reactions due to the 'cocktail effect. The concern has led to three tier governments (central, provincial and local) setting up monitoring systems in order to assess the safety situation and make informed decisions when passing legislation.

FARMERS' AWARENESS OF PESTICIDE RESIDUES

Farmers serve as the main unit of pesticide application. Hence, their degree of awareness of pesticide residues inherently affects their methods of pesticide application. Majority of the farmers are unaware of pesticide types, dose, frequencies and waiting periods and safer disposals (GC, 2015). Risks from pesticides are high because of the lack of knowledge of farmers, limited training and awareness on the safe production of food crops, the absence of an effective code of practices, and inadequate residue monitoring (FAO-TCP/NEP/3502, 2017). Commercial vegetable production in Nepal heavily relies on chemical pesticides. Pesticide residues have always been an important concern in agricultural safety. Most of the farmers have impression in their mind that spray/use of more pesticide will lead to higher production. The farmers do not have adequate knowledge regarding pesticide use, food and health safety. The concept of chronic poisoning and health risks is not fully understood by farmers. In general, farmers often follow the advice of their retailers for choosing pesticides. Farmers refer to pesticides as

medicines rather than poisons, a notion implanted in the mind of the farmer (Palikhe, 2002). The applications of pesticides are unscheduled and normally apply more than the recommended dose of pesticides. This activity raises concerns regarding chemical residues on vegetables and fruits. It is a known fact that farmers do not follow the pre-harvest waiting period. Waiting period is the duration after which the commodity treated with pesticides can be used. Each crop protection product has its own Pre-harvest interval (PHI), and the PHI for a specific product often varies by crop. There is a waiting period prior to harvesting. They apply pesticides near harvest time. Vegetables tend to be sprayed heavily up to the time of harvest, and then transported directly to market with no waiting period; moreover, many are consumed whole. In the absence of moral and legal barriers, vegetable growers are working on grow-fast sell-fast principle. Vegetables sold in market are mainly grown in commercial villages around the city and are harvested and sold fresh. Vegetables sprayed the day earlier are brought to the market the next day. These create a very significant potential for pesticide residues causing negative health effects on consumers. Awareness is needed (by both producers and consumers) of "win-win" practices that will lead not only to improvements in terms of yield and productivity but also for the environment, health and safety of workers.

CONSUMER AWARENESS

The consumer is the ultimate buyer and/or end-user of produce in horticultural supply chains. A consumer may be a business, a household or an individual. Public concern over pesticide residues in vegetables and fruits has been increasing during the past years. The general public concerns include: What about the chemicals the farmers use to keep their crops free from pests? Does my food contain any pesticide residues? How is my food checked for pesticide residues? Where can I find more information? How safe are the vegetables and fruits that we consume every day? Should I take fewer vegetables as they may contain pesticide residues? The use of pesticide might leave some residues on food crops. There is ground for suspicion of any wrong doing, since then consumers have tried to avoid eating it, but for how long? Pesticides used just before harvesting can lead to excessive residue in food, affecting the health of consumers. Pesticide residues affect the quality of agricultural goods. Consumers' perception of quality is based primarily on visual appearance and physical condition, with safety ranking second. Most consumers in Nepal think that fresh fruits and vegetables are safe since they are grown locally and they are not familiar with signs of unsafe food. A small elite group of consumers is becoming more conscious of the detrimental effects of chemical pesticides and is moving towards residue-free produce. Unfortunately, most of the consumers have little or no understanding of pesticide contamination.

Consumer concerns about pesticide residues in foods are widespread, which is reflected in a significant willingness to pay (WTP) for avoiding related risks. In developing countries, widely reported incidents of dangerous levels of pesticides in food have stimulated the demand for organic food, a movement to choose organic agriculture. Almost all the consumers were willing to pay up to 50% premium for the organic fruits and vegetables.

REDUCTION OF RESIDUES

Generally, the quantity of pesticides used in Nepal is still relative low compared to many countries in the SAARC region. As such, the issue of concern should be “proper use of pesticides” rather than purely “reduction of pesticide use”. In practice, the feasibility of pesticide reduction depends on the nature of the crop, the associated environmental and ecological conditions, and the farmer’s socio-economic situation. As consumers we do not have any control on the pesticides that is sprayed on fruits and vegetables in the farms but there are some quick do-it-yourself techniques that can help us get rid of the residues to a large extent.

How safe are the vegetables and fruits that we consume every day? Unfortunately, just washing vegetables is not enough to ensure produce clean enough for consumption. Can washing of produce help get rid of pesticides? Not really. Fruits and vegetables that we purchase and consume are safe, as long as we practice some measures before eating them. To some extent, washing of some fruits and vegetables with warm brine solutions are recommended to flush out the tainted pesticides from their outer surface.

Some pesticides are specifically created to stick to the surface of the crops and they don't come out by washing. To reduce the amount of pesticide residue, wash fruits and vegetables well in salt water (5 spoonful of salt to 1 liter of water), then rinse in fresh water. Immersing fruits and vegetables in water for 15 to 30 minutes can wash away part of the water-soluble pesticides; however, this process can never be 100% effective and is also likely to destroy some of the fruits nutritional value. Surface residues are amenable to simple washing operations whereas systemic residues present in tissues will be little affected. Certain pesticide residues can effectively be removed by blanching. But before blanching (a short treatment in hot water) it is very important to thoroughly pre-wash the vegetables and fruits. Discard the outer layer of leafy vegetables, such as lettuce or cabbage. Peel fruits and vegetables when possible. Trim fat and skin from meat, poultry, and fish to minimize pesticide residue that may accumulate in the fat. Many people choose to buy organic produce to avoid pesticide residues. Organic farming grows produce without the use of synthetic chemicals or pesticides.

In a developing country like Nepal there is a great need to regulate the use of pesticides where the extensive use of pesticides is causing serious health

and alarming environmental problems. To minimize the risk of pesticides on health GAP and different processing operations should be applied on fruit and vegetable crops that reduce the pesticide residues below the risk level. There is a need to educate the consumers through different media. Although alternative measures to chemical pesticide use are still limited, whatever is available should be rapidly transferred through various media to implementing agencies and farmers needing them. In particular, it is crucial to strengthen cooperation among researchers, extension workers and pesticide suppliers to help farmer gain the knowledge to better manage their crops. This paper suggests that great efforts to reduce potential health risks from chemicals should be implemented to improve farmer awareness against pesticides application and its hazards. Agricultural extension should be existed to play an effective and responsible role in these efforts. An improved approaches including farmer field school-integrated pest management (FFS-IPM) and, in general, good agricultural practices (GAPs) must be followed as a national strategy for continued crops production with minimal risks of pesticides to the environment and human health.

AWARENESS RAISING AND EDUCATION

Awareness raising and education are important/integral parts for improving pesticide management and food safety. Raising awareness among decision-makers can help generate necessary political support and resources for awareness raising/educational programmes. Awareness raising, education and training are considered essential to implementation of legal or regulatory scheme. The mass media should be enlisted to explain safety practices in pesticide use. General information about protective clothing, safe storage and disposal of pesticides, appropriate application technologies, and the like, should be made available through newspapers, radio, and television. Therefore, information, education and communication sectors need strengthening to raise awareness about proper use of pesticides and its safety measures. The quality of pesticides and their residue on marketable products is required to monitor regularly for public safety. Growing number of international agreements requires integrated and co-ordinate approaches at the national level. There is a good scope of working with appropriate intervention measures in this area for private sector, CBOs, NGOs/INGOs, research/academic institution stakeholders and journalists in order to monitor and reduce pesticide residues in agricultural products. Government should address the importance of educating various target groups in order to reduce pesticide risks and foster informed decision-making at all stages of the pesticide life cycle, and outlined some practical strategies for incorporating pesticides-related education into schools and universities.

DISCUSSION

Pesticide residues in crops are serious trade barriers. Unregulated and excessive utilization of pesticides is alarming due to its uneven distribution and usage on selective crops and the limited reliance on alternative chemicals like bio-pesticides and botanicals. Therefore, the first priority for the three tier governments is to organize and publish public campaigns to raise awareness of producers (farmers) and consumers on the important of food safety, especially based on pesticide management in pre and post-harvest of agricultural products. Nepal is oriented to the following recommendation: the need for awareness, education and training on the uses of pesticides to the farmers and effective monitoring program for pesticide residues in vegetables (Shrestha, 2002).

RECOMMENDATION

Government of Nepal has provided ample information and recommendation about the safe use of chemical pesticides through various means, however, there is widespread lacking in the implementation level. There seemed to be a mis-matching in principle and practice which needs to be studied why such things are happening and addressed through the "gapping of the maps programs". One of the main problem of not adopting the safe measures of chemical uses are lack of alternative compounds such as biopesticides and locally produced materials. Similarly, use of personal protective equipment (PPE) in hot and humid area is always difficult. Similarly, the overall feeling is that the effect of chemical pesticide is often quicker regardless of their associated hazards. As a result the producers often tempted to go with chemicals and do not want to go with other means that results slower effects. In order to address these issues, government needs strategies non-chemical measures of pest management programs. Collaborative initiation on biopesticides production with public private partnership is the key to move forward with biopesticides production.

Pre-harvest activities that have to be done:

- Train the farmers on the proper choices of chemical pesticides and their safe usage associated with elevated safety behavior;
- Promote using safe chemical pesticides including biopesticides and, botanical pesticides
- Train the technical staff in province extension workers, IPM-FFS trainers/facilitators and others organization or institution on safe use of pesticide;
- Train farmers, pesticide sellers, fruit and vegetable collectors and whole seller on pesticide on proper pesticide application techniques and safe use of pesticides

- Training manuals/guides should be simple language, easy to understand, and clearly illustrated. The contents should be relevant to the practical needs of farmers and with suggestions that farmers can implement.
- Publish campaign to people on impact of pesticide to the human and environment through many way such as training, TV broadcasting, radio, posters, pamphlet, flip chart with picture, leaflet, and street drama etc.
- Train farmers on pesticide residues in fruits and vegetables crop and pre harvest interval of pesticide application
- Extend the applications of IPM so as to reduce the need for pesticides.
- Promote Good Agriculture Practice (GAP) nationwide;
- Organize annual survey on pesticide available in market and cases of misuse by farmers and pesticide poisoning;
- Help proper pesticide use in vegetables, there is a need to prepare a recommended pesticide list with appropriate guidelines on how to use them on different crops and at different growing stages;

Postharvest activities that have to be done:

- Train farmers on post-harvest technology
- Produce quick test kits for detecting pesticide residues in the agricultural products (relevant to MRLs)
- Obtaining reliable data on the relationship between pesticide residues and PHI for each crop
- The central and provincial governments should help identify the quality standard of 'safe agro-products' that can be conveniently monitored
- Publish public awareness materials, e.g. posters, pamphlets/flyers, leaflets, radio/TV scripts on safe use of pesticides, FFS-based IPM Approach on Farmer, GAP, negative effects of pesticides, new technologies for pre and post-harvests, and alternative use of pest's control.

Policy level issues

Development of the mechanisms for producing safer products like biopesticides and botanical pesticides in joint venture of the national and international organizations. Research involvement in these aspects are almost negligible in Nepal. Hence, joint venture of public and private initiatives is a crucial. Aside from availing the products and their usages, harmoninsation of Pesticide Rules and Regulations are equally important.

International standards, networking, and collaboration

- Harmonies pesticide registration procedures and regulation including the establishment of residue analysis facilities accessible to every one
- Create enabling environment for agriculture trades through the promotion of niche agri-products.
- Coordinate the use of simple monitoring tests and standard protocols, ensuring quality assurance by linking their use to key analytical centers at Federal, Provincial and Municipal level.
- Encourage international collaborative research and exchange of information to obtain solutions to pesticide residue problems.

CONCLUSION

Consumers and all players in food production chains should be constantly informed on safe use of pesticides. Moreover, consumer bears responsibility to table safe food by ensuring safe source and abide to safe food preparation guidelines. It goes without saying, international, regional and national authorities have the responsibilities to guarantee safe food, free from pesticide residues and put in place traceability systems for both raw and processed food.

In Nepal, as in most of the other developing countries in the region, the capabilities, expertise and resources to fully implement the regulation are limited. Further, there is a need to strengthen the scientific and technical base for health and environmental risk assessment. There should be coordination and monitoring activity and integrated effort from governmental and non-governmental organizations that focus on the awareness raising of farmers on proper pesticide management and related issues. Therefore, information, education and communication should be strengthening to raise awareness about proper use of pesticides and its safety measures. So there is an urgent need to analyze the marketable produce and to generate awareness among farmers and consumers.Training manuals/guides should be simple language, easy to understand, and clearly illustrated. The contents should be relevant to the practical needs of farmers and with suggestions that farmers can implement. Redundancy in registration requirements should be reduced to expedite adoption of safer alternative products (such as bio-pesticides and reduced-risk conventional pesticides). Legislation promoting the use of safer pesticides is also needed.

Declaration of conflict of interest and ethical approval

Both the authors have drafted or written, or substantially revised or critically reviewed the article on from the field to dining table: Pesticides Residues. Both the authors have read the manuscript before submitting to the journal. The article also discussed conflict of interest (COI) situations. All applicable international, national, and/or institutional guidelines for the pesticide residues were followed.

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EMIGRATION AND FEMINIZATION IN NEPALESE AGRICULTURE: IMPLICATIONS FOR FOOD SECURITY

A.Pandey[1], K. Tripathi[2] and S. Devkota[3]

ABSTRACT

Nepalese labor industry of agriculture sector is dominated by female and has direct and indirect effect on food security. This paper has attempted to find and analyze consequences of male emigration and feminization in agriculture, and implication on food security. The study revealed foreign employment as major reason for international migration of Nepalese people. Higher male emigration 91.3% with large remittance inflow has ensured food secure condition in short run but there is long run food insecurity threats due to lower domestic production and higher investment on consumption. Further extra work burden in female due to absence of active male labor and limited agriculture knowledge and skills in agri-business has resulted land abandonment and underutilization of agricultural resources. The study suggested to develop female friendly agricultural practices, investment on productive enterprises and attract youth and female in agriculture to ensure sustainable food security.

Key words: Agriculture, Feminization, Food security, Land Abandonment, Outmigration

INTRODUCTION

In Nepal, the balance cereal distribution system is showing surplus food secure condition (MoALD, 2018). The statistical data of agriculture shows the positive aggregate national cereal balance. The cereals and pulses production in 2020 was increased by 2.3% and 5.8% (MoALD, 2021). The domestic production is insufficient to meet the demand of food, thus the cereal crops like rice, wheat, maize and other food like pulses, meat, etc. are imported to meet the demand of food. Despite of positive aggregate cereal production, twelve districts of high hills were still suffering from food insecurity in 2018 (MoALD, 2018). The Global hunger index of Nepal is improving over the years from 37.4 in 2000 to 19.5 in 2020. Nepal ranks 73rd out of 107 qualifying countries. Nepal is graduating from serious to moderate severity. However the food insecurity is still prevailed in mountain regions of mid-western, far western and central regions (Acharya, Ghimire, Upadhayay, and Poudel; GHI,

1 Directorate of Research and Extension, Agriculture and Forestry University, E-mail:pandeyamita01.ap@gmail.com

2 Department of Horticulture, Agriculture and Forestry University, E-mail: kmishra@afu.edu.np

3 Ministry of Agriculture and Livestock Development, Government of Nepal, E-mail: sudip.devkota@nepal.gov.np

2020). Improved and sustainable agriculture ensures national food security that eventually increases the economic growth and reduce the poverty of nations (Gauchan, 2008). Agriculture is the main pathway to achieve food and nutrition security. It contributes 27.08 percent to GDP of Nepal considering itself as a mainstay for the Nepalese economy (MoALD, 2021). Around 65.6 percent of the population are engaged directly in agriculture for their livelihood where 60.2% is represented by male population and 72.8 percent by female (CBS, 2012b).

Active participation of female labor in agriculture has increased from 36 percent in 1981 to 45 percent in 1991, 66.5 percent in 2016 and 57.5 percent in 2018 (CBS, 2014, 2016, 2019). This shows higher involvement of female in agriculture than male counterparts. Although female has a major functional role in food production and higher contribution to food security, national representative samples still lack the information of food and nutrition security in relation to female in their documents (Singh, Singh, and Ram, 2014).

Higher male labor emigration (91.3%) automatically transfers a household and farm responsibilities to female population. In this scenario, workload of farms and household has increased for female, while trend of the farming has decreased and land abandonment has increased (Chaudhary *et al.*, 2020b). Thus the land use system is changing with male emigration. During 1980s more than 80% of the population was engaged in agriculture. Agriculture used to be a dominant GDP contributor of a country. However, the recent data shows only 65.6% of the population engaged in agriculture. Likewise, the GDP contribution of agriculture in Nepalese economy has reduced to 27.08% (CBS, 2012b; MoALD, 2021; MoF, 2019). Further, lack of labor and female friendly mechanization, female are facing the drudgery in farming. In this scenario many female headed household have shifted from farming and relying on subsistence farming (Tamang, Paudel, and Shrestha, 2014). However the document related to food security of Nepal shows improved food security in present context when compared to the previous period (MoALD, 2018).

Thus, the objective of this paper is to find out what consequences does the female member of family bears after the male emigration and how the situation has affected on food security.

METHODOLOGY

This paper is completely based on secondary information The study represents the national issues on existing situation of female in agriculture, food security, and labor industry. The secondary information from Government reports like Annual Household Survey (AHS), Labor survey, Economic survey, Census reports and academic journals were reviewed.

RESULT AND DISCUSSION

LABOR OUT-MIGRATION

Foreign employment is a major reason for international migration of Nepalese people (IOM, 2019). Most of people in rural and hilly areas emigrates temporarily or permanently in search of jobs, education and other opportunities leaving the house and farm responsibilities to female and old aged people (IOM, 2019). The popular destination countries for labor migration are India, Qatar, United Arab Emirates, Saudi Arabia, Kuwait, Malaysia etc.(IOM, 2019). In 2018/19 among a total emigrated population of 236,630, 215630 (91.3%) accounted male and 20578 (8.7%) were female (MoLESS, 2020). Thus the emigration of male population is higher than female.

FEMALE IN AGRICULTURE INDUSTRY

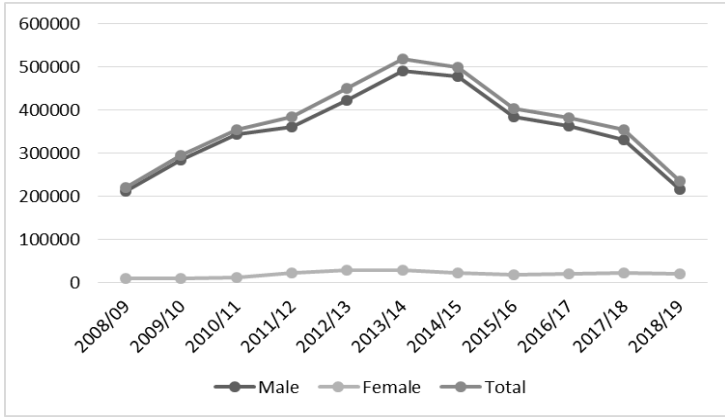

Figure 1. Trend of labor emigrant from Nepal (2008/09-2018/19)

Source: Ministry of labor, employment and social security (MoLESS, 2020)

Table 1: Employment rate of Male and female in formal and informal sector of Nepal

Employment	Formal employed			Informal employed		
	Male	Female	Total	Male	Female	Total
Agriculture	1.3	1.2	1.3	59.7	66.5	20.2
Non- Agriculture	39	32.3	36.5	45.8	32.9	41
Total	40.3	33.5	37.8	59.7	66.5	62.2

Source: Report on Labor Force Survey, (CBS, 2019)

From 1990 to 2019 there is tremendous increase in female to male ratio of labor participation (Worldbank, 2020). With increased participation of female in labor industry, economic active population of female has increased and higher than male (CBS, 2014). The majority of male are involved in construction, manufacturing and transport industries, while female are employed in agriculture, wholesale and retail trade (CBS, 2019). Further, the

employment rate of male is higher than female. From (Table 1) majority of formal sectors (40.3%) like waged agriculture and non-agricultural activities were occupied by male (CBS, 2019; NDRI, 2017), whereas as 66.5% female were employed in informal sectors basically in agriculture (paid and unpaid) (CBS, 2019). In general, among the total population engaged in agriculture (65.55% of total population), the share of female participation is 70.2% (CBS, 2011). Thus, increasing trend of female's involvement in agriculture as a labor force and occupation has feminized agriculture (Bhadra and Shah, 2007; CBS, 2015).

MALE EMIGRATION ON FEMALE HEADED HOUSEHOLD AND DECISION MAKING

In contrast to male, the female ownership to the land, assets and household is lower in Nepal (CBS, 2017; NPC, 2013). In the past, female used to have a submissive role in assets and household ownership. They used to agree the decision of the male member in the family, underrating and neglecting their own decisions (CBS, 2012a; MOHP, 2012). But the trend of female ownerships and female headed households is increasing in Nepal (CBS, 2016). The total female head household in 1996 was 12.4%, which was increased to 31.3% in 2016 (Worldbank, 2020a). One of the main reason for female headed household was emigration of male representatives (CBS, 2017; NPC, 2013; Shakya, 2014). However, pattern of household head is de-facto household head. There is an automatic shift of male responsibilities to female for a temporary period till the return of male (Joshi Rajkarnikar and Ramnarain, 2019; Pandey, 2019). Further, female in rural area are constrained by weak decision-making and bargaining power (FAO, 2019). Thus the decision making power of de-facto household head is vested upon the male representatives. Though there was improvement of decision making power of female after 2001, but from 2011 to 2016 there was decline in decision making power of female (MoH, NewERA, and ICF, 2017).

FEMALE HEADED HOUSEHOLD IN CONSUMPTION AND PRODUCTION

The mother group are found effective for increasing dietary diversity and food intake (MoALD, 2018). Feeding practices and nurturing behavior of females have the power to improve the nutritional status of children themselves and the family (MOHP, 2012). Different studies shows that female are more underweight in male headed household in comparison to female headed household (Kennedy and Peters, 1992). Thus, female headed household and decision making power plays positive and significant role in total calorie intake of house, improvement of nutritional status and reducing child mortality (IOM, 2019; MOHP, 2012). However the consumption in a female headed household is affected by several factors like the number of children, size of landholding, family and remittance. The female headed household with adequate or large remittance has a better nutritional status

than others. However, female headed households with low income and low remittance have worst food and nutritional status (NPC, 2013).

Female headed household with decision authority have control over household income, consumption pattern, choice for own health care, household purchases and food selection (MOHP, 2012).With male out-migration, there is increased in the decision making power of female on farm for selection of crops and varieties for crop production (IOM, 2019). Nepalese female are involved in several activities including agriculture (self-employed) and other household chores (MoPE, 2016; Pattnaik, Lahiri-Dutt, Lockie, and Pritchard, 2018). From 2008 to 2015/16, working hour of female has increased from 34.8 hours per week to 67.6 hours, whereas; working hour of male has increased at a slow rate from 43.1 to 54.1 hours per week (CBS, 2009, 2016). The entire tasks that used to be done by the male before out-migration are carried by the female. There is an extra burden of work in female headed households, including farm and household.

The female headed household with adequate or large remittance have better opportunities for commercial vegetable farming and high value crop production (Adhikari, 2008; Upreti, Ghale, and KC, 2016; Upreti, Ghale, Shivakoti, and Acharya, 2018). However, there is a severe scarcity of physically strong labor due to male emigration. Income from migrated labor have the ability to hire labor, but the prevailed labor scarcity, never gives an opportunity to move the subsistence farming towards more profitable commercial farming (Maharjan, Bauer, and Knerr, 2013). Thus a female household is based on small scale production and depending on lower labor required crops like vegetable. So, out-migration has negative impact on cereal production like paddy, wheat, maize and millet (FAO, 2019; Maharjan *et al.*, 2013). Further, the production value from farm managed by female is lower than farm managed by male. There are gender inequalities in accessing, adopting and using technologies. Likewise, there is distinct difference between the male and female for their agriculture knowledge and skills in selection of crop varieties, cultivation practices, harvesting and processing. Limited knowledge on markets demand and supply, weak decision making and bargaining power, and restriction opportunities on setting up micro-enterprises and agriculture business has hindered female entrepreneurial potential in Nepal (FAO, 2019). Thus female role in production is still lagging as compared to the male counterpart.

Male emigration and transfer of ownership to female, the social and cultural aspects has become wider for female. Female are more involved in several activities like saving, participation in cooperatives, which has increased their access to credit and loan, and gained political and economic position (Gartaula *et al.*, 2017). For this situation female has diverted from agriculture to other aspects (Gartaula, Niehof, and Visser, 2010). Also, the

socio-cultural aspects of society have hindered female to work in the field (FAO, 2019). Higher liquidity and reduced capital constraints have made easier to depend on external production (Maharjan *et al.*, 2013). Further, the cost of production in agriculture is higher, with respect to this they feel effective to depend on external production (FAO, 2019). The remittance has increased the consumption and enhanced the lifestyle of households, which is also a reason for internal migration from rural to urban areas. During 2019, among total internal migrants, 65.1% of population have migrated from rural to urban. The internal migration of female was found higher than the male counterpart. Around 10.4 % of internal migrants were found migrating to urban areas for easier lifestyle (CBS, 2019), Similarly, the cropping intensity of labor intensive agriculture depending on female is less resulting low production (Ojha *et al.*, 2017; Tamang, Paudel, and Shrestha, 2014). Thus the consequences of out migration from rural areas, land underutilization and land abandonment are severe in male emigrated household (FAO, 2019).

Table 2: Representation of annual working hour per week of male and female (2008-2015/16)

Category	2008	2013/14	2014/15	2015/16	2017/18
Male	43.1	47.9	49.9	54.1	48
Female	34.8	58.6	58.8	67.6	39

Source: Nepal Labor Force Survey and Annual Household Survey, Nepal

The out-migration of male representatives has created extra social and economic burden to female household head (FAO, 2019). The drudgery and extra physical burden creating triple work burden (production, reproduction and community) (FAO, 2019) have made female unable to farm. The table 2 depicts increasing annual working hour per week of female from 43.1 to 54.1 from 2008 to 2015/16. However the working hour has decreased to 48 in 2017/18, simultaneously with decrease of average annual working hour per week (44 hours) from 60.85 hours. Apparently male out-migration has feminized agriculture, but in fact it is a feminization of agrarian distress. This result was found similar with the finding of (Laxaa, 2015; Tamang *et al.*, 2014).

REMITTANCE, FOOD CONSUMPTION AND PRODUCTION

Table 3: Remittance inflow and its effect in food security indicators

Description	2013/14	2014/15	2015/16	2016/17
Remittance (Billion NRs)	543.3	617.3	665	695.5
Per capita food Consumption (Nominal)	31008	33090	33085	34978
Food Consumption score	62.8	66.5	65.2	71.6
Poor food consumption score	8	4.6	4.4	5.3
Acceptable food consumption	80	84.5	84	85

Source: Nepal Living Standard Survey (NLSS III), 2011; Annual Household survey (AHS), 2016/17

Over a last decade food insecurity and malnutrition nearly of 30 million population has reduced in Nepal (NPC and WFP, 2019). Till 2016, the food insecure population was reduced to 4.6 million people, with 20 %, 22% and 10% of mildly food insecure, moderately food-insecure and severely food-insecure respective household (NDHS, 2016). Nepal is making good progress in reducing the food insecurity (NPC and WFP, 2019). Remittance is the major contributor to reduce food insecurity (Sah, 2019). The study of (Regmi *et al.*, 2019) found remittance recipient household in food secured condition than the non-recipient household. The food adequacy and food consumption score of Nepal has increased in the context of past scenario. Further expenditure on per capita food consumption has increased with increase in remittance (Table 3).

Figure 2 depicts 24.5% of remittance shares to National GDP of Nepal (MoF, 2019). Remittance has significant contribution to economic growth of Nepal (Paudel, 2015). The additional income of remittance has positive impact in food consumption (Ghimire, 2018). Remittance has increased per capita income and purchasing power parity. The increased household income due to remittance is mainly used for purchasing food, goods and education (Jaquet, Shrestha, Kohler, and Schwilch, 2016). So, majority of remittance is used for improving the quality of life (Bhatta, 2013). Despite of food affordability and availability, huge import has increased trade deficit (Bhatta, 2013; Sharma, 2017). Thus, consumption oriented Nepalese society has threaten the trade balance in Nepal (Dahal, 2014; Sharma, 2017). Further, majority of remittance is from poor family, used for consumption, loan repayment and betterment of quality of life (Zwager and Sintov, 2017). The expenditure in food consumption is higher than production of good and service in Nepal (Bhatta, 2013; B. Khanal, Banskota, and Giri, 2017). According to NLSSII, about 79% of remittance was used for daily consumption and only 2% was used for capital formation (CBS, 2011).

There is a minimal investment of remittance in agricultural sector. The study of (Khanal, Alam, Khanal, and Regmi, 2015) found only 5% of remittance used for agriculture purpose and similarly, (Zwager and Sintov, 2017) found remittance contributed only 1% for improved farm production. While, the study of (Acharya *et al.*, 2019) found remittance used for purchasing seeds and fertilizers, surprisingly the study also found higher fallow land holding in emigrated households. Despite of increasing trend of remittance, there is no increment in agricultural land. There is insignificant remittance investment for extending agricultural land (Chhetri, KC, and Dhakal, 2020). Thus, a major portion of the remittance was used for consumption, saving, and investment in off-farm activities.

Though remittance is key factors in reducing poverty, improving human capital and financing imports, there is decrease in local production and

increased dependency on imported food sources (Sharma, 2017). Food security achieved from additional income from remittance has enhanced land abandonment and neglected crops farming. Hence, sustainable maintenance of livelihood and food security is hampered with better off income from remittances (Maharjan *et al.*, 2013). So there might be threat to depend over other countries for food.

LAND ABANDONMENT AND SHIFT FROM AGRICULTURE

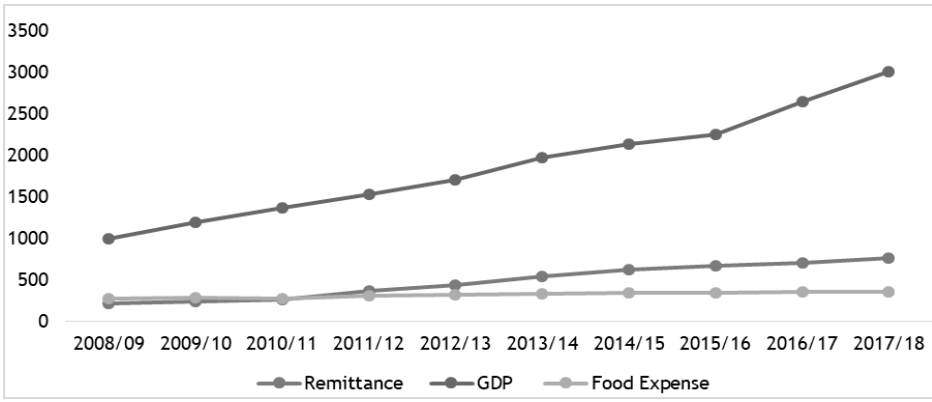

Figure 2. Increase trend of remittance inflow (NRs Billion), GDP (NRs Billion) and food expenditure (NRs) in Nepal

The socio-cultural changes with changing population dynamic has favored emigration (Ojha *et al.*, 2017). Traditional and subsistence farming is unable to maintain a sustainable household economy, which has made agriculture as unviable occupation. Low and reduced agricultural production as a serious threat has lead farmers to follow other alternatives. Thus better economic opportunities in foreign lands have made farming as less profitable. Among several factors, migration is one reasonable factor in land abandonment (Chaudhary *et al.*, 2020b). Land abandonment is most prevalent in the hilly and mountain region of Nepal. Around 23.9% of land was abandoned in 2010/11 which was increased to 37% in 2017 (Paudel *et al.* 2014; Ojha *et al.* 2017). Land abandonment has a serious effect in socio-economic and ecological aspect of people, especially for the poor people (Chaudhary *et al.*, 2020b; Jaquet *et al.*, 2016). The farmers who used to cultivate the productive land for many generations has completely abandoned the land (Jaquet *et al.*, 2016; K. P. Paudel, Tamang, and Shrestha, 2014). The land abandonment has triggered the invasion of wild species, soil degradation, genetic erosion, loss of agro bio-diversity and geomorphic damages like landslide, flood, siltation and erosion. Thus, soil fertility and productivity are decreasing thoroughly in those areas (Chaudhary *et al.*, 2020a, 2020b).

Thus agriculture is vulnerable, less productive, unsustainable and unattractive with long term impact in food security due to male emigration (Craven and Gartaula, 2015). Further, majority of returning labors are engaged in the construction program. The agriculture involvement of returning Nepalese toward agriculture is lower (CBS, 2019). Though the migrant labor has perspective to invest remittance in agriculture and livestock, in reality remittance was oriented to real state purchase. Only 7% of remittance was used as productive investment in business and farm activity (Zwager and Sintov, 2017).

CONCLUSION

Emigration has drained huge number of Nepalese labor in to the foreign land. Accompanied with this, there has been labor scarcity in Nepal including the agriculture sector. With huge number of male emigration (91.3%), their responsibilities of farm and household are transferred to female. Thus there is feminization in agriculture. However, the burden of farm and household, labor scarcity, drudgery has created agrarian distress in female. On the other hand, emigration has also increased the decision making power and female headed household, but analytically these power seems to be *defacto*, which means for temporary period until the return of male. Thus the consequences of emigration has resulted scarcity of productive labor and family labor for agriculture, leading to reduced crop farming and land abandonment. The land use system has converted from agricultural land to underutilized, abandoned and fallow, which has directly reduced the soil fertility and productivity. The degradation of biodiversity and change in land use system has converted the production pattern to the consumption.

Emigration has created farm distress on one hand, has improved the food consumption and purchasing power on another side. It has contributed in reducing the food insecurity. With the transfer of responsibilities, some female have developed their socio-economic status through mobilization of remittance and exploitation of opportunities. With aid of remittance, the household income has increased which has increased the household consumption mainly in food and education, for purchasing luxurious goods. While there is minimal investment of remittance on farming as well as other productive works. However, the entrepreneurial potential of female in farm production is untapped due to their limited knowledge and skills on agricultural practices, technologies and market. Besides there are also restriction for setting enterprises and agribusiness. Likewise, most of technologies are based for male access and adoption. Thus income from remittance has directly assisted to decrease the local production and increase dependency on external food sources which ensures food security for short run, but there is always threat in the long run to sustainable food security.

Male emigration and remittance are not best alternatives for achieving food security and empowering the women. It has deprived women creating high workload in one hand, and making them consumption oriented on other hand. This may break the production chain and misbalance the food security status of a country.

Thus to ensure food security on sustainable way, and to promote the domestic production, the agriculture programs and policies of Nepal should prioritize female friendly agricultural technologies and attract the youth including female for investing on enterprises like crop and livestock.

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EFFECTS OF DIFFERENT BIO-RATIONAL COMPOUNDS ON MORTALITY OF DIAMOND BACK MOTH (*Plutella xylostella* L.) LARVA UNDER LABORATORY CONDITION

A.M. Bhattarai[1*] and S. Tiwari[2]

ABSTRACT

A leaf dip technique of bioassay for mortality of DBM larvae was conducted in laboratory condition with room temperature of 25±2°C, relative humidity of 80±3% and 13:11 ratio of Light: dark period at Department of Entomology, Agriculture and Forestry University, Rampur, Chitwan with three replication and eight treatments; i.e. i) Lipel (Bacillus thuriengiensis var. kursataki) 2gm/l, ii) Racer (Beauveria bassiana1.15% WP) 2gm/l, iii) Derisom (Fractions of Derris indica) 2ml/l, iv) Anosom (Extracts of Annona spp. 1%) 2ml/l, v) Neemix (Neem oil 60% w/w, Azadiractin content less than 300 ppm) 2ml/l, vi) Anthsuper (Chloropyrifos 16% A.I. + Alphacypermethrin 1%EC (w/w) 2ml/l, vii) cow urine (1:5 with water) and viii) control (water spray) in Completely Randomized Design (CRD). The larval mortality was taken after 3, 9, 21, 33, 57 and 93 hours after the treatment application. The larval mortality was found to be significantly higher in Anthsuper treated with 100% mortality of larvae within 33 hours after treatment application followed by cow urine, botanicals (Neemix, Derisom and Anosom) and microbials (Racer and Lipel) where the larval mortality over control was found to ranging from 10% to 47.57% during the experimental period. The larval mortality was 47.57% for Cow urine and Neemix followed by 38.14% for Anosom, 33.29% for Racer, 28.57% for Derisom and 19% for Lipel.it is concluded that chemical pesticide Anthsuper is superior for immediate control of the pest but considering the safety of environment and human health; for long-term control of the pest botanicals and microbials would be more efficient.

Key Words: Anthsuper, botanicals, crucifers, DBM, microbials

INTRODUCTION

Cabbage is one of the most important crucifers vegetables in the context of Nepal, where crucifers is contributing 28% of economy among the vegetable production. It covers an area of 28,071 ha, 468,836 mt production and 16.7 mt/ha average productivity in Nepal (VDD, 2016). Different factors like varieties, quality seeds, cultivation practices, fertilizers, diseases and insect pests are the limiting factors for their production.

Diamondback moth (*Plutella xylostella* L.) is one of the major leading pest factors for low productivity of cruciferous crops (RPPL, 2003; NARC, 2016;

1 Mahendra Ratna Multiple Campus, Institute of Agriculture and Animal Sciences, TU, Nepal

2 Agriculture and Forestry University, Rampur, Chitwan, Nepal

* Corresponding Author: ananta.bhattarai@mrmc.tu.edu.np / palpali.ananta@gmail.com

PPD, 2018) and has caused heavy loss in cole crops in Nepal. Larvae are the damaging stage of the pest where they damage the crop by feeding on foliage parts of the crop and hinder the growth of the plant leading significant reduction in yield. DBM is known to cause yield loss from 31 percent (Abraham and Padmanabhan, 1968) to 100 percent (Cardleron and Hare, 1986) and the conservative estimate of total costs for managing this pest is estimated to be US$4 billion to US$5 billion (Zalucki *et al.,* 2012).

The essential oils extracted from the botanical plants like *Corymbia* spp. And *Eucalyptus* spp. have insecticidal activity and caused up to 80% larval mortality against *Plutella xylostella* L. (Filomeno, et. al., 2017).

Diamondback moth is the most serious one because of the development of resistance with many common commercially available chemical pesticides including DDT (Ankersmit, 1953), bacterial insecticide, *Bacillus thuringiensis* (Tabashnik, Cushing, Finson, and Johnson, 1990), diamide (Gong, Yan, Gao, Guo, and Xue, 2014) and many others commercially available chemical pesticides due to intensive use of those insecticides (Rindland and Enderby, 2011).

The objective of the study was to find out the effect of different bio-rational compounds (chemical and bio-pesticide) on mortality of diamond back (*Plutella xylostella* L.) larvae in laboratory condition.

MATERIALS AND METHODS

LOCATION OF EXPERIMENTAL SET UP, PERIOD, DESIGN AND UNIT

The experimental location for bioassay was laid out in the IPM laboratory of Department of Entomology, Agriculture and Forestry University, Rampur, Chitwan.

The experiment was conducted in April 2015 in Completely Randomized Design (CRD).

Each experimental unit consisted of 10 third instar larvae of *P. xylostella* (L.) which was replicated three times with eight treatments. In total there were twenty-four experimental units. The treatments were allocated randomly using three-digit random numbers selected from random number table

Plutella xylostella L. adult was reared on cages; where biology was observed and let them bred. The experimental unit of larvae was taken from the cages which were free of any treatments to be applied during the experimental period.

TREATMENTS

200 ml solution of insecticide/ bio-pesticide with distilled water was made for each treatment. The leaf dip bioassay technique was applied. The treated leaf size has a diameter of 4 cm and was changed every 24 hours. All this bioassay activity was conducted under the controlled room condition in Entomology Laboratory with room temperature of 25±2°C, relative humidity of 80±3% and 13:11 ratio of Light: Dark period. The treatment consisted as given below:

Table 1. Treatment details for bioassay of *P. xylostella* (L.) in Laboratory, Rampur, Chitwan, 2015

Treatment	Common Name	Chemical/Scientific Name	Dose
1	Lipel	*Bacillus thuringiensis* var. *kurstaki* (SP)	2gm/l
2	Racer	*Beauveria bassiana* 1.15% WP	2gm/l
3	Derisom	Fractions of *Derris indica*	2ml/l
4	Annosom	Extracts of *Annona* spp. 1%	2ml/l
5	Neemix	Neem oil 60%w/w, Azadiractin content less than 300 ppm	2ml/l
6	Anthsuper	Chloropyrifos 16% A.I. + Alphacypermethrin 1%EC (w/w)	2ml/l
7	Cow urine	-	1:5 with water
8	Control (Water spray)	-	-

OBSERVATION, DATA RECORDING AND ANALYSIS

The mortality record of DBM larvae were taken at an interval of 3, 9, 21, 33, 57 and 93 hours after the setup of the experiment.

Data were tabulated using Microsoft Excel software. The larval population was transformed by square root transformation (SQRT ~$\sqrt{}$(x+0.5)) and analyzed using R-Studio (Version 4.0.0) software package to see the effect of bio-pesticide on diamondback moth (*Plutella xylostella* L.) third instar larvae. Means separation was done by DMRT at 5% level of significance (Gomez and Gomez, 1984).

RESULT AND DISCUSSION

LARVAL MORTALITY BY CHEMICAL TREATMENT

The larvae treated with chemical insecticide Anthsuper (Chloropyrifos 16% A.I. + Alphacypermethrin 1%EC) was found to be significantly at par with

other (botanicals, cow urine and control) treatments during the whole period of experiment on the mortality of DBM larvae in the laboratory in different duration with range of more than 65% mortality after three (3) hours treatment up to 100% mortality rate within a duration of 33 hours of treatment. Comparatively higher reduction of larval population of *Plutella xylostella* (L.) was found with Anthsuper treated plots immediately after application containing Chloropyrifos 16% A.I. and Alphacypermethrin 1%EC; which was supported by Leibee and Savage (1992) where the combination of Chloropyrifos and Cypermethrin was most effective to control *Plutella xylostella* and *Trichoplusia ni* in field condition. The larval population of DBM was found to be controlled by cent percent even 15 days after treatment application when Chlorpyriphos 50% EC + Cypermethrin 5% EC was sprayed (Boopathi, Pathak, Agachan, and Das, 2010).

Table 2. Bioassay of *P. xylostella* (L.) larvae in laboratory for calculating mortality incurred by different treatments (Relative Humidity=80±3%, temperature= 25±2°C and 14:10 Light: Dark Period) in Rampur, Chitwan, 2015

Treatments	Pre-Treatment Population of larvae	Average number of Dead Larvae					
		3 Hours after Treatment Application	9 Hours after Treatment Application	21 Hours after Treatment Application	33 Hours after Treatment Application	57 Hours after Treatment Application	93 Hours after Treatment Application
Lipel@2 gm/l	10	0.00^{B}±0.00	1.67^{BC}±0.33	2.00^{BC}±0.00	2.67^{CD}±0.67	3.67^{B}±0.33	4.33^{C}±0.33
		(0.7071068)	(1.4623408)	(1.5811388)	(1.761199)	(2.037823)	(2.195950)
Racer@ 2gm/l	10	0.00^{B}±0.00	1.00^{BCD}±0.58	1.33^{C}±0.33	2.00^{D}±0.00	4.33^{B}±0.33	5.33^{BC}±0.33
		(0.7071068)	(1.1709968)	(1.3435429)	(1.581139)	(2.195950)	(2.413309)
Derisom @2ml/l	10	0.67^{B}±0.67	1.67^{BC}±0.67	2.67^{B}±0.33	2.67^{CD}±0.33	4.00^{B}±0.58	5.00^{BC}±0.58
		(0.9984508)	(1.4401061)	(1.7742654)	(1.774265)	(2.112452)	(2.338679)
Anosom @2ml/l	10	0.67^{B}±0.67	2.67^{B}±0.33	3.33^{B}±0.33	3.33^{BC}±0.33	4.33^{B}±0.67	5.67^{BC}±0.88
		(0.9984508)	(1.7742654)	(1.9543259)	(1.954326)	(2.187081)	(2.469814)
Neemix @2ml/l	10	0.67^{B}±0.67	1.67^{BCD}±1.20	2.67^{B}±0.67	4.00^{B}±0.00	5.00^{B}±0.58	6.33^{B}±0.33
		(0.9984508)	(1.3510573)	(1.7611993)	(2.121320)	(2.338679)	(2.612544)
Anthsup er@2ml /l	10	6.67^{A}±0.88	7.67^{A}±0.33	9.67^{A}±0.33	10.00^{A}±0.00	10.00^{A}±0.0	10.00^{A}±0.00
		(2.6664322)	(2.8565216)	(3.1876492)	(3.240370)	(3.240370)	(3.240370)
Cow urine@ 1:5 with water	10	0.00^{B}±0.00	0.33^{CD}±0.33	2.00^{BC}±0.58	3.67^{BC}±0.33	5.33^{B}±0.88	6.33^{B}±0.67
		(0.7071068)	(0.8796528)	(1.5589041)	(2.037823)	(2.401714)	(2.607478)

Control (Water spray)	10	0.00^{B}±0.00 (0.7071068)	0.00^{D}±0.00 (0.7071068)	0.33^{D}±0.33 (0.8796528)	2.00^{D}±0.58 (1.558904)	2.33^{C}±0.33 (1.677702)	3.00^{D}±0.00 (1.870829)
LSD		0.56383	0.616382	0.382776	0.319176	0.357269	0.299813
CV		30.69	24.47	12.60	9.20	9.08	7.02
F-test		'***'	'***'	'***'	'***'	'***'	'***'
Mean		1.06	1.46	1.76	2.01	2.27	2.47
MS Error		0.1061	0.1268	0.0489	0.034	0.0426	0.03

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

CV: Coefficient of Variation; S: Significant; LSD: Least Significant Difference; values with the same letters in a column are not significantly different at 5% by DMRT (Duncan's Multiple Range Test); figures after ± indicate standard error and figure in parenthesis indicate mean value of $\sqrt{(x+0.5)}$ transformation data

LARVAL MORTALITY WITH BOTANICALS

The mortality of *P. xylostella* (L.) larvae were not significantly higher than control in the initial period of experiment but found to be increasing and were significantly at par in long duration (21 hours, 33 hours, 57 hours and 93 hours after treatment) than control with percentage reduction over control by 24%, 31% and 24% in21 hours after treatment application for derisom, anosom and neemix respectively and 28%, 38% and 47% in 93 hours after treatment for derisom, anosom and neemix respectively.

Azadirachtin extract was evident to have significant larval mortality in leaf-dip bioassay against second instar larvae over synthetic azadirachtin and have high anti-feedant and repellent effects with ovicidal activity against *P. xylostella* L. at relatively higher dose range (Verkerk and Wright, 1993). Neem based pesticides are effective against a wide range of pests (Singh and Singh, 2009) with very low toxicity to non-target organisms; without toxic residue left to contaminate the environment and insects do not develop resistance to it (Prakash and Rao, 1997).

An aqueous emulsion of an ethanolic seed of *Annona squamosa* was found to be 2.5 times more effective than 1% Rotenone against diamondback moth, *Plutella xylostella* L. in an experiment conducted in three greenhouse trials in Maluku, Indonesia (Leatemia and Isman, 2004). 100% larval mortality was observed when larvae of DBM were treated with higher concentration of ethanolic leaf extract of *Annona muricata* (5mg/ml) and larval survival was significantly reduced when treated with low concentration (Trindade, Luna, De Lim, Da Silva, and Sant'ana, 2011). Similarly, the efficacy of ethanolic leaf extract of *Annona muricata* was tested in a greenhouse against DBM larvae on cabbage plants, where aqueous extract gives 90% mortality of larvae, 1.3-fold higher than mortality caused by 1% rotenone dust (Leatemia and Isman, 2001).

Similarly, 100% mortality of DBM larvae was found when ethanolic leaf extract of *Annona muricata* (5 mg/l) was applied. The extract of *Derris* sps was found to cause up to 69.74% mortality of *Lipaphis erysimi* when a concentration of 1 mg/ml was applied (Hu *et al.*, 2005).

LARVAL MORTALITY WITH COW URINE

The mortality of *P.xylostella* (L.) larvae were not significantly higher than control in first 9 hours after treatment application of experiment but found to be increasing and were significantly at par in long time; 21 hours, 33 hours, 57 hours and 93 hours after treatment application with percentage reduction over control by 17%, 20%, 39% and 47% for 21 hours, 33 hours, 57 hours and 93 hours after treatment application respectively. Results from previous studies suggested that 75% of larval population of flea beetle was reduced by application of cow urine (Subedi and Vaidya, 2003). Foliar spray of cattle urine 1:7 ratio of water is beneficial for controlling hairy caterpillar and larval insects (Poudel, 2008). Solution prepared from cow urine and water in ratio of 1:5 as foliar spray was beneficial for controlling aphids, larva and mites in cucurbits vegetables (GC and Neupane, 2009).

LARVAL MORTALITY WITH MICROBIALS (ENTOMO-PATHOGENS).

The larval mortality of *P. xylostella* (L.) larvae was found to be with mixed result when compared to control and was not found to be significantly at par. In the initial stage of the experiment lipel; bacteria-based insecticide causes higher mortality than that of Racer a fungus- based insecticide. But in long duration i.e. 57 hours and 93 hours after treatment application in experiment the microbial pesticide cause significantly higher larval mortality compared to control. The percentage controls of racer and lipel over control were 26% & 17% and 33% & 19% for 57 hours and 93 hours of treatment respectively.

The activity of the fungus was effective at ideal temperature of 25°C and relative humidity of 80% (G.C. and Keller, 2013). The different strains of *Beauveria bassiana* can cause mortality of the 3rd instar larvae of *Plutella xylostella* ranging from 41-64% in laboratory condition (Agrawal, Simon and Tayde, 2017). Sood, Mehta, Kashyap and Lal (2001) studied bio-efficacy of *B. bassiana* (Bals.) under laboratory condition and reported that larval mortality of diamondback moth (DBM) varied from 6.7% to 86.7%. Application of *Bt.* at sub-lethal doses deter the pupal weight, pupal duration and adult emergence of DBM and was practically significant in pest control in Taiwan; and was found to be more effective than conventional chemical insecticides for controlling DBM on cruciferous vegetables in winter (Hou and Chou, 1993).Highly susceptible strain of *Plutella xylostella* to *Bacillus thuringiensis* lost its susceptibility after 10 insecticide sprays in two generations in the field with a 36-fold increase in its LC50 (Branco and Gatehouse, 2001).

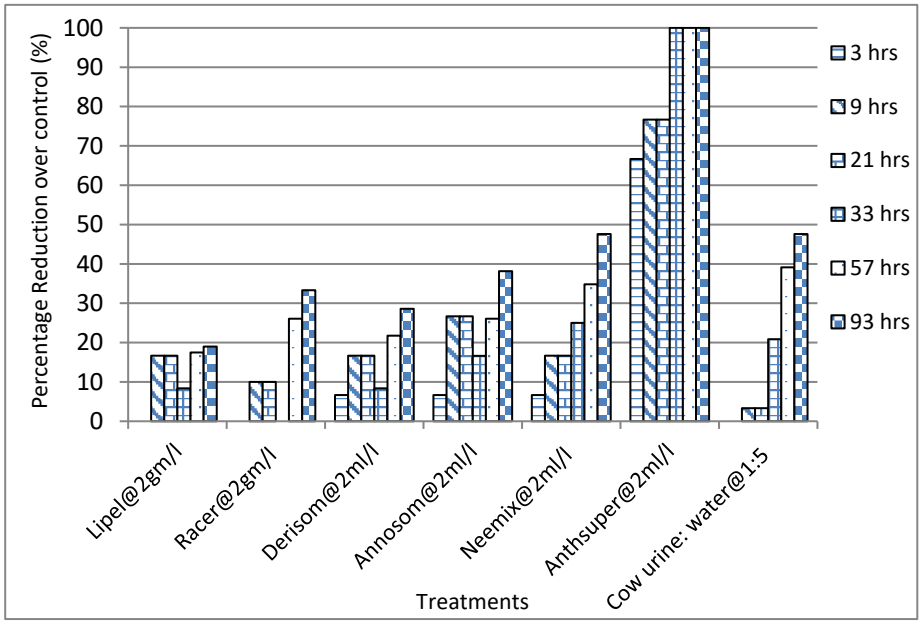

Fig 1: Percentage Population Reduction over Control (PROC) of different treatments at different time intervals

CONCLUSION

As the mortality of DBM larvae on bioassay was found to be significantly higher in Anthsuper than those of other compared treatments; Anthsuper (Chloropyrifos 16% A.I. + Alphacypermethrin 1% EC) can be recommended to apply for immediate control of the pest when they are above the economic threshold level. Considering the significantly higher mortality rate of cow urine, neemix, anosom and derisom followed by racer and lipel when compared to control can be applied in the field when the insect appears in the field because cow urine, botanicals and microbials are safer to the natural enemies when compared to anthsuper; which kills natural enemy upto 100% and also the pest DBM has been found to develop resistance to Anthsuper (Chloropyrifos 16% A.I. + Alphacypermethrin 1%EC). The use of cow urine, botanicals and microbials are found to be environmentally friendly and was found to control the pest significantly in longer duration also. Similarly, the use of cow urine, botanicals and microbial are encouraged to control/ manage the pest in Integrated Pest Management (IPM).

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AREA-WIDE CONTROL PROGRAM IN MANAGEMENT OF CHINESE CITRUS FLY, *BACTROCERA MINAX* (ENDERLEIN) (DIPTERA: TEPHRITIDAE), IN CITRUS ORCHARDS, SINDHULI, NEPAL

D. Adhikari[1]*, R.B. Thapa[1], S.L. Joshi[2] and J.J. Du[3]

ABSTRACT

Chinese citrus fly, Bactrocera minax (Enderlein) *(Diptera: Tephritidae) is one of the important citrus pests in Nepal, India and Bhutan including China where it was originated. Since 2014/15, the problem of B. minaxin sweet orange fruit is being faced by citrus growers in Sindhuli, Nepal. To mitigate the problem of B. minax,* Chinese citrus fly in the orchards, a*field practice of area wide control program (AWCP) was piloted in the selected 231 citrus orchards for the first time in Sindhuli in 2018 which has been adopted by 1153 citrus growers in 2019. The obvious recessions of mean fruit damage percentages due to B. minax in the sweet orange orchards at different locations in 2018 (range: 3.9 ± 1.1% to 29.7 ± 9.6%) and 2019 (range: 2.6 ± 0.8% to 7.5 ± 2.3%) have been achieved by virtue of B. minax management through AWCP with poisonous protein bait component and sanitation measure in the citrus orchards.*

Key words: AWCP, *Bactrocera minax,* Chinese citrus fly, protein bait, sanitation and sweet orange

INTRODUCTION

The Chinese citrus fly, *Bactrocera minax* (Enderlein) (Diptera: Tephritidae), is a major pest of citrus fruits especially in Asia (Gao *et al.*, 2013; Chen *et al.*, 2012; Drew *et al.*, 2006) with a geographical distribution, exclusively, in China, Bhutan, India (Sikkim and Western Bengal) and Nepal (CABI, 2020). It has oligophagous feeding habit concentrated only in citrus preferably to *Citrus aurantium*, *C. maxima*, *C. reticulata* and *C. sinensis* and related genera of Rutaceae as host plants (CABI, 2020). This China originated species of fruit fly is an invasive insect (Yang *et al.*, 2013), and, seemingly, it invaded Nepal first in the citrus orchards in the eastern parts of the country from India (Sikkim and West Bengal) and Bhutan (Joshi, 2019; Adhikari and Joshi, 2018; Bhandari *et al.*, 2017; Wang *et al.*, 2016; Drew *et al.*, 2013). Reportedly,*B. minax*inherited univoltine in life cycle with more than 5 months long over-wintering pupal diapause in soil under the canopy of the host tree (Zhou *et al.*, 2012; Dorji *et al.*, 2006; Dong *et al.*, 2013; Allwood *et al.*, 1999). Khan *et al.* (2005) highlighted on the weather factors as a whole imposed maximum effect on fruit fly infestation in fruit crops. Chen and Xie (1955) reported that the Chinese citrus fly (*B. minax*) was one of the *Bactrocera* species bearing

1 Agriculture and Forestry University, Nepal, * PhD Scholar, *Email: adhikari.debraj@gmail.com*

2 Nepal Agricultural Research Council, Nepal

3 Beijing Ecoman Biotech Co. Ltd., China

uniquely larger body size in its all stages of life cycle. This species of fruit fly has been reported as the most cold tolerant amongst *Bactrocera* species (Xia *et al.*, 2018; Luo and Chen, 1987; Fan *et al.*, 1994).

Area-wide control program (AWCP) is an economically viable, environmentally sensitive and sustainable pest management measure that involved developing and integrating biologically-based pest control technologies into a comprehensive management package in a large crop area (Adhikari *et al.*, 2020). It included eco-friendly pest management measures instead of traditional blanket pesticide spray. AWCP was implemented for the first time in the country'spest management history from April to July 2018 in 40 ha of the citrus orchardsin Sindhuli district through the joint effort of Prime Minister Agriculture Modernization Project (PMAMP), Project Implementation Unit (PIU), Junar Superzone (Sindhuli), Karma Chemicals (Kathmandu), Beijing Ecoman-Biotech (China) and the sweet orange growers of Tinkanya, Sindhuli, Nepal to manage the Chinese citrus fly, *B. minax*. The major management measure of Chinese citrus fly employed were spot application of lethal protein bait and sanitation of the maggot infested fruits. The objective of this program was to suppress the population of the Chinese citrus flies to minimize the extent of fruit damages due to their infestations. This program was conducted in some selected sweet orange citrus orchard farmers as a pilot program in 2018.Encouraged with success in managing this pest through AWCP movement in 2018, it motivated a large group of farmers of Junar Superzone area of Sindhuli district in 2019 and 2020 to adopt AWCP in their citrus orchards against the Chinese citrus fly. This paper presents the outcomes of AWCP in the recession of fruit losses by Chinese citrus fly in the premises of citrus (sweet orange) orchards in Sindhuli district.

MATERIALS AND METHODS

Main pest management activities included in AWCP against Chinese citrus fly (CCF) in the citrus orchards of Sindhuli are i) treatment preplanning (stakeholder's consultation) of poisonous protein bait spray (spot application),ii) fruit damage/loss assessment and monitoring the adult fruit fly emergence to fix onset of protein bait spray in orchards, iii) orientation to spray-persons and orchards owners, and coordinating protein bait spray treatments in each of the farmers owned orchard clusters (n = 5 in 2018 and n = 8 in 2019) and iv) post treatment orchard-field sanitation.Scheme for seasonal phenology stages of fruit bearing citrus tree (Table 1, second row), phenophase determination of *B. minax* (Table 1, third row) together with the crop-season-based AWCP procedures are shown in Table 1 (fourth row). The AWCP working detail against CCF in Sindhuli such as clustering citrus orchards including their owners in Table 2 and number of citrus orchards, with their respective clusters and spray-persons involved in years 2018 and 2019 are presented in Table 3.

Table 1. Seasonal phenology of fruit bearing citrus trees, *B. minax* and AWCP adopted measures in Sindhuli, Nepal

Months / Particulars	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Stages of citrus tree/fruit	Flowering and fruit setting					Fruit development and maturity					Fruit ripening and harvesting	
Life stages of *B. minax*	Pupae (inside soil)					Adult emergence and egg laying in fruit rind			maggots (inside fruit)			Pupae (inside soil)
Measures of AWCP						**Protein bait spray** (spot application)			**Orchard sanitation** (collection of nfested fruits)			

Table 2. Citrus orchard owners and clustering citrus orchards in AWCP domain at Golanjor 4, Tinkanya, Sindhuli, Nepal

SN	Citrus orchard owners (representative of farmers in the respective cluster of orchards)	Cluster identity (n = number of farmers included in cluster of orchards)	SN	Citrus orchard owners (representative of farmers in the respective cluster of orchards)	Cluster identity (n = number of farmers included in cluster of orchards)
1	Posta Bahadur Thakuri	1. Golanjor-4, Tinkanya, Majh Kubhinde (n = 82)	15	Yam Bahadur Sinjali	3. Golanjor-4, Tinkanya, Tamaure (n = 38)
2	Chandra Bahadur Tamang		16	Lal Bdr. Purbachane Magar	
3	Madhu Malla Thakuri		17	Ram Bahadur Bhujel	
4	Mukti Bahadur Thakuri		18	Shiva Bahadur Pulami	
5	Man Bahadur Thakuri		19	Nara Bdr. Jargha Magar	
6	Lek Bahadur Thakuri		20	Padam Kumar Magar	
7	Bishnu Thakuri		21	Dan Bahadur Ramtel	4. Golanjor-4, Tinkanya,
8	Yadhav Bahadur Thakuri		22	Bhakta Bahadur Aale	

9	Gunda Bahadur Thakuri		23	Pokche Aale	Mathillo Aalegaun (n = 43)
10	Prem Thakuri		24	Krishna Bahadur Magar	
11	Prem Bahadur Jyu Thakuri		25	Dok Bahadur Thada	
12	Bhanubhakta Magar	2. Golanjor-4, Tinkanya, Tallo Aalegaun (n = 29)	26	Rukman Gurung	5. Golanjor-4, Tinkanya, Ranikhola (n = 39)
13	Purna Bahadur Thada Magar		27	Tirtha Bahadur Gurung	
14	Gunda Bahadur Thada Magar		28	Chandra Bdr. Purbachane	

CITRUS ORCHARD OWNER PARTICIPATION IN AWCP DOMAIN

The locations of different farmers owned sweet orange orchards were categorized in five different clusters in Golanjor Rural Municipality–4, namely 1) Majhkubhinde, 2) Tallo Aalegaun, 3) Tamaure, 4) Mathillo Aalegaun, and 5) Ranikhola, respectively, at varying altitude in masl accompanied with associated number of orchards in parentheses 1089 (82), 1225 (29), 1268 (38), 1380 (43), and 1462 (39), respectively.

The number of citrus orchard owners participated in the pilot AWCP were 231 (farmers included in 5 different clusters of orchards) from Golanjor-4, Tinkanaya, Sindhuli in 2018 With the influence of AWCP encouraged results in the management of *B. minax*, the number of participants increased to 1153 (farmers included in 8 different clusters of orchards) in AWCP in 2019 covering 8 clustered citrus orchards of four local governments of Sindhuli district namely; Sunkoshi rural municipality-7 (Majhuwa), Kamalamai municipality-3 (Jalkanya), Golanjor rural municipality 1-6 (1-Dundbhanjang, 2-Bittijor, 3-Bhuwaneswori, 4-Tinkanya, 5-Ratanchura and 6-Baseswor) and Tinpatan rural municipality-7 (Toshramkhola) i.e. the command area of Junar Superzone under PMAMP, PIU, Sindhuli.Similarly, the numbers of spray-persons involved increased from 10 (2018) to 26 in 2019 (Table 3).

Table 3. Farmers, orchards and spray-persons involvement in AWCP against *B. minax* in Sindhuli, Nepal

Year	No. of citrus orchards owned hy farmers	No. of clusters of orchards	No. of spray persons
2018	231	5	10
2019	1153	8	26

AWCP TECHNOLOGY

The Ecoman-Biotech developed AWCP technology in China was applied in the citrus orchards of Sindhuli. This technology included the Great Fruit Fly Bait (protein bait) along with its treatment method and spray scheduling.

FEMALE *B. minax* BAIT MATERIAL FOR AWCP

The Great Fruit Fly Bait a commercial product of Ecoman-Biotech, China was a readymade bait material mixed of two components, namely Protein hydrolysate (bait) 25 % and 0.1 % Abamectin (insecticide).

Fig. 1. Protein bait application on lower leaf surface (Left)
and sanitation of orchard collecting dropped infested fruits (Right)

PREPARATION OF BAIT SOLUTION AND SPOT APPLICATION

An aqueous bait solution for treatment was prepared from the Great Fruit Fly Bait (GFFB) and water at a ratio of 1 part GFFB in 2 parts of water. Thus, prepared aqueous bait solutionwas sprayed @ 50 ml solution over 0.5 to 1 m^2 area under side of the leaves (Fig. 1 Left) in one tree among three productive sweet orange trees at a location in weekly interval,which was repeated for 10-12 times (Ecoman-Biotech, 2018).

ORCHARD-FIELD SANITATION

After completing treatment schedule, orchard-field sanitation operation was practiced to prevent sheltering *B. minax* pupaein soil under the host tree canopy in the orchard. The orchard sanitation operation included the distribution of plastic bags each of dimension length and width (64 cm and 40cm) and thickness of sheet was 45 grams per square meter (GSM) to farmers to put in dropped CCF infested fruits periodically (Fig. 1 Right). Periodically collected CCF infested fruits were then buried into pit of 1 to 1.5 m depth with 30 cm thick soil coverage at the ground-level. Besides, some growers dipped maggots infested fruits in water pond, kept in bio-gas plant, burned in fire, maggots fed to poultry and fruit fed to livestock or/and processed locally to make liquor in order to prevent pupation and break life cycle of the fruit fly.

B. DAMAGE ASSESSMENT

B. minax fruit damage was assessed in each orchard by sampling three productive trees at harvesting stage in the AWCP domain of 28 citrus orchards (Table 2). In course of *B. minax* fruit damage assessment, infested fruits were ascertained by observing oviposition sting and/or matured maggots escaped holes on the rind surface in fruits through visual observation. The suspected dropped fruits were cut-opened for the presence of maggots inside. The overall damaged fruits due to *B. minax* from AWCP included 5 clusters in 2018 and 8 clusters in 2019 to compare mean damaged fruits obtained in 2017, i.e. to with no AWCP orchard management condition.

STATISTICAL ANALYSIS

Microsoft Excel 97-2003 worksheet was used to derive mean and standard error of mean for fruit damage assessment from the data generation of different citrus orchards. Student 't-test' was performed for the mean comparison among the means of *B. minax* incurred sweet orange fruit damages from each of the orchard clusters before AWCP in 2017 and after in 2018 and 2019.

RESULTS AND DISCUSSION

FRUIT DAMAGE ASSESSMENT

The highest CCF mean sweet orange fruit damage percentage in no AWCP situation in 2017 (before AWCP) revealed (86.7 ± 13.3%) in Ranikhola followed by Tallo Aalegaun (78.3 ± 4.4%), Tamaure (78.3 ± 7.0%), Mathillo Aalegaun (63.6 ± 15.8%) and Majhkubhinde (27.7 ± 7.8%). In 2018 (after AWCP), the mean fruit damage percentage receded in the localities to a tune of 29.7 ± 9.6% (Ranikhola), 19.4± 2.4% (Tamaure), 8.0 ± 3.9% (Tallo Aalegaun), 6.6 ± 2.7% (Mathillo Aalegaun) and 3.9 ± 1.1% (Majhkubhinde) respectively. Similarly, in 2019, a receded pattern of mean fruit damage percentage obtained in the clustered orchards in 2019 to a tune of 7.5 ± 2.3% (Ranikhola), 7.0 ± 0.8% (Tamaure), 4.3 ± 1.5% (Mathillo Aalegaun), 2.9 ± 0.5% (Majhkubhinde) and 2.6 ± 0.8% (Tallo Aalegaun) respectively. Hence, with AWAP in 2018 and 2019, the mean fruit damage in each location receded remarkably in comparison to without AWAP in 2017. The recessions in mean fruit damagein 2018 and 2019 are obviously an impact of AWCP with applications of the Great Fruit Fly Bait in the citrus orchard clusters (Table 4).

The obvious recessions of mean fruit damage percentages in 2018 (range: 3.9 ± 1.1% to 29.7 ± 9.6%) and 2019 (range: 2.6 ± 0.8% to 7.5 ± 2.3%) by virtue of *B. minax* management in citrus orchards through AWCP and the mean fruit damage percentages (range: 27.7 ± 7.8% to 86.7 ± 13.3%) before AWCP inception in 2017 in different orchards were statistically verified using

Student's 't-test' for an efficacy confirmation of the AWCP management against CCF in Sindhuli citrus orchards. The statistical results of Student's 't-tests' against the mean fruit damage percentages in different orchards without AWCP *B. minax* managementof three years in the same orchards with AWCP *B. minax* management in 2018 and 2019 are shown in Table 4. In Majhkubhinde, the mean fruit damage (MFD) 27.7% in 2017 reduced to 3.9% in 2018 (highly significant ($p \leq 0.0065$)); in Tallo Aalegaun, MFD 78.3 % in 2017 reduced to 8.0% in 2018 (very highly significant; $p \leq 0.0001$); in Tamaure, MFD 78.3% in 2017 reduced to 19.4% in 2018 (very highly significant: $p \leq 0.0001$); Mathillo Aalegaun, MFD 63.6% in 2017 reduced to 6.6% in 2018 (highly significant; $p \leq 0.0117$); in Ranikhola, MFD 86.7% in 2017 reduced to 29.7% in 2018 (highly significant; $p \leq 0.0126$). In contrary to 2017 orchard management situation, the MFD% for each of the clustered orchards location obtained in 2018 and 2019 (Table 4, columns 4 and 6) with AWCP management situation are not statistically different in 't-test' (Table 4, columns 4, 6 and 7) except Tamaure (MFD 19.4% in 2018 vs 7.0% in 2019 (very highly significant; $p \leq 0.002$) and Ranikhola (MFD 29.7% in 2018 vs 7.5% in 2019 (significant; $p \leq 0.0433$).

The variation in effectiveness of management of Chinese citrus fly might be due to the orchards' location, surrounding's vegetation, skills of spray-persons for spot application and other managerial aspects. Van Schoubroeck (1999) highlighted on the need of both monitoring and management measures for the development of effective IPM practice.

Table 4. Locationwise fruit damage assessment due to *B. minax* in Sindhuli, 2017-2019

S N	Location (no. of orchard owners)	Mean fruit damage % in 2017 (± SE)	Mean fruit damage % in 2018 (± SE)	T-test for mean fruit damage %in 2017 and 2018 (*P*-value)	Mean fruit damage % in 2019 (± SE)	T-test for mean fruit damage % in 2018 and 2019 (*P*-value)
1	Majhkubhinde (11)	27.7 ± 7.8	3.9 ± 1.1	0.0065**	2.9 ± 0.5	0.2309(ns)
2	Tallo Aalegaun (3)	78.3 ± 4.4	8.0 ± 3.9	0.0001***	2.6 ± 0.8	0.1198(ns)
3	Tamaure (6)	78.3 ± 7.0	19.4 ± 2.4	0.0001***	7.0 ± 0.8	0.0002***
4	Mathillo Aalegaun (5)	63.6 ± 15.8	6.6 ± 2.7	0.0117**	4.3 ± 1.5	0.2373(ns)
5	Ranikhola (3)	86.7 ± 13.3	29.7 ± 9.6	0.0126**	7.5 ± 2.3	0.0433*

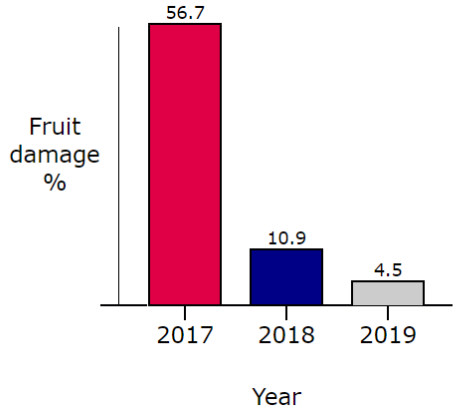

Fig. 2. Average fruit loss due to Chinese citrus fly in sweet orange orchards in Sindhuli, Nepal

Fig. 2 shows the comparison in the pattern of *B. minax* incurred the overall mean sweet orange fruit damage percentages obtained in 2017 (without AWCP management practice) with 2018 and 2019 (with AWCP management practice against the Chinese citrus fly). Sweet orange fruit losses due to Chinese citrus fly reduced drastically from 56.7 ± 6.4% in 2017 to 10.9 ± 2.1% and 4.5 ± 0.6% in 2018 and 2019, respectively. The result is statistically very highly significantly different ($p \leq 0.0001$) (Fig. 2). The statistics of sweet orange fruit losses due to Chinese citrus fly was 56.7±6.4%, which indicates that due to AWCP for CCF indicated sweet orange fruit production in Sindhuli district increased by 45.8%. Acharya and Adhikari (2019) reported less than 7 % fruit loss from the trees sprayed with Great Fruit Fly Bait in 2018.

CONCLUSION

Spot applications of lethal protein bait (the Great Fruit Fly Bait) for *B. minax* adult fly control, and orchard sanitation to prevent its pupae to pupate in soil remained major components of AWCP that helped achieve managing Chinese citrus fly in sweet orange orchards in Sindhuli, Nepal. The AWCP is eco-friendly management practice where both the technical and managerial aspects run side by side for the successful implementation of the program. AWCP saved sweet orange fruits from *B. minax* by 45.8 % in the sweet orange orchards of Sindhuli district. Thus, AWCP management of Chinese citrus fly, *B. minax*, in citrus orchards, Sindhuli, Nepal has emerged as a proven practice to sweet orange (junar) farmers in the localities, and bears a great scope of dissemination of this management practice against *B. minax* in citrus orchards in other potential citrus dominated districts in Nepal.

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VARIETAL SCREENING OF RICE GENOTYPES FOR THE RICE WEEVIL, *Sitophilus oryzae* (Linnaeus) (Curculionidae: Coleoptera) At Laboratory Condition

*M.K. Pal[1], S. Tiwari[2], R. Regmi and F. Md. Ali[3]

ABSTRACT

The rice weevil, Sitophilus oryzae (Linnaeus) *is a major pest of rice at storage condition in Nepal. A lab experiment was conducted for varietal screening of rice genotypes against S. oryzae at the National Rice Research Program, Hardinath, Dhanusha, Nepal in 2020. The study was carried out in Completely Randomized Design (CRD) in a three replicates. Fifty gram of each seven popular rice genotypes i.e Sambha Mansuli Sub-1, Ramdhan, Radha-11, Bahuguni-1, Bahuguni-2, Hardinath-2 and Lalka Basmati were used to screen the potential weevil resistant rice cultivars. Ten pairs of newly emerged adult S. oryzae of uniform age obtained from stock culture were released in each plastic jar in no-choice tests, while twenty five pairs of S. oryzae were released in the center, in choice tests. Results were evaluated based on the grain damage percent, weight loss percent, and total live weevil population for 90 days from the date of experiment. The result demonstrated that Lalka Basmati was the least damaged rice cultivar followed by Bahuguni-2. The highest weevil population over 90 days was recorded in Sambha Mansuli Sub-1 followed by Hardinath-2 and the least weevil population was found on Lalka Basmati followed by Bahuguni -2 in both test conditions. Lowest to highest damage ranking of rice genotypes was: Lalka Basmati<Bahuguni-2<Bahuguni-1<Radha-11<Ramdhan<Hardinath-2<Sambha Mansuli Sub-1. Thus, promotion of Lalka Basmati & Bahuguni-2 varieties is recommended to reduce the infestation of rice weevil in the storehouse condition. This information is useful for host plant resistant breeding program for the plant breeder.*

Key words: Genotypes, grain, rice weevil, storage, varietal screening

INTRODUCTION

Rice is the major cereal crop of Nepal which is cultivated in diverse agro-climatic regions of the country. This crop has the highest share (46%) and fulfills around 53% of the total edible grain requirement (MoAD, 2015) followed by maize (25-29%) and wheat (23-27%), respectively in Nepal. Rice is solely responsible for 20% AGDP & 7% GDP in Nepal (CBS, 2016/17). In 2018/19 AD, the area under rice cultivation was 14,91,744ha, with total production of 56,10,011 mt and productivity of 3.96 mt/ha (MoALD, 2018/19). In the

1 Ministry of Land Management, Agriculture and Co-operatives, Province 2, Dhanusha, Nepal

2 Department of Entomology, Faculty of Agriculture, Agriculture and Forestry University, Chitwan, Nepal

3 National Rice Research Program, Hardinath, Dhanusha, Nepal

* Corresponding author email: ramanpal273@gmail.com

Nepalese diet, the rice supplies about 39% energy, 29% protein, and 7% fat (Basnet, 2008). The grain of rough rice consists of the hull or husk (18-28%) and the caryopsis or brown rice (72-82%) and the brown rice consists of an outer layer (pericarp, tegmen, and aleurone layers) called bran (6-7%), the embryo (2-3%), and the edible portion (endosperm 89-94%) (Chen *et al.*, 1998).

Most insect damage to the grain in the storage condition is caused by five primary storage insects *viz*, granary weevil (*Sitophilus granarius* L.), rice weevil (*Sitophilus oryzae* L.), maize weevil (*Sitophilus zeamais* L.), lesser grain borer (*Rhyzopertha dominica* F.) and Angoumois grain moth (*Sitotroga cerealella* Olivier) (USDA, 2015). Among these, rice weevil (*S. oryzae*) is one of the severe damaging pests of cereal grains like rice, sorghum, wheat, barley and maize, and also for their products (Baloch, 1992; Grenier *et al.*, 1997; Neupane, 1995). In general, the losses (pre- and post-harvest) due to pests have been estimated to be 15-20% (Neupane, 1995). Even 1% loss of rice grain during storage accounts for 56000 mt annual loss of rice which can feed 3,36,000 persons per year in Nepal (MoALD, 2018/19). Minimization of post-harvest loss can be more economical than to increase the yield. With the increasing yield of high yielding varieties (HYV) of rice, storage loss is always neglected in Nepal.

Most of the newly released rice varieties and hybrids are highly susceptible to the attack of insect pests either in storage or field conditions (Gimma *et al.*, 2008). So, farmers are not getting much benefit from the increased productivity potential of newly released varieties and hybrids. The yield-oriented research of Nepalese scientists concentrated their efforts to release high yielding fine & aromatic rice varieties. A chemical composition like carbohydrate, protein & amylose content of grains determines the choice of food as well as the behavioral process of insects (Belloa *et al.*, 2000). The susceptibility of rice weevil is negatively correlated with the hardness of grain and crude fiber content which leads to reduce the damage of paddy (Singh, 2002). Similarly, limited information is available on post-harvest/storage insect pests of improved varieties of rice in Nepal. Therefore, there is a need to evaluate the varietal preference of storage insect pests for popular rice varieties.

MATERIALS AND METHODS

The research was conducted at the Entomology Laboratory in the National Rice Research Program (NRRP), Hardinath, Dhanusha, Nepal from January to June 2020. The research station is located at a latitude $26^0$47'46.5"N and longitude $85^0$57'49.35"E and an altitude of 93.0 meters from the sea level. The experiment was laid out in a Completely Randomized Design (CRD) with three replicates. Total seven popular rice genotypes popular in Terai region of Nepal

are listed in Table 1 and genotype details are given in Table 2. The genotypes were selected as these are commercially grown by the farmers in the periphery of research area.

Newly emerged 10 pairs of male and female fresh adult weevils were used in each plastic jar for no-choice test while 25 pairs weevil were released in the center for choice test.

Table 1: Detail of treatments on the varietal screening of rice genotypes against rice weevil

Rice genotypes	No choice test		Choice test	
	Grain wt. (gm.)	No. of weevils (pairs)	Grain wt. (gm.)	No. of weevils (pairs)
Sambha Mansuli Sub-1	50	10	50	25 pairs in center
Ramdhan	50	10	50	
Radha-11	50	10	50	
Bahuguni-1	50	10	50	
Bahuguni-2	50	10	50	
Hardinath-2	50	10	50	
Lalka Basmati	50	10	50	

Table 2: Characteristics of rice genotypes used in experiments

	Sambha Mansuli Sub-1	Ramdhan	Radha-11	Bahuguni-1	Bahuguni-2	Hardinath-2	Lalka Basmati
Origin	IRRI	India	India	Nepal	Nepal	Nepal	Nepal
Released year	2011	2006	1995	2018	2018	2010	2010
Production season	Summer (Rainy)	Summer (Rainy)	Summer (Rainy)	Summer (Rainy)	Summer (Rainy)	Summer (Rainy)	Summer (Rainy)
Maturity days	145-150	130-137	145-150	135	142	125	150
Yield potential	3.5-4	4-7.2	4	5.5	5.8	3.1-4.2	2.5-3.5
Recommended domain	Terai & Inner Terai (upto 500 m of mid hill) Irrigated and Swampy Land	Terai& inner terai (Valley, Makawanpur, Chitwan & Nawalpur)	Central Terai (Parsa, Bara, Rautahat, Sarlahi, Mahottari & Dhanusha)	Terai (upto 700 masl)	Terai (upto 700 masl)	Terai & Inner terai	Mid & Eastern Terai

Awn	Absent	Absent	Absent	Absent	Absent	Absent	Present
Husk color	Light brown	Light brown	Brown	Light brown	Brown	Brown	Red
Grain shape	Short and fine grain	Long and fine grain	Long grain	Long grain	Long grain	Long & thick grain	Long grain
Remarks	TGW:19gm Protein:10.3%	TGW:21gm Protein: 6.05% Amylose :22.08%	TGW:21.8gm Protein:7.24% Amylose: 22.5%	TGW:22gm Protein: 7.3 % Amylose :22.4%	TGW:23.5gm Protein: 7.43% Amylose :24.3%	TGW: 25.8gm Protein:8.1%	TGW:18.33gm Protein :8 % Amylose:23.4%

Source: (MoALD, 2018/19; SQCC, 2017)

NO-CHOICE TEST

A total of 21 plastic jars (15.0 cm x 9.0 cm) with a screened hole on their lids were taken in no-choice test for 7 rice genotypes that was replicated thrice for each genotype. Fifty gram (50 gm) sample of sterilized rough rice was taken for each rice genotype that was kept in individual plastic jar. Then, 10 newly hatched matured pairs (10 male & 10 female) of fresh weevils from the stock culture were released in each jar with tightly covered ventilated lid. All jars were placed in the laboratory at room temperature of 31.3 ± 1.5 ^{0}C.

CHOICE TEST

In choice test, 50 gm rough rice of different rice genotypes was kept in each plastic jar (15.0 cm x 9.0 cm). The plastic jar was circularly arranged in large and circular (40 cm x 45 cm) paper cartoon and it was replicated thrice. The distance between one plastic jar to another plastic jar in a cartoon was approx.10.0 cm. In each replication, seven plastic jars having sterilized rough rice were kept in a circular manner where 25 pairs of rice weevils were released in the center of the paper cartoon. In the choice test, the lid of each jar was opened to allow free movement of weevils towards their preferred genotypes. Four circular holes were made on sides of the jar to allow free movement of weevils. The cartoon was tightly covered by plastic tape to prevent escape of rice weevil and a large hole that covered with fine net was made on the cartoon to allow free movement of air.

DATA RECORDED

- Thousand-grain weight: Thousand-grain weights of all the treatments and replications were taken before the experimental setup and during each time of data recording.
- The moisture content of grains: Moisture content of all the genotypes of rice was recorded before the experimental setup and during each time of data recording with the 55 Wile-moisture meter devices.

- The number of damaged and undamaged grains: The number of damaged and undamaged grains was examined by taking a 10 gm random sample from each treatment.
- Weight of damaged and undamaged grains: The weight of damaged and undamaged grains was taken with the help of a digital weighing balance- Electronic Compact scale (SF-400A) of CE Company.
- Percentage of damaged and undamaged grains:The percentage of damaged and undamaged grain was taken by the following formulae.

$$\text{Damage (\%)} = \frac{Nd}{Tn} \times 100$$

$$\text{Undamage (\%)} = \frac{Nu}{Tn} \times 100$$

(Enbakhare and Lawogbomo, 2020)

Where,

Nd: No. of damaged grains
Nu: No. of undamaged grains
Tn: Total number of grains

- Weight loss percentage: The weight loss percentage of grains was calculated by using the count and weight method using the following formula,

$$\text{Weight loss (\%)} = \left[\frac{UNd \quad DNu}{\{U(Nd + Nu)\}} \right] \times 100$$

(Lal, 1998)

Where,

D: Weight of damaged seeds
U: Weight of undamaged seeds
Nd: No. of damaged seeds
Nu: No. of undamaged seeds

- The weevil population: The number of both live and dead weevils in all the treatments was counted during each time of data recording.
- Room temperature and relative humidity: The temperature and relative humidity of the laboratory was recorded using digital Thermo-Hygrometer device (HTC-2).

Weevil multiplication in the plastic jars was observed at 15 days interval up to 90 days from the first count. The weevil population number and grain damage was recorded by counting the number of adults (from 50 gm grain) and damaged & undamaged grains (from 10 gm grain) respectively.

The data were tabulated in MS Excel, analyzed by using RStudio software, and mean comparisons was done by using Duncan's Multiple Range Test (DMRT) at 5% level of significance (Gomez and Gomez, 1984).

RESULT AND DISCUSSION

CHOICE TEST

Effect of weevil on mean grain damage percentage (number basis)

The mean grain damage percent (number basis) was significantly different (p<0.05) among rice varieties over 90 days of experiment. The highest grain damage percent was in Sambha Mansuli Sub-1 (1.68%) and the lowest in Lalka Basmati (0.78%). Damage in Sambha Mansuli Sub-1 was statically at par with Hardinath-2 (1.48%) while Lalka Basmati was at par with Bahuguni-2 (0.79%) (Table 3). However, the numbers of grains damage was not high.

Effect of weevil on mean grain damage percentage (weight basis)

The mean grain damage percent (weight basis) was also observed in similar trend as on the number basis. The highest grain damage percent was in Sambha Mansuli Sub-1 (1.81%) and the lowest in Lalka Basmati (0.76%). Damage in Sambha Mansuli Sub-1 was statically at par with Hardinath-2 (1.51%) while Lalka Basmati was at par with Bahuguni-2 (0.78%) and the remaining varieties shown intermediate effects (Table 3).

Effect of weevil on mean weight loss percentage

The mean weight loss percent was significantly different (p < 0.05) among rice varieties over 90 days after treatment. The highest weight loss percent was in Sambha Mansuli Sub-1 (1.07%) and the lowest in Bahuguni-2 (0.57%). Damage in Bahuguni-2 was at par with Lalka Basmati (0.59%) and Radha-11 (0.62%) (Table 3). Weight loss of grains was fluctuated with the weight of damaged and undamaged grains.

Effect of genotypes on mean number of live weevils

The mean number of live weevils was significantly different (p < 0.05) among rice varieties over 90 days after treatment. The highest number was in Sambha Mansuli Sub-1 (4.10%) and the lowest in Lalka Basmati (1.01%). The damage of Lalka Basmati was at par with Bahuguni-2 (1.25%) (Table 3).

Table 3: Effects of rice weevil on selected parameters over 90 days under choice condition

Rice varieties	Mean grain damage % (number basis)	Mean grain damage % (weight basis)	Mean weight loss %	Mean number of live weevils
Sambha Mansuli Sub-1	1.68^{a}	1.81^{a}	1.07^{a}	4.10^{a}
Ramdhan	1.19^{b}	1.13^{c}	0.78^{b}	2.13^{d}
Radha-11	1.16^{b}	1.16^{c}	0.62^{cd}	2.73^{c}
Bahuguni-1	1.27^{b}	1.21^{bc}	0.81^{b}	1.58^{e}
Bahuguni-2	0.79^{c}	0.78^{d}	0.57^{d}	1.25^{ef}
Hardinath-2	1.48^{ab}	1.51^{ab}	0.76^{bc}	3.27^{b}
Lalka Basmati	0.78^{c}	0.76^{d}	0.59^{d}	1.01^{f}

SEm (±)	0.081	0.091	0.042	0.241
CV (%)	16.3	16.00	11.2	12.90
p- value	<0.001	<0.001	<0.001	<0.001
Significance	s	s	s	s

NO- CHOICE TEST

Effect of rice weevil on mean grain damage (number basis)

The mean grain damage percentage (number basis) was significantly different ($p < 0.05$) in various rice varieties over 90 days after treatment. The highest grain damage percent was in Sambha Mansuli Sub-1 (1.69%) and the lowest in Lalka Basmati (0.63%). The damage of Sambha Mansuli Sub-1 was statically at par with Hardinath-2 (1.39%) while Lalka Basmati was at par with Bahuguni-2 (0.76%), Bahuguni-1 (0.86%) & Radha-11 (0.96%) (Table 4).

Effect of rice weevil on mean grain damage percentage (weight basis)

Similarly, mean grain damage percent (weight basis) was significantly different ($p < 0.05$) in various rice varieties over 90 days after treatment. The highest grain damage percent was in Sambha Mansuli Sub-1 (1.86%) and the lowest in Lalka Basmati (0.64%). The damage of Sambha Mansuli Sub-1 was statically at par with Hardinath-2 (1.85%) while Lalka Basmati was at par with Bahuguni-2 (0.76%), Bahuguni-1 (0.84 %) & Radha-11 (0.95%) (Table4).

Effect of rice weevil on mean weight loss percentage

The mean weight loss percent was significantly different ($p < 0.05$) among various rice varieties over 90 days after treatment. The highest weight loss percent was in Sambha Mansuli Sub-1 (1.15%) and the lowest in Lalka Basmati (0.50%). The damage of Lalka Basmati was at par with Bahuguni-2 (0.55%) and other varieties had intermediate weight loss (Table 4).

Effect of genotypes on mean number of live weevils

Counting of live weevil population was significantly different ($p < 0.05$) among various rice varieties over 90 days after treatment. The highest number was in Sambha Mansuli Sub-1 (6.60%) and the lowest in Lalka Basmati (3.19%) (Table 4). Fluctuation of live weevil's population was in the intermediate range in other remaining varieties.

Table4. Effects of rice weevil on selected parameters over 90 days under no-choice condition

Rice varieties	Mean grain damage % (number basis)	Mean grain damage % (weight basis)	Mean weight loss %	Mean number of live weevils
Sambha Mansuli Sub-1	1.69^{a}	1.86^{a}	1.15^{a}	6.60^{a}
Ramdhan	1.07^{bc}	1.03^{c}	0.70^{bc}	4.25^{c}
Radha-11	0.96^{cd}	0.95^{cd}	0.69^{bc}	4.39^{c}
Bahuguni-1	0.86^{cd}	0.84^{cd}	0.62^{cd}	3.94^{d}
Bahuguni-2	0.76^{cd}	0.76^{cd}	0.55^{de}	3.50^{e}
Hardinath-2	1.39^{ab}	1.85^{a}	0.78^{b}	4.95^{b}
Lalka Basmati	0.63^{d}	0.64^{d}	0.50^{e}	3.19^{f}

SEm (±)	0.081	0.092	0.052	0.233
CV (%)	18.62	18.11	8.51	3.05
p- value	<0.001	<0.001	<0.001	<0.001
Significance	s	s	s	s

Rice weevil preferred Sambha Mansuli Sub-1, followed by Hardinath-2 while refused Lalka Basmati, followed by Bahuguni-2 varieties with respect to damage percent based on the number & weight of grains, weight loss percent, and live adult weevil count over the 90 days after experiment. The factors that confer resistance to the grains against the infestation of rice weevil are varied. Smith (2005) in his study reported that such variation in the resistance level of different rice varieties for rice weevil normally because of their morphological characters or the presence of allelochemicals in the rice grains. The presence of awn in the Lalka Basmati variety probably makes it least damaged to others as awn is a needle-like appendage of grains which hinders weevil from making oviposition hole on the grain (Grundbacher, 1963). Similarly, amylose content of Lalka Basmati (23.4%) & Bahuguni-2 (24.3%) is higher than others (less than 23%) which determine their resistance level and found to be more resistant than others. This is also supported by Abraham *et al*. (1972) who found that the most resistant variety had the highest amylose content. Additionally, less thousand-grain weight (TGW) of Lalka Basmati (18.33gm) may be the causes of least grain damage with minimum weevil count as Ahmad (2018) reported that the percentage of infestation of rice weevil decreases with the reduction of thousand-grain weight of varieties. This is because of fine sized grains of varieties having less TGW, which make weevils unfit for oviposition on grains as Ashamo (2006) mentioned that oviposition, development, and F1 adult emergence were favored by bigger grains. More number of weevil emergence on Sambha Mansuli Sub-1 & Hardinath-2 variety was recorded as their thin hull cover, compared to others which makes it easy to deposit their eggs inside the grains. These findings are somewhat in line with Regmi *et al*. (2017). Ajao *et al*. (2019) who observed that small seed size, tightness of it hull, and reddish caryopsis of a particular variety could explain why it was resistant to *S. oryzae* attacks. However, the infestation in all cases seems to be less because of the hull covering of grains in rough rice as hull comprises 18 to 25% of the rough rice. According to Brasse (1960) and Russell (1968), an intact and tight hull of grains contributes to resistance with rice weevil *S. oryzae* while imperfect glumes contributed to susceptibility. Therefore, rice varieties exhibit varying degrees of susceptibility to damage by insects. Varietal resistance against weevil can be developed as a major component of insect pest management which is comparable with other management tactics. It can be a major way for reducing postharvest losses of grains which may be useful for plant breeders to work for varietal resistance.

CONCLUSION

Rice weevil (*S. oryzae*) is the severe damaging pests of rice in the storage condition. Losses of agricultural commodities during the post-harvest period have been considered a major problem in Nepal. Lalka Basmati was a less susceptible variety followed by Bahuguni-2 while Sambha Mansuli Sub-1 was the most susceptible variety followed by Hardinath-2 concerning grain damage percent (number & weight basis), weight loss percent, and live adult weevil population for both no-choice & choice conditions, respectively. Therefore, this experiment concluded that cultivation of Lalka Basmati & Bahuguni-2 varieties is the way to save grains from the attack of storage insect pest, which minimizes the postharvest loss of stored rice.

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EFFECTS OF SOWING DATES ON GRAIN YIELD AND OIL CONTENT OFRAPESEED (*Brassicacampestris var* L. *toria*) VARIETIES IN MIDDLE TERAI REGION, NAWALPARASI, NEPAL

M.P. Khatiwada[1], N.K. Chaudhary[2], S.K. Sah[3] and J.P. Dutta[4]

ABSTRACT

A field experiment was laid out in split-plot design with sowing date in the main plot and varieties in the sub-plot to determine the effects of sowing dates on growth, yield and oil content of rapeseed varieties. Four sowing dates 15 days apart set on October 13th, 28th, November 12th and 27th and four rapeseed varieties (Unnati, Preeti, Pragati and Local landrace) were used. The results revealed that the highest grain yield and oil content was obtained from the October 28th sowing date and it was statistically different from all other dates of sowing. On average, oil content was decreased by 5.75% and seed yield by 0.65 t/ha for every fortnight delay in sowing from October 28th sowing date. Highest yield and oil content was obtained from variety Preeti and it was statistically different from all other three varieties. Variety Preeti was the best yielding variety for October sowing date while variety Unnati was the best for November sowing date. Preeti is recommended to be sown on October 28th in middle terai area for optimum yield but under late sown condition, Unnati is preferred for obtaining the optimum yield.

Key words: Grain yield, oil content, rapeseed, sowing date, variety

INTRODUCTION

Oil seed crops are the third important crops of Nepal after cereals and legumes both in area and production. Oil seeds occupy about 5.87% of the total cultivated land (30,91,000 ha) of the country with a total production of 1,35,494 mt and their average productivity is about 0.747 t/ha (MoAC, 2009). The average productivity of oilseed crops in Nepal is very low as compared to that of the world average (1.28 t/ha, NORP, 2007/08). There are many crops being cultivated for oil seed purpose in Nepal, among them tori (*Brassica campestris*L. var. *toria*) is particularly important and cultivated from Terai (60 masl) to high hill (2500 masl). Agro-ecologically, Terai and inner Terai occupy 77% area of the total oil crops followed by hills with 20.6% (NORP, 2007/08).

1 Senior Crop Development Officer, Centre for Crop Development and Agro Diversity Conservation, Shree Mahal, Lalitpur, Nepal

* Corresponding author email: m.khatiwada1@gmail.com

2 Former Dean, Institute of Agriculture and Animal Sciences, Kathmandu, Nepal

3 Professor, Department of Agronomy, Agriculture and Forestry University, Chitwan, Nepal

4 Professor, Department of Agricultural Economics and Agribusiness Management, Agriculture and Forestry University, Chitwan, Nepal

Among *Brassica* oil seed crops, rapeseed (*Brassica campestris* L. *var. toria*) occupies 80% of the total area under oilseed crops. Nepal was a rapeseed exporting country during 1970's, but at present the country is spending a huge amount of precious foreign exchange by importing it to bridge the wide gap between production and consumption (Ghimire, 2001, MoAC, 2009). The productivity of rapeseed has been declining for last many years as reported from various parts of the country (Chaudhary *et al.*, 1993). The growing condition changed due to climate change, nominal or no use of fertilizers, micronutrient deficiency, little attention in terms of maintaining the plant population, crop management with proper protection measures could be the major factors associated with the yield decline of rapeseed (Ghimire and Awasthi, 2000).

There is a great scope of increasing yield of rapeseed by selecting high yielding varieties and improving the management practices. Optimal time of sowing is one of the important factors for rapeseed production (Mondal and Islam, 1993). Sowing at proper time allows sufficient growth and development of a crop to obtain a satisfactory yield. The grain yield and maturity of rapeseed are greatly influenced by environmental conditions regardless of genotypes. Different sowing times provide variable environmental conditions within the same location for growth and development of crop and yield stability (Pandey *et al.*, 1981). Decreasing crop yield in delayed sowing dates has been reported by many workers (Degenhardt and Kandra, 1981; McDonald *et al.*, 1983). Hocking *et al.* (1997) in a comparison of canola, mustard and linola found a decline in oil content by 2.7% for each 1 ^{o}C rise in average temperature during grain filling stage. Detailed physiological studies have shown that water stress after flowering reduces oil content (Mailer and Cornish 1987; Champolivier and Merrien 1996). Jensen *et al.* (1996) found that oil content was 43.2% in well-watered plants and 39.9% in drought affected plants.National Seed Board (NSB) of Nepal has released a few high yield potential varieties of rapeseed. These varieties may differ in their response to sowing dates for yield, yield components and oil content. Therefore, the major objective of this study was to evaluate the effects of sowing dates and varieties on seed yield and oil content of rapeseed in the middle Terai conditions of Nepal.

METHODOLOGY

A field experiment was conducted at Tamsariya-7, Nawalparasi, Nepal during October 2009 to February 2010.The soil analysis of the experimental field at a depth of 0-20 cm was sandy loam in texture with strongly acidic in reaction (pH 4.6) and medium in total nitrogen (0.19%), available phosphorus (50.4 kg/ha) and available potassium (259 kg/ha).Four varieties Unnati (V1), Preeti (V2), Pragati (V3) and Local landrace (V4) were used to assess their

performance on four sowing dates October 13th (SD1), October 28th(SD2), November 12th(SD3) andNovember 27th(SD4). The experimental design was split-plot design with three replications assigning sowing dates as main-plot factor and varieties as sub-plot factor. The unit plot size was 2.5 x 2.4 m^2 and the crop was planted in the rows spaced 25cm with 5cm plant to plant distance. FYM (farm yard manure) was applied at the rate of 6 t/ha two weeks before sowing. The chemical fertilizer dose used for the experiment was 60:40: 20 kg/ha of NPK and S, Zn and B in the form of gypsum, $ZnSO_4$ and boric acid at 25, 5 and 1 kg/ha was applied respectively. Half of the urea and whole amount of other chemical fertilizers were applied as a basal dose in all the treatments furrows opened at a depth of 8-10 cm at the time sowing. The remaining 50% of the total dose of nitrogen was splitted in two equal halves and first halve was applied before first irrigation at initiation of flowering stage and the second halve applied before second irrigation stage at grain filling stage. Bevisteen (Carbendazim 50% WP) at the rate of 2 gm/litre of water and Roger (Dimethoate) at the rate of 2 ml/litre of water were sprayed at an interval of 10 days starting from 25 to 70 days after sowing (DAS) to control alternaria blight and aphid infestation. All other recommended practices were followed and kept uniform for all treatments.

For dry matter accumulation, five plants from four destructive rows were continuously uprooted and all leaves was detached from the main stem and packed in the envelope and placed in the electronic oven.

Envelope separately and placed in the oven for complete drying. Temperature was maintained at 70 ^oC for 72 hours for complete drying of leaves and stems (Schonfeld *et al.*, 1988). After complete drying, dry weight of the leaves and stem was taken and calculated for the individual plants.Total dry weight was calculated from summation of the leaves and stem dry weight.

Number of primary branches, number of siliqua per plant, number of grains per siliqua, siliqua length, abortion percentage, test weight and grain yield were calculated when siliquae of the crop turned brownish as an average of 10 randomly selected plants from net harvested rows per plot. Soxhlet Extraction Assembly method (Robinson, 2004) was used to estimate the crude fat of rapeseed sample. Data collected were statistically analysed by M-STATC 1997 computer program. All the analysed data were subjected to DMRT for mean comparison at 5% level of significance.

RESULTS AND DISCUSSIONS

DRY MATTER ACCUMULATION

Total dry matter production per plant at 70 DAS was significantly higher on October sowing dates compared to November sowing dates. At 70 DAS, significantly higher dry matter per plant was observed on October 13thand October 28thsowing dates and it was declined with delayed sowings. CCC

(2011) reported that at full flower stage in canola, stems become the major photosynthetic structure although leaves are still important. At the beginning of ripening, pod walls and stems account for the majority of photosynthesis while leaves make only a small contribution. Higher dry matter production per plant on October 28th sowing date compared to other dates of sowing may be due to the higher plant height and more number of siliqua per plant. Finally, there were 17.53, 36.36, and 54.8% reduction in total dry matter per plant at 70 DAS on October 13th, November 12th and November 27th sowing dates, respectively (Table 1).

Total dry matter production was significantly affected by varieties at 70 DAS of rapeseed as well. Preeti produced significantly higher dry matter compared to other three varieties. The lowest dry matter per plant was produced by Local landrace at 70 DAS and it was 33.59% lower than that of Preeti (Table 1). Plant height, leaf area index(LAI) and number of branches per plant, might be the reasons for attaining high total dry matter in Preeti compared to other varieties.

NUMBER OF BRANCHES PER PLANT

Number of branches per plant was significantly influenced by sowing dates (Table 1). The highest number of branches per plant was produced on October 28th sowing date and the lowest number on November 27th sowing date. This finding was in conformity with the findings of Shahidullah *et al.* (1997) who stated that crop sown on October 27th recorded higher number of primary and secondary branches per plant as compared to November 6th and November 16th sowing dates.

In this study, Preeti produced significantly the highest number of branches per plant which was followed by Unnati and Pragati. Similarly, Local landrace produced significantly the lowest number of branches compared to improved varieties under study.

SILIQUA PER PLANT

Sowing date had a great influence on the number of siliqua per plant, which may have apparent impact on seed yield (Table 1). The highest number of siliqua per plant was attained on October 28th sowing date. A serious reduction of siliqua per plant was noted with early as well as late sowing dates viz. October 13th, November 12th, and November 27th. This finding was in conformity with the findings of Bhuiyan *et al.* (2008) who stated that the highest number of siliqua per plant was obtained in October 30th sowing date and the lowest on November 30th sowing date.The reason for this lowering of siliqua per plant beyond November 15th sowing may be attributable to the fact that was probably fall in temperature had presumably switched plants to earlier initiation before they reached a critical size in terms of dry matter production (Scott *et al.*, 1973).

Siliqua per plant was significantly influenced by varietal characteristics. Preeti produced the highest number of siliqua per plant followed by Unnati and Pragati. Similarly, Local landrace produced the lowest number of siliqua per plant (Table 1).

SILIQUA LENGTH

Siliqua length was significantly influenced by sowing dates (Table 1). The siliqua mesasured highest in length on October 28th sowing date followe,d by October 13th and November 12th sowing dates. The lowest length of siliqua was obtained on November 27th sowing date. Afroz *et al*. (2011) found the highest siliqua length from November 10th sown crop and the lowest siliqua length from the plants of November 30th sowing date when the mustard crop was sown at 10 days interval from November 10th to November 30th.

Preeti had significantly the highest length of siliqua followed by Unnati and Pragati. The lowest length of siliqua was observed in Local landrace.

NUMBER OF SEEDS PER SILIQUA

Number of seeds per siliqua was significantly influenced by sowing dates. The highest number of seeds per siliqua was obtained on October 28th sowing date and the lowest seeds per siliqua were found on November 27th sowing date (Table 1). The result of the present investigation with respect to seed per siliqua fairly agreed with the findings of Ghose and Chatterjee (1998). They reported that delay in sowing resulted decrease in the number of seeds per siliqua in rapeseed and mustard.

Seeds per siliqua were significantly influenced by varietal characteristics as well. Preeti produced the highest number of seed per siliqua followed by Unnati and Pragati. Similarly, Local landrace produced the lowest seeds per siliqua compared to other varieties. Highest number of seeds per siliqua with Preeti might be attributed to the higher number of branches per plant, higher number of siliqua per plant and higher length of siliqua compared to other three varieties (Table 1).

Table 1. Yield attributing characters, grain yield and oil content as influenced by different date of sowing and varieties

Treatments	Dry matter (g/plant)	Branches/ Plant	SPP[1]	SL[2]	SPS[3]	Abor[4]	TW[5]	Yield t/ha	Oil Content %
Sowing dates									
SD1	10.51^{b}	2.80^{b}	54.79^{b}	5.57^{b}	10.08^{b}	21.34^{bc}	2.60^{b}	1.06^{b}	37.48^{b}
SD2	12.75^{a}	3.58^{a}	59.64^{a}	6.09^{a}	14.89^{a}	19.18^{c}	2.83^{a}	1.27^{a}	38.25^{a}
SD3	8.11^{c}	2.13^{c}	50.14^{c}	5.26^{c}	8.26^{c}	23.52^{ab}	2.16^{c}	0.76^{c}	36.56^{c}
SD4	5.76^{d}	1.4^{d}	45.49^{d}	4.19^{d}	6.12^{d}	26.85^{a}	1.91^{d}	0.48^{d}	35.39^{d}

LSD	2.23**	0.65*	4.64**	0.27**	1.01**	3.50**	0.04**	0.12**	0.20**
SEm±	0.64	0.18	1.59	0.08	0.29	1.01	0.01	0.03	0.05
Varieties									
V1	7.77^{b}	2.63^{b}	54.95^{b}	5.69^{b}	5.69^{b}	24.45^{a}	2.68^{b}	1.01^{b}	37.68^{b}
V2	8.75^{a}	3.01^{a}	72.38^{a}	6.21^{a}	6.21^{a}	21.55^{b}	2.95^{a}	1.16^{a}	39.01^{a}
V3	6.80^{c}	2.27^{c}	47.56^{c}	4.99^{c}	4.99^{c}	25.71^{a}	2.12^{c}	0.76^{c}	36.11^{c}
V4	5.81^{d}	2.00^{d}	35.16^{d}	4.21^{d}	4.23^{d}	19.19^{b}	1.76^{d}	0.64^{d}	34.88^{d}
LSD	0.96**	0.25**	4.64**	0.50**	0.50**	2.66**	0.23**	0.07**	1. 14**
SEm±	0.33	0.08	1.59	0.17	0.14	0.96	0.08	0.027	0.39
CV%	15.76	12.19	10.49	11.37	10.79	13.91	11.75	10.81	3.66

Treatments means followed by the common letter (s) within a column are non-significantly different based on DMRT at 5% level of significance.

Note: 1. Siliqua/plant 2. Siliqua length 3. Seeds/siliqua 4. Abortion 5. Test weight

TEST WEIGHT

Test weight was significantly influenced by sowing dates. The highest test weight was observed in rapeseed on October 28th sowing date and the lowest test weight observed on November 27th sowing date. It indicates that test weight is reduced with delay in sowing (Table 1). Bhuiyan *et al.* (2008) recorded that the highest test weight in rapeseed was recorded on October 30th compared to October 20th and November 10th sowings.

Test weight was significantly influenced by varietal characteristics. Preeti had the highest test weight which was followed by Unnati and Pragati. The lowest test weight was observed on Local landrace.

GRAIN YIELD

Grain yield was significantly influenced by sowing dates. The highest grain yield was observed on October 28th sowing date (Table 1, Figure 1). This might be due to higher number of branches per plant, higher number of siliqua per plant, higher number of seeds per siliqua and higher test weight of the crop sown on October 28th sowing date. On average, seed yield was decreased by 0.65 t/hafor every fortnight delay in sowing from October 28thto November sowing dates.There was17.05% reduction in grain yield for October 13th, compared to October 28th sowing date. Accumulation of higher dry matter per plant might have attributed to higher yield in October 28th sowing date compared to October 13th sowing date. Recorded yield depression on sowing dates from October 28th to November 27th may be due to the dominance of vegetative growth over the reproductive one as described by

Mendham *et al*. (1990). This finding was supported by Bhuiyan *et al*. (2008) who noted significantly higher yield on October 30th sowing date compared to October 20th, November 10th and November 30th sowing dates.

Grain yield was also significantly influenced by varietal characteristics. Preeti produced significantly the highest grain yield followed by Unnati and Pragati. Local landrace produced the lowest grain yield. The yield difference of the varieties: Unnati, Pragati and Local compared to Preeti were 12.63%, 34.14% and 44.78%, respectively (Table 1).

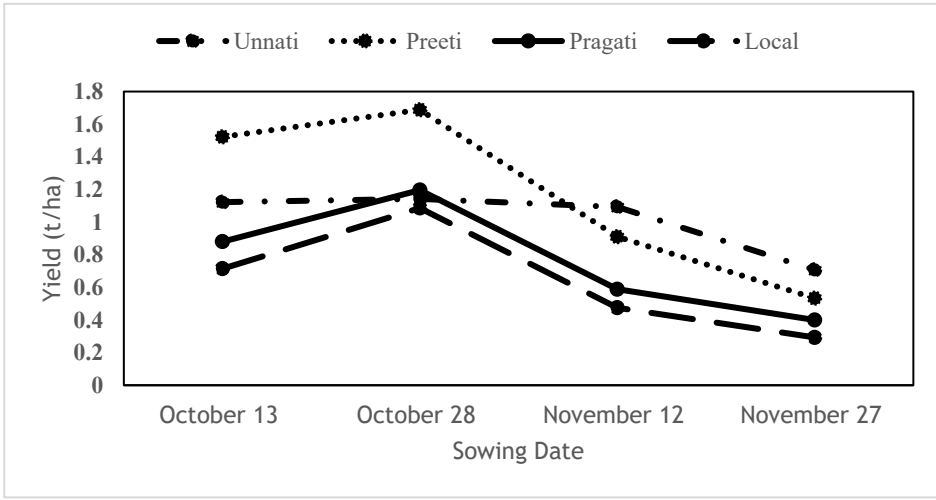

Figure 1. Interaction effect as influenced by different date of sowing date and varieties on grain yield per hectare

The interaction effect of sowing time and variety on grain yield per hectare was found significant (Figure 1). The highest grain yield of each of the variety was obtained on October 28th compared to other dates of sowing. Sowing of Preeti on October 28th produced significantly the highest seed yield. This yield was significantly higher than those obtained from Unnati, Pragati and Local. But one important aspect was noted that in November sowing dates, grain yield was significantly higher for Unnati compared to Preeti. Thus, variety Preeti was the best yielding variety for October sowing dates while variety Unnati was the best suitable for November sowing dates.

OIL CONTENT

Sowing date and variety had a significant effect on oil content (Table 1). On average, oil content was decreased by 5.75% for every fortnightly delay in sowing from October 28thto November sowing dates.The highest oil content on October 28th sowing date compared to October 13th sowing date might be attributed to the occurrence of light rainfall during the grain filling period of the crop. Si and Walton (2004) reported that oil concentration increased with

increasing post-anthesis rainfall in canola. They further reported that oil concentration increases by 0.7% with every 10 mm rainfall received after anthesis in Western Australia. The lowest oil content on November 27th sowing date might be attributed to the prevalence of higher temperature at the post-anthesis period of the crop and the lowest test weight. Oil concentration decreased with increasing post-anthesis temperature in canola and Indian mustard (Si and Walton, 2004). Similarly, Shastry and Kumar (1981) reported that reduction in test weight caused reduction in seed development with the result that the oil content in seed was reduced with a delay in sowing.

Further, the variety Preeti had the highest oil content (39.01%) followed by Unnati (37.68%), Pragati (36.11%) and Local landrace (34.88%), respectively. The lowest oil content was observed in Local landrace which was about 12% lower than that of Preeti. The highest oil content of the variety Preeti may be attributed to the higher harvest index (HI) and longer post-anthesis duration of the variety compared to other varieties (Table 1). Oil concentration increased with longer post-anthesis duration because extension of post-anthesis duration would allow pods of younger ages within a crop to have more time to grow and to accumulate oil, thus increasing oil concentration of the crops (Si and Walton, 2004). Robertson *et al*. (2004) also reported that high HI was positively associated with the high oil content in canola crop.

CONCLUSION

October 28th sowing date was found the best sowing date of rapeseed for obtaining maximum yield and oil content. The late planting of rapeseed adversely affected yield components, grain yield and oil content. Yield and yield attributes of Preeti was best for October sowing dates whereas for November sowing dates Unnati could be recommended.

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SOCIO-ECONOMIC EFFECTS OF ORGANIC CERTIFICATION OF NEPALESE ORTHODOX TEA

P. Mishra[1] and R.R. Kattel[2]

ABSTRACT

Organic certified orthodox tea production has high potential of improving agrarian livelihoods, environmental sustainability, and export markets. There has been limited study on economic benefits and social impact of certified orthodox tea production. This study was conducted to identify such impacts in Ilam district of Nepal. Primary data were collected through a pre-tested semi-structural interview schedule by using Kobo Toolbox, Direct Observation, Focus Group Discussions and Key Informant, and secondary data from journals, articles, bulletin, and reports from different organizations. Data were analyzed using economic, and social-related variables in a multiple regression model to identify whether the organic certification contributed to higher household income. The study revealed that price premium received by farmers for organic certified orthodox tea was almost 1.7 times of that received for organic non-certified orthodox tea. Despite higher price available, B/C ratio in case of organic certified growers is not significantly different from that of non-certified orthodox tea growers due to extra labor input and lower yield in certified production. Certified orthodox tea growers have a guaranteed market to sell their products to contracted tea processing factories. Moreover, non-certified growers were also facing problems in credit access and due to low product marketability and selling price as well as insect pests and diseases. Hence, policy focuses on promoting organic certification and increasing yield in organic certified orthodox tea plantations are appreciative.

Keywords: Export, Income, Organic-certification, Orthodox-tea

INTRODUCTION

Agriculture is the way of livelihood in Nepal that majorly anchors economy there. The agricultural sector covers 26.5% of the National GDP employing about 65.6% total population (MoALD, 2019). Agricultural intensification based on external inputs to increase agricultural production was started in Nepal in 1960s after successful introduction of the green revolution in agriculture. This intensification, with indiscriminate use of agrochemicals, resulted in pollution of water, air and soil; degradation of ecosystems; health hazards; and economic losses (Pokharel and Pant, 2008 and 2009). Organic agriculture is one of several approaches to sustainable agriculture development practiced

1 Corresponding Author, MSc. Ag., Department of Agricultural Economics and Agribusiness Management, AFU, 9846556555,Pabmis007@gmail.com

2 Assistant Professor, Department of Agricultural Economics and Agribusiness Management, AFU,9841373843,rrkattel@afu.edu.np

today, which is ecologically safe, economically viable, and socially acceptable (Scialabba, 1999).

Orthodox tea is also known as 'hill tea' or 'leaf tea' is produced through special process, where top two leaves and a bud from each branch (*duee pat eksuiro*) are picked up and processed by hand-rolling or using machines that mimics hand-rolling (Rana, 2007). Demand for hill orthodox tea has always been high in overseas markets due to its distinct naturally occurring aroma, tippy appearance, bright liquor, slightly fruity flavor, and exquisite bouquet (Yami and Khanal, 2002). The global market demands not only the quality of the product but also environmental and social responsibility. Improper use of chemical fertilizer and pesticides by conventional growers is creating environmental issues, soil degradation and non-tariff barriers like SPS and TBT in pursuance of the global trade regimes.

A total of 15,685 MT tea is annually exported from Nepal, which is about 90% of total production. Out of this, 80% is sold to India, and only 10% is exported to other countries (NTCDB, 2018).

As people being health-conscious, only quality assured product is high in demand. Thus, organic certified orthodox tea has high exportable potential in the international market and, for globalization, has to follow international processes (Van Der Vorst *et al.*, 2000). Nepal has received a trademark for its hill tea that when certified fulfills the international standard (NTCDB, 2018). Organic certified orthodox tea is fetching a good prices in export markets. However, producers fail to fetch expected benefit from orthodox tea despite high demand for Nepali-certified orthodox tea due to lack of certification by a national agency and laboratories testing residual level of agrochemicals. Most of the certification done by tea factories via international agency at their own cost in a group through the cooperatives (Mohan, 2016). Internationally recognized certifying agencies are National Association of Sustainable Agriculture Australia (NASAA), Institute for Market Ecology (IMO, Switzerland), Ethical and Environmental Certification Institute (ICEA, Italy), Ecocert France, One Cert America, Organic Certification, HACCP, ISO, USDA-NOP, JAS, Organic or Fair Trade (NEAT, 2011).

Organic agriculture, aiming to sustain soil health, ecosystems and people, has been developing very quickly around the world in recent years. Based on the principles of health, ecology, fairness and care, organic agriculture can contribute to environmental benefits and improve livelihoods among resource-poor, smallholder farmers. A different study showed organic certified tea production improved food security and reduced the indebtedness of farmers in India (Panneer selvam *et al.*, 2010. Eyhorn *et al.*, 2007).

In Nepal, conventional tea productivity is higher than organic tea productivity but due to low product marketability and selling price as well as insect-pests and diseases problems no significant differences in profits (Dhakal and Dahal, 2016). Organic certified orthodox tea growers can sell their products at a higher prices with a guaranteed market (Mohan, 2016). In Nepal majority of tea growers (59%) follow conventional method of tea production while 30% are in conversion, and the rest (11%)as organic certified growers (NTCDB, 2017). These reflect there is need for conversion of conventional growers to organic certified orthodox tea growers. As there has been limited empirical research regarding the actual benefits of certified organic production. This study was conducted to identify socioeconomic effects of organic-certified orthodox tea production in Ilam district of Nepal.

MATERIALS AND METHODS

Jhapa, Ilam, Panchthar, Tehrathum, and Dhankuta are major tea producing districts in Nepal that collectively constituted 'Nepal's Tea Zone'. Ilam, the largest orthodox tea producing district, was purposively selected for this study where Ilam, Suryodaya, and Deumai Municipalities, and Phakphokthum Rural Municipality were sites selected purposively considering concentration of certified orthodox tea growers and organic certification program already applied. Data were collected from a total of 160 households (80 HHs from certified growers and 80 HHs from non-certified growers). Primary data were collected through an interview schedule with orthodox tea growers[3], Focus Group Discussions (FGDs), Key Informants Interview (KII), and Direct Field Observations, and secondary from studies conducted by different agencies. Analysis was done by using Statistical Package for Social Science (SPSS, version 20.0), and STATA (version 12.0 software). Data were analyzed using economic, and social related variables in multiple regression model to identify whether the organic certification contributed to higher household income. The multiple regression function estimated in the study can be expressed as

$$Y_i = \beta o + \beta_1 Certification_i + \varphi Xi + \mu i \qquad (1)$$

Where,

Yi =Annual household income from the tea sector (dependent variable),

ß0 = constant term,

ß1 = Coefficient of the Certification Dummy (CERTI), and

Xi = other independent variables in the regression model.

The econometric model used in the study is specified as follows:

3 A semi-structured questionnaire was prepared in KoBoToolbox (https://ee.kobotoolbox.org/x/#YsZV)

$$\ln Y_i = \beta_0 + \beta_1 Certification_i + \varphi \sum X_{ki} + \mu i \quad (2)$$

Where,

lnY_i= Annual household income from tea sub-sector (NRs. in natural log) in Income Regression Function

$Certification_i$= Adoption of organic certification in study area (Yes=1, 0=Otherwise)

X_{ki}= set of explanatory variables in Income Regression Function

μi = Error term

RESULTS AND DISCUSSION

Socio-economic characteristics of farm households: Household characteristics (such as family members and age) were almost the same in both certified and conventional orthodox tea growers (Table1). Certified growers differed from conventional producers in this study in that they organized into cooperatives and sold products for export rather than domestic markets. As a result, certified growers had advantages over non-certified growers for a higher premium price of green tea leaves, access to credit, receiving training and technical services (Chen and Scott, 2014).

Table 1. Socio-economic characteristics of certified and non-certified orthodox tea growers.

Variables	Total (n=160)	Certified orthodox tea growers (n=80)	Non-certified orthodox tea growers (n=80)
Gender(Male=1)%	90.0	93.8	91.9
Age of household head (years)	48.33	49.16	47.50
Household size	5.16	5.23	5.112
Economically active HH membe	3.58	3.48	3.687
Tea production area(ha)	0.63	0.64	0.62
Organization		Cooperative	Independent
Market orientation		Export	Domestic market

COST AND BENEFIT

Certified orthodox tea growers were supported by cooperative and private processing factories. Private processing factories made written agreement with cooperatives and farmers for organic production or not to violate the rule of organic production, provided them with training, purchased all their organic tea as well as paid total cost for certification. Yields were found relatively low among the certified orthodox growers as shown in Table 2. This is why the price premium obtained for organic tea, almost double the price available for non-certified tea, barely compensated for the yield difference. Thus, the net income and average profit from tea were not significantly different between the certified and non-certified orthodox tea growers.

Table 2. Economics of production of orthodox tea in the study area.

Variables	Total Average (n=160)	Certified orthodox tea(n=80)	Non-certified orthodox tea (n=80)	Mean Difference	t value
Average productivity(kg/ha)	5637.50	3483.41	7791.78	-4308.37***	-6.64
Costof production per kg	41.64	50.78	32.51	18.26***	9.71
Return per kg	56.30	70.74	41.87	28.87***	11.64
B/C ratio	1.52	1.46	1.58	-0.12	-0.306

Note: *** indicates significant at 1% level

As fertilizer was not used in organic certified orthodox tea production, certified growers raised more livestock than non-certified orthodox tea growers for manure. Thus, certified growers fetched significantly higher income from livestock sector (Table 3).

Table 3.Share of different enterprises in household income in the study area.

Annual HH income (%)	Total (n=160)	Certified growers(n=80)	Non-certified growers(n=80)	Mean difference	t value
Tea sub-sector	31.98	28.48	35.49	-7.00	-1.88
Agriculture(except tea)	11.91	13.87	9.95	3.92**	1.97
Livestock sector	20.42	23.55	17.29	6.26***	2.39

Note: *** and ** indicate significant at 1% and 5% level, respectively

BENEFIT FROM ORGANIC CERTIFIED ORTHODOX TEA PRODUCTION

Certified orthodox tea growers have a guaranteed market to sell their products to contracted tea processing factories. Agricultural chemicals sprayed on the plants can last for years and are extremely harmful to farmers' health via contaminated air, water, and foods. As certified orthodox tea production is based on the principles of health, ecology, fairness and care, which also contributed to environmental benefits and improved livelihoods of smallholder farmers. Major benefits of organic certification of orthodox tea as felt by farmers are summarized in Table 4.

Table 4. Types of benefit reported from certified orthodox tea growers

Benefits	Index	Ranking
Price security	0.94	I
Market guarantee	0.92	II
Environmental benefit	0.86	III
High price	0.70	IV

Notes: Benefits, identified in HHs survey, were ranked from 1 to 0.2 in 5 point scale (1= very high, 0.8= high, 0.6= medium, 0.4=low, 0.2=very low)

Similarly, low selling price, insect pests and diseases, and reduced access to credit because of not being a member in any cooperative were major problems faced by non-certified growers (Table 5). Smallholder farmers often borrowed money for crop inputs (fertilizer, pesticides) at very high interest rates (Panneerselvam *et al.*, 2011) that indebted them and impacted their livelihood.

Table 5. Key Issues on production and marketing.

Problems	Certified growers (n=80)		Non-certified growers (n=80)	
	Index	Rank	Index	Rank
Shortage of labor	0.94	I	-	-
Low production	0.86	II	-	-
Problem of local transportation	0.7	III	0.73	III
Low selling price			0.96	I
Insect-pests and diseases	-	-	0.92	II
Lack of financial resources	-	-	0.70	IV

Notes: Problems identified in HHs survey were ranked from 1 to 0.2 in 5 point scale based on severity (1= very highly severe, 0.8= highly severe, 0.6= moderately severe, 0.4= less severe, 0.2= very less severe)

IMPACT OF CERTIFICATION ON ANNUAL TEA INCOME

An income regression model was used to identify factors determining the annual tea income; estimated results are shown in Table 6.

The value of the coefficient of multiple determinations (R^2) is 63%. It indicates the variation in the annual household income from orthodox tea sector explained by the independent variables included in the Ordinary Least Square (OLS) regression model. In addition-statistic (21.54) confirms the stability of the overall regression equation and joint significant at 1% level (P=0.000) in explaining HHs tea income.VIF is 1.44 and none of the variables has value higher than 1.9; it means there is no multicollinearity between independent variables included in the model. Error terms are also randomly distributed.

The model revealed that organic certified orthodox tea production practice is negative and highly significant with household income from the orthodox tea subsector. Similarly, tea cultivated land (Log tea land) hacter in log, is found positively significant at 1% level to determine household income from the tea sector. As well, education was positively and statistically significant at 5% level. Other independent variables in the model such as age of HH head, gender of HH head, HH size, and access to credits were positive but statistically non-significant. Similarly, independent variables such as number of economically active members, ethnicity, and migrated members were negative but statistically non-significant.

Organic certified orthodox tea production practice had a negative relationship with HHs income due to orthodox tea. The reason behind this is a low volume sold. Although organic tea fetches a higher price per unit, the productivity is low. Méndez *et al.*, (2010) reviewed the effects of organic and fair trade certifications for coffee producers in Central America and found that farmers did receive higher prices for their product, but the volume sold per producer was quite low.

Table 6. Regression estimates for determinants of income from tea (NRs. in natural logarithms).

Variables	Coefficients	Standard error	T	P
Economic active members in number	-0.042	0.03	-1.07	0.286
Certification *Production	0.0001	0.00	2.42	0.017
Age of HH head	0.0008	0.00	0.19	0.849
Gender of HH head (Dummy)	0.168	0.17	0.98	0.330
Ethnic group (Dummy)	-0.203	0.10	-1.92	0.057
Education (Dummy)	0.267**	0.13	2.09	0.039
Household size	0.066	0.04	1.81	0.072
Livestock holding(LSU)	-0.085**	0.04	-2.34	0.021
Certification adopted (Dummy)	-0.539***	0.14	-3.60	0.000
Log tea land (ha in log)	0.865***	0.08	11.07	0.00
Migrated member (Dummy)	-0.102	0.10	-0.98	0.329
Access to credit	0.072	0.10	0.71	0.476
Constant	9.52***	0.33	28.67	0.00
F (12,147)	= 21.54***			
Probability> F	= 0.000			
R^2	= 0.63			
Adjusted R^2	= 0.60			
Root MSE	= 0.55			
VIF	= 1.4			

Note: *** and** indicate significance at 1% and 5% levels

CONCLUSION

Certified orthodox tea growers were supported by cooperative and private tea processing factories. Certified orthodox tea growers have a guaranteed market to sell their products to contracted tea processing factories. But, yields were found relatively low among the certified orthodox growers, and price premium, almost double of the non-certified orthodox tea price, barely compensated the yield difference. Thus, the net income and average profit from tea were not significantly different among certified and non-certified orthodox tea growers. High focus must be laid on increasing production in organic certified orthodox tea plantations.

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CHARACTERIZATION AND DIVERSITY ASSESSMENT OF NEPALESE GARLIC (*Allium sativum* L.) LANDRACES

P. Thapa[1], R. P. Manali[2], A. Karkee[3], K. H. Ghimire[4], B. K. Joshi[5] and K. K. Mishra[6]

ABSTRACT

*A research was carried out at the field of National Agriculture Genetic Resources Centre (NAGRC), Khumaltar, Lalitpur, Nepal in 2019 with the objective of phenotypic characterization and genetic diversity assessment of thirty-seven local garlic landraces.The phenotypic diversity was assessed based on fifteen qualitative and nine quantitative characters by sing non replicated rod row designfollowing the descriptors developed by IPGRI, 2001. Descriptive statistics were calculated by using MS Excel 2016 and UPGMA clustering and PCA was done with MINITAB-17. The diversity index (*H'*) and coefficient of variation for different traits ranged from 0.54-0.96 and 16.89-87.85, respectively. Four clusters identified and CO 10307, CO 10482 and CO 10615 of fourth clusterswere superior in terms of quantitative characters. Five principal components contributed95.2% of the cumulative variance. This result will be helpful for breeder and researchers to comprehensively understand the agro-morphological characters as well as diversity of the Nepalese garlic collection.*

Key words: Agro-morphological characterization, Bulb crop, Diversity, Landrace, PCA, Variation

INTRODUCTION

Nepal is anecologically diverse country where 65% populations are involved in agriculture. Due to the diversified geography and climate, large number of species of agricultural crops exist in the country. A total of 1,506 species of agricultural crop and forage genetic resources have been reported in Nepal (Upadhyay and Joshi 2003, Joshi *et al.*, 2020). Till 2020, there are 13,069 landraces of 330 species of different crops conserved in national gene bank (Genebank, 2020). Those plant species which do not produce seeds and need

1 Technical Officer, National Agriculture Genetic Resources Centre, NARC, Khumaltar, Lalitpur, Nepal. Corresponding email: pradip.thapa876@gmail.com, Mobile no: +977 9846593083

2 Technical Officer, National Agriculture Genetic Resources Centre,NARC, Khumaltar, Lalitpur, Nepal

3 Scientist, National Agriculture Genetic Resources Centre,NARC, Khumaltar, Lalitpur, Nepal

4 Senior Scientist, National Agriculture Genetic Resources Centre, NARC, Khumaltar, Lalitpur, Nepal

5 Senior Scientist, National Agriculture Genetic Resources Centre, NARC, Khumaltar, Lalitpur, Nepal

6 Senior Scientist, National Agriculture Genetic Resources Centre, NARC, Khumaltar, Lalitpur, Nepal

vegetative parts to regenerate i.e. recalcitrant and vegetatively propagated plant species are neededto be maintained in the field and regenerated every year for conservation (Mainali *et al.*, 2020). Taro park, field genebank and community field genebank were established in 2012 to conserve non-orthodox crop species in Pokhara, Khumaltar and Kailali, respectively (Joshi, 2019). A total of 241 landraces of 34 various recalcitrant species including 49 landraces of garlic have been collected from different sites of the country are maintained and regenerated every year in Khumal field genebank (Genebank, 2020).The main contributions of landraces to plant breeding are useful traits for more efficient nutrient uptake and utilization and genes associated with adoption to different stress (Newton *et al.*, 2011). The relatively high level of genetic variation of landraces is one of the advantages over improved varieties. Although yields may not be as high, the stability of landraces in face of adverse condition is typically high. But very few numbers of landraces i.e. only 37 local landraces of 19 crops have been utilized in breeding to develop 41 crop varieties in Nepal (Joshi *et al.*, 2020). Lack of knowledge about specific trait(s) of landrace is one of the main reasons behind low utilization of landraces. Besides this, characterization and landrace enhancement are required to increase the utilization of landraces.

Garlic (*Allium sativum* L.) is second most widely cultivated bulb crop after onion in the world, which belongs to family amaryllidaceae. Cultivated garlic is known for at least 5000 years and is believed to be originated in Central Asia where garlic grows wild (Fritsch and Friesen, 2002). There is high diversity of *Allium* species from Mediterranean basin to Central Asia and Pakistan (Fritsch and Friesen, 2002). Garlic is grown globally but China is leading country in area and production followed by India, Republic of Korea, Egypt and Russian Federation (FAO, 2012). Garlic is grown in 8116 ha in Nepal with the production of 56,668 ton (MOALD, 2018/19). Garlic is being cultivated for bulb and fresh vegetables (green bulb), however bulb production is popular in the country.

In Nepal, there issubsistence cultivation of few land races of garlic identified by farmers themselves and few other exotic germplasms introduced from adjoining country at different dates. Till now, none of the garlic genotypes has beenregistered or released from NARC for cultivation in Nepal. The basic pre-requisite for variety improvement is the presence of genetic variability in genetic stocks. In Nepal, Introduction, clonal selection and heterosis breeding are practiced for improvement of vegetatively propagated crops (Joshi, 2017).Clonal selection is a major breeding method for garlic which showed high degree of variation in bulb size, color, growth habits, plant height, number and size of the cloves, days to harvesting, resistance to storage capacity, dormancy and adaptation to agro-climatic situations (Singh *et al.*, 2012).Variability observed among different clones of garlic is due to mutation

providing opportunities through natural and human selection for adaptation to various growing environments (Singh *et al.*,2018).Evaluation and characterization of preserve traits among garlic landraces is fundamental for their efficient utilization in plant breeding schemes and effective conservation programs (Lampasona *et al.*, 2003).Its evaluation will identify landraces that could be useful to obtain cultivars using clonal selection to be used in breeding programs (Kumar *et al.*, 2015).Wider adoption of short duration and high yielding variety to different agro-ecological zones is necessary to accelerate the garlic production in the country (KC *et al.*,2004).To increase the production of garlic crop, there is an urgent need to screen the landraces to get more divergent cultivars for qualitative and quantitative traits. This study was therefore conducted with the objective of phenotypic characterization and assessment of genetic diversity of local garlic landraces using morpho-agronomic characters among thirty-seven landraces collected from different parts of the country.

METHODOLOGY

EXPERIMENTAL MATERIALS AND DESIGN

The experiment was carried out at NAGRC Khumaltar, Lalitpur during 2019. Geographically it is located at an altitude of 1368 m, latitude of 27°40'N and longitude of 085°20'E. The characterization blocks have black loamy soil. Thirty-seven garlic landraces collected from different parts of the country as depicted in Table 1 and Figure 1 are grown in field gene bank of NAGRC. Experiment was conducted in non-replicated rod row design for agro-morphological characterization. Cloves were separated from the bulb, and only the healthy cloves were selected for planting. Each landrace was planted on 6th Nov 2019, in 1.08 m^2 (120cm × 90cm) plot with the spacing of 20cm × 15cm. Fertilizers were applied @ 100:50:60 kg N_2:P_2O_5: K2O/ha.Total phosphorus and potassium and half of the nitrogen was applied before planting and rest of the nitrogen was top dressed in two equal splits (30 and 45 days after planting) during weeding. Weeding and pulverizing of soil were done regularly whenever necessary to keep the plots free from weeds and to ensure good aeration in soil. The garlic plants when the tops turn yellowish or light brownish and show signs of drying up indicate the symptom of maturity. The bulbs were lifted, freed from earth and the leaves were tied at the top. The bulbs were cured for 2 to 3 days in the shade before storing them in an ordinary room. Thoroughly cured garlic bulbs stored well in ordinary well-ventilated room.

Table 1: Garlic accessions with their collection districts

S.N.	Accessions	Collected district	Altitude (m)	Latitude (N)	Longitude (E)
1	ARM-02	Kaski	850	28.225	83.975
2	ARM-05	Parbat	952	28.281	83.601
3	ARM-07	Baglung	1993	28.257	83.502
4	ARM-11	Lalitpur	1681	27.475	85.260
5	ARM-14	Sindupalchok	3158	27.965	85.685
6	ARM-20	Lalitpur	1311	27.664	85.368
7	ARM-24	Makwanpur	1828	27.642	85.179
8	ARM-25	Kaski	1170	28.260	83.070
9	ARM-28	Baglung	1183	28.217	83.651
10	ARM-27	Kaski	1392	28.287	83.956
11	ARM-08	Kaski	878	27.937	83.651
12	CO 4812	Rasuwa	1509	28.092	85.250
13	CO 6060	Dolakha	1417	27.596	86.061
14	CO 6077	Dolakha	1200	27.611	86.063
15	CO 10306	Argakhanchi	958	27.985	83.114
16	CO 10307	Argakhanchi	960	27.986	83.115
17	CO 10399	Doti	1529	29.360	80.987
18	CO 10448	Sindhuli	1750	27.152	85.901
19	CO 10482	Sindhuli	1650	27.370	85.750
20	CO 10615	Ramechhap	1150	27.560	86.221
21	ARM-18	Lalitpur	1330	27.679	85.393
22	ARM-09	Kaski	1000	28.250	83.072
23	ARM-03	Parbat	875	28.163	83.651
24	ARM-16	Jumla	3075	29.287	82.118
25	CO 4816	Rasuwa	768	27.200	85.430
26	ARM-26	Kaski	1392	28.287	83.956
27	ARM-19	Lalitpur	1338	27.642	85.343
28	ARM-06	Kaski	1485	28.314	83.969
29	ARM-13	Lalitpur	1388	27.627	85.331
30	Humla Collection-442	Humla	2250	29.873	81.876
31	Mahottari Collection	Mahottari	250	26.958	85.955
32	Surkhet-72	Surkhet	334	28.716	81.335
33	Surkhet-100	Kailali	399	28.733	81.226
34	Surkhet-105	Surkhet	381	28.716	81.335
35	Surkhet-116	Kailali	378	28.732	80.861
36	Surkhet-245	Surkhet	525	28.811	81.553
37	Surkhet-289	Surkhet	526	28.711	81.335

AGRO-MORPHOLOGICAL TRAITS MEASUREMENT

Agro-morphological traits were measured at various growth stages according to descriptors for garlic developed by International Plant Genetic Resources Institute (IPGRI, 2001). Five random plants from each landrace were selected for agro-morphological traits evaluation. Fifteen qualitative traits i.e. plant vigor, external cloves, leaf color, anthocyanin coloration at the base of pseudo stem, bulb skin color, thickness of neck, bulb shape of base, bulb skin thickness, peeling, cracking of bulb skin, clove skin color, anthocyanin stripes on clove skin, clove shape, easiness of dividing bulb into cloves and compactness of cloves were observed at different growth stages. Likewise, nine quantitative traits i.e. days to emergence, plant height, clove length, clove width, clove diameter, numbers of cloves per bulb and weight/bulb, bulb diameter and biomass yield were recorded as mentioned in descriptors. Fresh biomass yield was recorded by accumulating all parts of the plant in the total plot during harvesting time.

Shannon–Weaver diversity indices (Shannon and Weaver, 1949) were calculated in order to estimate the phenotypic diversity for each qualitative trait with Microsoft Excel using the formula:

$$H' = \left[\Sigma\left(\frac{n}{N}\right) \times \left\{\mathrm{Log2}\left(\frac{n}{N}\right) \times (-1)\right\}\right] / \mathrm{Log2}\kappa$$

Where, H' is the standardized Shannon–Weaver diversity index, *k* is the number of phenotypic classes for a character, n is the frequency of a phenotypic class of that character and N is the total number of observations for that character. For theShannon–Weaver diversity index(H') ofquantitative traits, accessions were divided into 10 phenotypic classes as <x-2sd, x-2sd, x-1.5sd, x-sd, x-0.5sd, x, x+0.5sd, x+sd, x+1.5sd, x+2sd and >x+2sd are as the margins of the classes, where x is average and sd is standard deviation.The diversity index was considered as low (0.10≤H'≤0.40), intermediate (0.40≤H' ≤0.60),high (0.60≤H'≤0.80) and very high (H'≥0.80) (Eticha *et al.*, 2005).

DATA ANALYSIS

Descriptive statistics including mean, maximum, minimum, coefficient of variation (CV) and diversity index (H') was calculated by using MS Excel 2016 and UPGMA clustering and Principal Component Analysis was done with MINITAB 17 for quantitative characters. Estimates of similarities among the accessions were calculated using Euclidean distance and average linkage and PCA was conducted to know the contribution of traits in total variation among the accessions.

RESULTS AND DISSCUSSION

DIVERSITY BASED ON QUALITATIVE TRAITS

Frequency distribution for fifteen qualitative traits is presented in Table 2. Among qualitative variables, all characters were polymorphic. The diversity index *(*H'*)* ranged from 0.54 to 0.96, which indicate tremendous diversity present in the garlic landraces for qualitative traits. Very high diversity index (H') was inferred for most of the traits such as thickness of neck, external cloves, peeling quality, cracking of bulb skin,anthocyanin stripes on clove skin, plant vigor, bulb skin thickness, easiness of bulb dividing into cloves, leaf color, anthocyanin coloration at base of pseudo stem, clove shape 0.83 and compactness of cloves. However, this value of diversity index (H') was found high for bulb skin color and intermediate for bulb shape at base.

The existence of high genetic diversity in the Nepalese garlic landraces increases the space for selection for breeders as well as for farmers. This diversity can be utilized in crop improvement and enhancement of genetic potential of garlic accessions. Agro-morphological traits can be considered by farmers to discriminate varieties regarding selection and adoption of a variety. Similar results are reported in garlic by Pooler and Simon (1993) as well as Simon and Jenderek (2003).

Table 2: Morphological character-based diversity index of garlic accessions

S.N.	Qualitative characters	Shannon-Weaver index	Descriptor's states	Frequency	Proportion %
1.	External cloves	0.95	0- Absent	18	49
			9- Present	19	51
2.	Plant vigor	0.89	2-Very weak	3	8
			3- Weak	8	22
			4- Slightly weak	5	14
			5- Intermediate	11	30
			6-Slightly vigorous	4	10
			7-Vigorous	3	8
			8-Very vigorous	1	3
			9Extremelyvigorous	2	5
3.	Leaf color	0.84	2-Very light	3	8
			3- Light	4	10
			4- Slightly light	15	41
			5- Intermediate	15	41

4.	Anthocyanin coloration at base of pseudo stem	0.84	2-Very Weak	2	5
			3- Weak	7	19
			4- Slightly Weak	13	36
			5- Intermediate	12	32
			6- Slightly strong	3	8
5.	Bulb skin color	0.63	1- White	26	70
			2- Light pink	1	3
			4- Light brown	10	27
6.	Thickness of neck	0.96	1- Extremely thin	3	8
			2-Very thin	2	5
			3- Thin	5	14
			4- Slightly thin	8	21
			5- Intermediate	5	14
			6- Slightly thick	5	14
			7-Thick	5	14
			8-Very Thick	4	10
7.	Bulb shape of base	0.54	1- Recessed	1	3
			2- Flat	29	78
			3- Round	7	19
8.	Compactness of cloves	0.81	3-Loose	4	11
			5-Intermediate	10	27
			7-Compact	20	54
			9- Very compact	3	8
9.	Bulb skin thickness	0.88	2- Very thin	1	3
			3- Thin	14	37
			4- Slightly thin	8	22
			5- Intermediate	8	22
			6- Slightly thick	6	16
10.	Peeling	0.94	1- Extremely easy	2	5
			2- Very easy	5	14
			3-Easy	7	19
			4- Slightly easy	9	24
			5-Intermediate	4	11
			6- Slightly hard	3	8
			7-Hard	7	19
11.	Cracking of bulb skin	0.93	2-Very frequent	3	8
			3-Frequent	10	27
			4- Slightly frequent	9	24
			5-Intermediate	11	30
			6- Slightly rare	4	11
12.	Clove skin color	0.93	1-White	24	65
			2-Light pink	13	35

13.	Anthocyanin stripes on clove skin	0.90	0-Absent 9-Present	12 25	32 68
14.	Clove shape	0.83	3- Slim round 5- Flat 7- Thick round	18 3 16	49 8 43
15.	Easiness of dividing bulb into cloves	0.86	2- Very easy 3-Easy 4- Slightly easy 5-Intermediate 6- Slightly hard 7-Hard 8- Very hard 9-Extremely hard	1 4 4 12 6 7 2 1	3 11 11 32 16 19 5 3

DIVERSITY BASED ON QUANTITATIVE TRAITS

Nine quantitative traits were measured for evaluating variation among garlic landraces (Table 3). The result showed existence of high variation with quantitative traits among the landraces. The coefficient of variation ranges from 16.89 (Clove length) to 87.85 (Biomass yield). Out of nine quantitative characters, eight have CV value more than 20% indicating greater variability among the landraces. The result indicated that there was high level of variation in characters of interest i.e. Biomass yield, weight/bulb and number of cloves/bulbs in garlic. Shannon Weaver index ranges from 0.54-0.78 which showed moderate to high level of diversity among the landraces for quantitative traits. High diversity was found in clove width (H'=0.78) and intermediate diversity was found in days to emergence and biomass yield (H'= 0.54).

The estimate of coefficient of variation depicted a clear picture of extent of variability present in the available landraces (Table 3). High variation in quantitative characters may be due to the collection of garlic germplasm from different ecological regions of the country. Pathak (1994) reported that utilization of existing variability and selection of the best genotypes to produce superior clone might be the best approach of breeding and crop improvement in garlic. The number of cloves per bulb and weight of average 10 cloves attributed to the yield potential of the accessions which varied from each other might be due to their differences in genetic configuration. This result was supported by Andres *et al*. (1996). There was moderate to high variation found in biomass yield, weight/bulb, days to emergence, plant height, length and width of cloves, and bulb diameter among the garlic landraces. This variation can be used by breeder for selection and development of high yielding varieties. High variation in plant height indicated the potential of accessions for the development of garlic varieties

for fresh consumption which have greater number of fresh leaves. Kohli and Prabal (2000), Khae *et al*. (2005), Kumar *et al*. (2006), Panthee *et al*. (2006), Gupta *et al*. (2007), Singh *et al*. (2012) and Singh *et al*. (2015) have also reported the similar results.Recent genetic studies revealed the presence of considerable genetic diversity among the garlic clones (Buso *et al*., 2008). Garlic shows wide morphological diversity in bulb size and color, leaf length, growth habits, and agronomic traits such as stress and drought tolerance (Panthee *et al*., 2006).

Table 3: Analysis of garlic accessions in terms of quantitative characters

S.N.	Characters	Mean±SE	Std.	CV %	Min.	Max.	SWD (H')
1.	Days to emergence	9±0.32	1.95	20.82	7.00	18.00	0.54
2.	Plant height at 30 days (cm)	15.9±0.62	3.82	24.06	8.82	27.00	0.68
3.	Plant heightat 120 days (cm)	35.6±1.50	9.11	25.64	22.40	60.80	0.69
4.	Clove length (cm)	3.7±0.10	0.62	16.89	2.50	4.90	0.68
5.	Clove width(mm)	10.4±0.33	2.01	19.27	6.30	14.10	0.78
6.	Number of cloves/bulbs	19±1.27	7.71	39.90	5.00	39.00	0.71
7.	Weight/bulb (g)	17.16±2.01	12.25	71.39	2.33	62.67	0.63
8.	Bulb diameter (mm)	31.9±1.18	7.19	22.53	18.79	53.51	0.70
9.	Biomass yield (kg/plot)	1.79±0.25	1.57	87.85	0.21	8.03	0.54

SE = Standard Error, Std. = Standard Deviation, CV = Coefficient of Variation, Min. = Minimum, Max. = Maximum, SWD = Shannon–Weaver diversity, H' = notation for Shannon–Weaver diversity index

CLUSTER ANALYSIS

The cluster analysis grouped the landraces into four clusters for nine quantitative traits (Figure 2). The critical examination of the dendrogram revealed four clusters with minimum of 35.60% similarity level in UPGMA clustering. Cluster-1 has landraces having lowest mean value for plant height, clove length, weight/bulb, number of cloves per bulb, longitudinal diameter of bulb, biomass yield and intermediate mean value for days to emergence and clove width. Landraces in Cluster-2 haveintermediate mean value for days to emergence, number of cloves per bulb, plant height, clove length, weight/bulb, longitudinal diameter of bulb and biomass yield. Cluster-3 consists of landraces having longer days to emergence and lower plant height, clove length and width, weight/bulb, number of cloves per bulb, longitudinal diameter of bulb and biomass yield than that of Cluster-4.Similarly, Cluster-4 consists of landraces with shortest days to emergence and highest mean value for plant height, clove length and width, number of cloves/bulbs, weight/bulb, longitudinal diameter of bulb and biomass yield than remaining cluster. Characterization of landraces and clustering of them based on their morphological and genetic similarity helps to identify and select the best parents for hybridization. Hence, grouping of landraces using multivariate

analysis such as UPGMA clustering would be valuable for the breeders in such a way that the most promising landraces in the population may be selected from different clusters for crop improvement. Landraces of Cluster-4 i.e. CO 10307, CO 10482 and CO 10615 are superior in terms of plant height, clove length and width, weight/bulb, no of cloves per bulb, longitudinal diameter of bulb and biomass yield. These landraces can be included in garlic improvement program after further selection process.

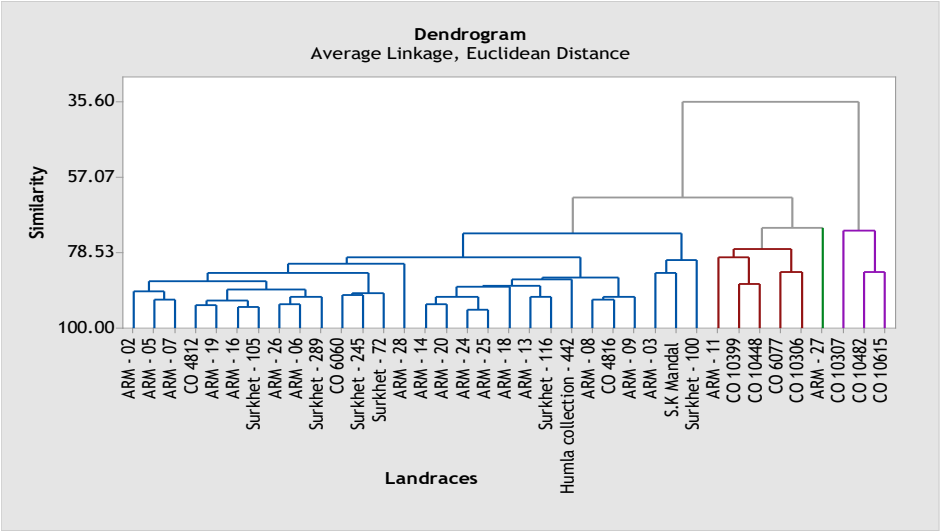

Figure 1: Dendrogram of 37 garlic landraces derived by UPGMA from nine quantitative traits

Table 4. Number of accessions with average of major quantitative traits in each cluster

Variables	Cluster-1	Cluster-2	Cluster-3	Cluster-4
Number of accessions	28	5	1	3
Days to emergence	9.60	8.6	11	7.66
Plant height (30 days)	14.32	18.5	16.2	25.80
Plant height (120 days)	31.34	45.00	39.20	57.80
Clove length (cm)	3.48	4.12	3.60	4.80
Clove width (mm)	10.48	9.84	9.50	11.21
Weight/bulb (g)	12.12	28.44	14.60	50.56
Number of cloves/bulbs	16.27	22.84	29.29	34.26
Bulb diameter(mm)	29.17	36.72	31.91	49.51
Biomass yield (kg/plot)	1.41	2.71	1.51	6.33

PRINCIPAL COMPONENT ANALYSIS

Table 5 shows the principal component analysis with eigen values, eigen vectors and variances which partitioned the total variation into five principal components contributing 95.2% of the cumulative variance. The first two principal components with eigen value greater than 1 accounted for 78.7% of the entire variability. The first PC explained 63.5% of the total variance, the traits such as Biomass yield, bulb diameter, plant height and weight/bulblargely contributed in the positive direction while days to emergence loaded in the negative direction. The second PC accounting for 15% of the total variance which was mainly influenced negatively by clove width and positively by number of cloves/bulbs. The traits contributed negatively on the third PC (9%) were days to emergence and clove width. Principal component analysis partitions the total variance into components and measures how each component contributes to total phenotypic variation. Biomass yield, number of cloves per bulb,Bulb diameterand plant height contributed positively for phenotypic variation in our experiment. These traits are directly correlated with yield. These traits can be used for the development of high yielding garlic varieties.

Table 5: Principal Component Analysis of nine quantitative characters

Variables	PC-1	PC-2	PC-3	PC-4	PC-5
Eigen value	5.71	1.37	0.82	0.40	0.25
Proportion	0.63	0.15	0.09	0.04	0.02
Cumulative Variance (%)	63.5	78.7	87.9	92.3	95.2
Days to emergence	-0.181	0.279	-0.922	0.058	-0.119
Plant height at 30 days (cm)	0.382	0.164	0.093	0.213	0.010
Plant height at 120 days (cm)	0.377	0.196	0.045	0.170	-0.583
Clove length (cm)	0.322	-0.298	-0.162	-0.745	0.079
Clove width (cm)	0.113	-0.744	-0.246	0.507	0.168
Number of cloves/Bulb	0.323	0.437	-0.066	0.073	0.677
Weight/bulb (g)	0.377	-0.121	-0.183	-0.232	-0.238
Bulb diameter (mm)	0.398	-0.071	-0.122	0.062	0.245
Biomass yield (kg/plot)	0.397	0.065	-0.000	0.219	-0.193

CONCLUSION

There was high diversity found in both qualitative as well as quantitative traits among Nepalese garlic landraces. Thisresultwill obviously be helpful for breeder and researchers to comprehensively understand the agro-morphological characters as well as diversity of the Nepalese garlic collection and more easily select the target landraces. Garlic landraces named as CO 10307 from Arghakhanchi, C0 10482 from Sindhuli and C0 10615 from Ramechhap were found superior based on economically important traits such as biomass yield plant height, clove length and width, no of cloves per bulb and longitudinal diameter of bulb. These landraces could be evaluated further in multiple environments and used to develop new garlic varieties.

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EVALUATION OF DIFFERENT BARLEY GENOTYPES FOR THEIR PHENOLOGICAL TRAITS, YIELD AND YIELD ATTRIBUTES IN THE WESTERN MID-HILL OF NEPAL

R.Acharya[1*], B.Adhikari[2], S.Bharati[3], H.Paudel[3], S.Subedi[4] and B.Acharya[5]

ABSTRACT

There is a need to increase the yield potential of barley by utilizing improved cultivars. So, the present study was done to assess the performance of barley genotypes for phenological and yield attributing traits. A field study was carried out at Lumle,Kaski in Nepal involving seven barley genotypes during two growing seasons in 2018/2019 and 2019/2020, employing RCB design replicated three times. The results, combined for the years, showed significant differences for all traits except effective tillers/m^2 and thousand grains weight. The grain yield was highest for B86122-1-0K-3 (2.756 t/ha and was at par with the genotypes Xveola-28 (2.411 t/ha) and B90K-024-1-1-2-0K (2.350 t/ha) and significantly higher than the Bonus (standard check) (1.852 t/ha). These superior genotypes should be further evaluated at on-station and on-farm conditions of western hills of Nepal so that low and stagnating barley yield in Nepal can be improved.[1]

Keywords: Barley, genotypes, phenological traits, grain yield

INTRODUCTION

Barley is an important and one of the first cultivated grains among cereals (Kant, 2016). It belongs to the grass family, Poaceae, the subfamily Festucoideae, tribe Hordeae and genus *Hordeum*. While the cultivated barley belongs to the subspecies *vulgare*, its wild forms belong to subspecies *spontaneous*. Barleys are self-pollinating and diploid annuals (2n=14). The barley spike has three florets contained in three each set of attached spikelets. The spike bears such spikelets in the alternate fashion to the side of the rachis. Depending on the numbers of kernels developed in the triplet, they are distinguished as six-rowed barley (all three florets developed into kernel) and two-rowed barley (only central floret developed into kernel and two lateral florets sterile)(MacGregor, 2003).

1 Directorate of Agricultural Research, NARC, Gandaki Province, Lumle, acharya.afu@gmail.com

2 Agriculture and Forestry University, Rampur, Chitwan, bhawana111.ba@gmail.com,

3 Institute of Agriculture and Animal Sciences, Tribhuwan University, bharatisuraj022@gmail.com, hira95poudel@gmail.com

4 Hill Crops Research Program, NARC, subedi.subash1@gmail.com

5 Li-Bird, Nepal, avinab.agriworld@gmail.com

In Nepal, there are hulled and hull less or naked barley (*Mudule jau, uwa*) in cultivation whose popularity differs according to location and their use. Owing to the range of nutritional benefits it possesses, barley is used as food for both humans and livestock and malting. Barleys are used for making *sattu* and *khole* in high hills and in mountainous regions (Paudel, 2016). The presence of high dietary fiber and ß- glucan in barley makes it a better choice over other cereals (Naser *et al.*, 2018). Barley has prospects for diverse end uses. Currently, barley's interest is increasing worldwide for its nutritional value, health benefits, and industrial importance (Al-Sayaydeh *et al.*, 2019). Barley comes fourth in terms of production and productivity in the world (Erdenetsogt *et al.,* 2019). Globally, it was cultivated in 51 million hectares of land with production of 158 million metric tonnes for the year 2019 (FAOSTAT, 2021). It ranks fifth in Nepal's case in terms of area and production behind rice, maize, wheat, and finger millet (MoALD, 2020).The area, production and productivity of barley in Nepal for the year 2019 is 30550 ha, 24409 Metric tonnes and 1.25 ton/ha respectively. Nepal's barley yield increased from 1.058 tons/ha in 1961 to 1.238 tons/ha in 2018, growing at an average annual rate of 0.30 percent (FAOSTAT, 2020).With its ability to sustain biotic and abiotic stress, this annual cereal crop is cultivated from dry areas to humid subtropics (Sravani *et al.*, 2018) and from the Terai to the high hills in Nepal (Baniya *et al.*, 1997). Barley dominates the cropping system of the high hills of Nepal and grows under extreme weather conditions. Though barley is an underutilized crop in Nepal, it has a great potential for expansion (Agrawal *et al.,* 2018). The increased production and product diversification can contribute to food and nutritional security.

Poor Nepalese farming communities of the high hills cultivate barley for nutrition, socio-cultural preferences, traditional and religious uses. The stagnating yield of barley for decades indicates the inadequacy of research and development work in the crop. Besides, low productivity, deteriorating local food systems, changing food habits, and policy constraints for underutilized crops like barley are the challenges limiting their cultivation and consumption, leading to decreasing acreage and lower yield (Adhikari *et al.,* 2017). A range of agronomic factors like the genotype, seeding rates, climatic factors, soil fertility, weeds, etc., affect barley production (Tawaha *et al.,* 2003); however, the climatic conditions and the cultivar's response to them is the primary determinant. Thus, the evaluation of barley accessions for different agro-morphological traits and yield performance at different locations is crucial for crop improvement in Nepal (Kandel *et al.*, 2019). There is a need to increase the yield potential of barley and reduce the gap between potential and realized yield by utilizing improved cultivars (Newton *et al.,* 2011). Therefore, the main objective of the study is to evaluate the phenological traits and the yield performance of barley accessions in the mid-hill climate of Lumle, Kaski.

METHODOLOGY

Plant Materials: In this study, seven barley genotypes were used that included a released barley cultivar (Bonus- Origin Sweden) as a standard check, a Lumle Jau as a local check, and rest 5 Nepalese barley breeding lines (Xveola-28, NB-1003-37/1214, B90K-024-1-1-2-0K and B86122-1-0K-3) were received from the Hill Crops Research Program of Nepal Agricultural Research Council at Kabre, Dolakha.

Field Experiments: The barley genotypes were grown for two growing seasons (2018-2019 and 2019- 2020) in agronomy fields of the Directorate of Agricultural Research (DOAR), Lumle, Gandaki Province (28º17'49.75" N, 83º49'2.50" E; elevation: 1675 m). The soil type of the research plot was sandy loam (Table. 1). The climatic conditions for the area were recorded for both the experimental years (Table. 2). The crop was sown on 2nd November 2018 for the first year and 5th November 2019 for the second year at the rate of 120 kg seeds per hectare. Organic fertilizer was applied in the form of farm yard manure at the rate of 6 tons/ha, while the chemical fertilizer dose was 60:30:30 kg N_2:P_2O_5:K_2O/ha, provided through urea, diammonium phosphate, and muriate of potash. The experiment was conducted after the harvesting of the summer maize in the field.

The experiment was conducted in a randomized complete block design (RCBD) with three replications. Each plot area was 6 m^2 comprising eight rows having a length of three-meter. Seeds were sown continuously within the rows separated at a distance of 25 cm.

Traits Measurement: Days to 50% heading, days 80% physiological maturity (no green tissue remained in 80% of plants in each plot), plant height, spike length was measured. Effective tillers per meter square were counted.

Plants were harvested at maturity. Grains per spike were recorded from five randomly selected spikes from each plot. The four-meter square net plot were harvested. Grain yield was measured and adjusted to 12 percent moisture content. After proper drying, weight of thousand grains was taken.

Data analysis: The analysis of variance (ANOVA) and coefficient of variation (CV %) for traits under study were statistically analyzed using R- studio. Mean separation was analyzed using the least standard error of the difference between means and Least Significant Difference (LSD) test was done at 0.05 level of probability.

Table 1. Soil properties in the experimental field at DOAR, Lumle, Kaski, Nepal

Soil properties	Value	unit
P^H	4.8	
Soil texture	Sandy loam	
Soil Nitrogen content	0.26 – 0.45	Percentage
Soil available Phosphorus content	300	Kg/ha
Soil Available Potassium content	186	Kg/ha
Organic matter content	6.8	Percentage

RESULTS

Growing Seasons and Weather conditions: Analyzing weather data during the two growing seasons recorded at the meteorological station at DOAR, Lumle showed that mean, maximum and minimum temperatures for the first two months of growing seasons (November to December) were higher in 2019/2020 growing season except for minimum temperature in December 2020. The minimum, maximum and mean temperature in February, March, and April were higher in 2018/19 than in 2019/20 (Table. 2). The data for January looked similar for both the years.

Lumle is the region of highest rainfall in Nepal. The annual rainfall can exceed 5000 mm. In the first growing season (2018/19) there was less winter rainfall in before sowing period (October) and after sowing period (November and December) and higher rainfall during flowering phase (February) as compared to the second growing season (2019/20) (Table. 2).

Table 2. Temperature and Rainfall regimes during the experiment at DoAR, Lumle, Kaski, Nepal

Month	2018/19				2019/2020			
	Temperature (℃)			Total Rainfall (mm)	Temperature (℃)			Total Rainfall (mm)
	Max	Min	Average		Max	Min	Average	
October	20.4	11.3	15.9	50.8	20.8	12.5	16.6	245.6
November	17.7	8.5	13.1	8.0	19.3	10.4	14.8	10.0
December	14.1	4.8	9.4	0.0	14.3	4.7	9.5	55.6
January	13.9	3.8	8.9	76.9	12.7	3.9	8.3	99.0
February	15.1	5.8	10.4	141.8	14.3	5.5	9.8	55.7
March	19.1	8.2	13.7	68.1	18.6	8.1	13.3	83.7
April	20.9	12.6	16.7	232.5	20.6	10.9	15.8	305.2

Performance of barley under field conditions: Phenological traits like days to heading, days to maturity, etc. indicate the adaptability of the crop in the given environment.

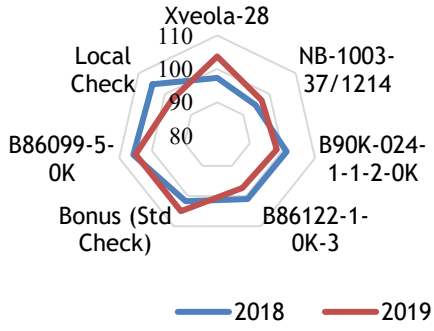

Figure 1. a. Radar diagram of days to 50% heading for genotypes in two different years

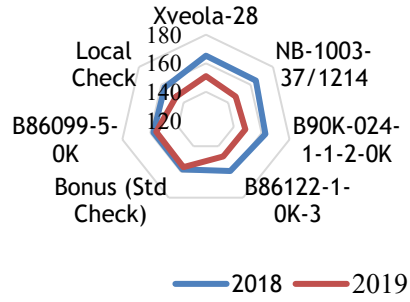

Figure 1. b. Radar diagram of days to 80% heading for genotypes in two different years

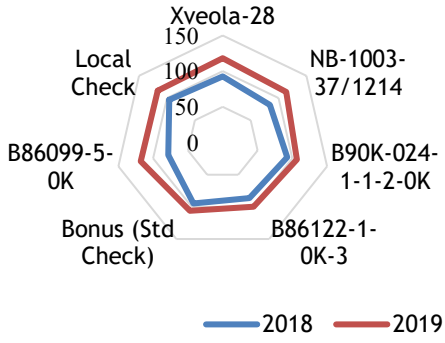

Figure 1. c. Radar diagram of plant height (cm) for genotypes in two different years

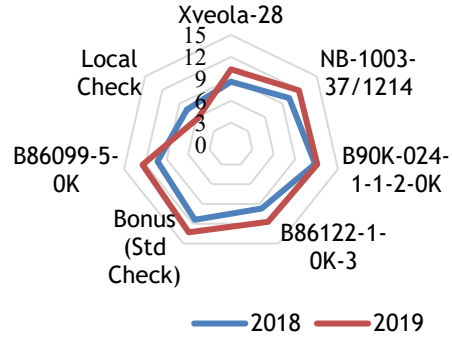

Figure 2. d. Radar diagram of spike length (cm) for genotypes in two different years

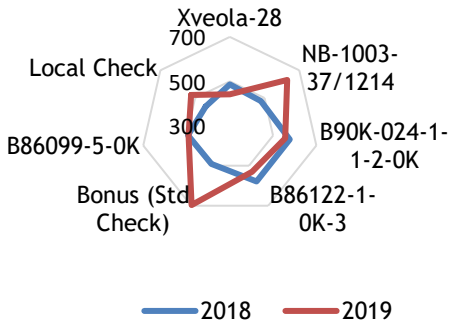

Figure 1. e. Radar diagram of effective tillers/m2 for genotypes in two different years

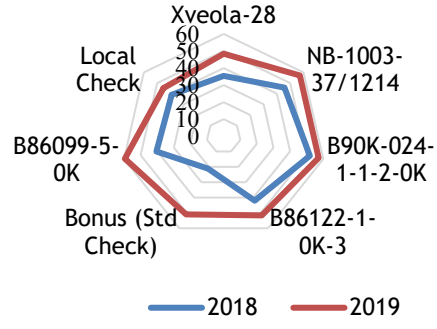

Figure 1. f. Radar diagram of grains per spike for genotypes in two different years

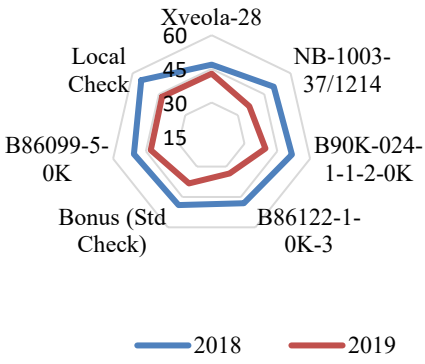

Figure 1. g. Radar diagram of effective tillers/m2 for genotypes in two different years

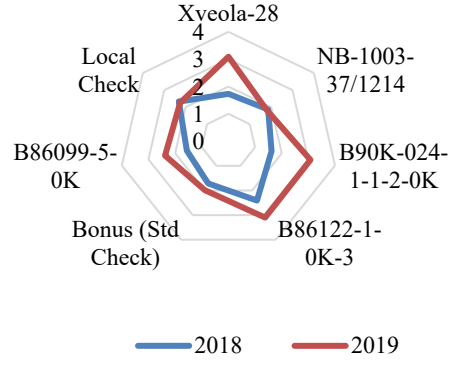

Figure 1. h. Radar diagram of grains per spike for genotypes in two different years

Some differences within the genotypes in their characteristics were observed in different years which were due to the differences in climatic conditions. The longest duration of 105 days for 50% anthesis was observed for the genotype B86122-1-0K in both the years while the genotype NB-1003037/1214 had the shortest duration of 95 days and 97 days in 2018 and 2019 respectively for 50% anthesis (figure 1. a). Some discrepancies among the

genotypes were observed for the days to 80% maturity. Xveola-28 was late (165 days) to 80% maturity for the year 2018 while local check was earliest to mature. In the following year, Bonus (standard check) was late (156 days) in attaining 80% maturity (figure 1 b). Barleys grown in the year 2019 were relatively taller than the year 2018 (figure 1 c). The radar diagram for the spike length of genotypes in two different years shows that the longest spike (11.8 cm) was observed for the genotype B90K-024-1-1-2-0K in the year 2018 while the Bonus (standard check) had longest spike (13.3 cm) in the year 2019. In both the years Local check had the shortest spike length of 7.7 cm and 5.8 cm in the corresponding years (figure 1 d).

The number of effective tillers per meter square varied distinctly over the years of trial for genotypes namely NB-1003-37/1214 and Bonus (standard check) while it was similar for other genotypes. The highest number of effective tillers per meter square (578) was observed for the genotype B86099-5-0K in the year 2018 while bonus (standard check) had the highest (696) effective tillers per meter square in the year 2019 (figure 1. e). Higher grains per spike were observed in the year 2019 than 2018 for all genotypes. The highest number of grains per spike (59) was observed for the genotype B86099-5-0K in the year 2019 while it was highest (52) for the genotype B90K-024-1-1-2-0K in the year 2018 (figure 1. f). The highest thousand grain weight of 55.1 g and 43.2 g was observed for local check in the years 2018 and 2019 respectively (figure 1. g). Radar diagram for the grain yield shows that the year 2019 was better as compared to the previous year for the genotypes Xveola-28, B90K-024-1-1-2-0K, B86122-1-0K-3, B86099-5-0K while it was similar for others. The highest grain yield of 3.09 tons per hectare was observed for Xveola-28 in the year 2019.

The ANOVA for the years combined showed the significant differences among the genotypes for days to 50% heading and days to 80% maturity (Table. 3). The genotype NB-1003-37/1214 was earliest for 50 % heading, while the local check was earliest to mature, which was statistically similar to the genotype NB-1003-37/1214. In addition, the genotype B86099-5-0K showed delayed heading, whereas the genotype Xveola-28 was the latest to attain maturity. For plant height, clear significant differences were observed among the genotypes (Table. 3). The genotype local check was significantly tallest genotype, which was statistically similar to the Xveola-28, while the genotypes B86122-1-0K-3 and B90K-024-1-1-2-0K were significantly the shortest. For spike length, local check showed a significantly shortest spike, whereas Bonus (Standard check) showed the longest spike, which was not significantly different from all the genotypes except Xveola -28.

Table 3. Combined results on effect of genotypes on phenological and growth attributes of barley

Genotypes	Days to 50% heading	Days to 80% maturity	Plant height (cm)	Spike length (cm)
Xveola-28	101	158	105	9.5
NB-1003-37/1214	96	152	99	11.1
B90K-024-1-1-2-0K	100	156	93	11.9
B86122-1-0K-3	99	154	93	10.7
Bonus (Std Check)	103	157	100	12.4
B86099-5-0K	105	157	98	11.4
Local Check	101	152	106	6.8
Mean	100.7	155.5	100.26	10.5
CV (%)	1.46	0.43	2.78	9.67
$LSD_{0.05}$	2.62	1.19	4.97	1.81
P value	< 0.001***	< 0.001***	0.001**	< 0.001***

***refers to significant at 0.01 and *** refers to significant at 0.001 level of significance*

There was no significant difference between the genotypes for effective tillers per meter square (Table. 4). The mean effective tillers per meter square were 529.50. For grains per spike, the genotype B90K-024-1-1-2-0K showed significantly the highest grains per spike, which was statistically similar to the genotypes NB-1003-37/1214 and B86099-5-0K. There was no significant difference among the genotypes for a thousand grains weight. The mean thousand grains' weight was 44.9 grams. Combined over the years, data showed significant differences for grain yield (P= 0.005) (Table. 4). B86122-1-0K-3 was the highest yielding genotype, which was statistically similar to the genotypes B90K-024-1-1-2-0K and Xveola-28.

Table 4. Combined results on effect of genotypes on yield and yield attributing traits of barley

Genotypes	Effective tillers/m^2	Grains/spike	Thousand grains weight (g)	Grain yield (t/ha)
Xveola-28	463.7	41.9	44.9	2.411
NB-1003-37/1214	554.7	51.5	43.5	1.834
B90K-024-1-1-2-0K	566.5	54.5	45.7	2.350
B86122-1-0K-3	554.7	46.8	40.7	2.756
Bonus (Std Check)	594.0	36.0	43.7	1.852
B86099-5-0K	492.0	50.0	46.7	1.969
Local Check	480.7	42.1	49.2	2.288

Mean	529.5	46.1	44.9	2.209
CV (%)	15.97	8.32	9.00	11.02
LSD $_{0.05}$	150.57	6.83	7.19	0.43
P value	0.446	< 0.001***	0.320	0.005**

***refers to significant at 0.01 and *** refers to significant at 0.001 level of significance*

DISCUSSION

Theevaluation of agro-morphological, phenological and yield attributing traits of the genotypes has a direct relevance to farmers and the breeders (Gupta, Upadhyay, & Shah, 2014). There is necessity of testing these genotypes at different locations and different year for stability and adaptability studies because such studies are useful in recommending and releasing a genotype for cultivation in wide as well as specific environment. The variations in the traits like days to heading, days to maturity, plant height, spike length, effective tillers per meter square, and grain yield; within the genotype over the years could be due to the change in environmental factors (Figure 1). A good soil moisture content during sowing time and vegetative growth stage of the crop in second growing season (2019/20) might have led to better crop emergence, better nutrition use efficiency and better growth leading to higher plant height (Figure 1. c) as compared to first season (2018/2019) (Table. 2). The flowering phase was accompanied by higher rainfall in the first season (Table. 2) which might have affected pollination leading to lesser grains per spike in the first growing season (Figure 1. f.). The plant height was positively correlated to yield attributing characters in barley (Amgai, Pantha, Chettri, & Budhathoki, 2013). The higher plant height in second growing season (Figure 1. c.) might have contributed to the greater yield (Figure 1. h.)

The significant variation among genotypes in phenological and yield attributing traits like days to heading, days to maturity, plant height, spike length and grains per spike led to significant variation in grain yield. These results are in accordance to findings of Dhami *et al.,* (2017). The similar findings were reported for the genotypes under study in Coordinated Varietal Trial in RARS, Lumle in 2015/16 (Annual Report 205/16). These genotypes can perform differentially at different locations due to differences in microclimate and genotypes and environmental interaction. The genotypes Xveola-28, B86122-1-0K-3, and B90K-024-1-1-2-0K were better yielding genotypes as compared to the Bonus (standard check) and local check. They should be tested further in same location and other research areas from yield perspective.

CONCLUSION

The present study analyzed the performance of the barley genotypes in the climatic condition of Lumle, Kaski. The variability shown by the same genotypes in phenological and yield attributing traits in different year is the expression of temporal variability of climate. The result indicates possibility of these genotypes for cultivation in the western mid-hills of Nepal with similar altitude and climatic conditions. The higher yielding genotypes viz. Xveola-28, B86122-1-0K-3, and B90K-024-1-1-2-0K should be utilized for on farm and on station trial so that they can be released or registered for enhancing the barely production in Nepal.

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SPECIALTY RICE VARIETIES AND LANDRACES

S.S.Karkee[1]

ABSTRACTS

Rice is a staple food for half of the world's population and is the major source of calories for the people of rice-growing countries. Nowadays, nutritionists are more concerned about hidden hunger as people with sufficient food intake may be deprived of important nutrients that may be absent in the food they consume. Similarly, white rice (polished rice) that only contains endosperm is lacking several essential nutrients like Fe, Zn, fiber, and antioxidant compounds, etc. To increase the nutritive content of these rice and minimize the problem of hidden hunger, different rice varieties are being tested with artificial addition of nutrients, such varieties are called biofortified rice. Special rice like black, purple, brown rice, contain natural antioxidant compounds in their outer bran layer, aromatic rice is rice in aroma, glutinous rice is popular for their sticky and sweet test. At the same time these special rice are also rich in several micronutrients. In addition to nutrition content, people's taste preferences are also considered a major concern. This review paper focused on specialty rice varieties and landraces along with their unique values.

Keywords: Aromatic rice, Biofortified rice, Pigmented rice, Starchy rice

INTRODUCTION

Rice is staple food and more than 2 billion people obtain 60-70% of the daily calorie intake from rice in Asia only. The grains of rice are being consumed in its milled form or white rice by approximately half of the population of the world (Puri *et.al,* 2014). People preferences towards white rice due to easy cooking, palatability, longer storage and fancy appearance (Upadhyay and Karn, 2018). Before consumption these rice under goes processing steps like hulling and polishing results removal of outer layers of husk, bran, and embryo i.e., only the endosperm region is left (Roy *et al.,* 2011) in contrast. This layer of rice is important as it contains various important elements and compounds like Fe, Zn, thiamine, niacin, Flavonoids, melatonin, phenolic, vitamins, minerals, etc. that are essential for human health.

There are several landrace cultivars of rice which are naturally rich in nutrients and qualities like aroma, taste, etc. that might be absent in modern rice cultivars (Berni *et al.*, 2018). More than 276 secondary metabolites from rice have been identified that mainly include phenolic acids, flavonoids, terpenoids, steroids, alkaloids, and their derivatives. These metabolites exhibit various kinds of biological activities such as antimicrobial, antioxidant, cytotoxic, and anti-inflammatory properties (Wang *et al.,* 2018).

1 Agriculture and Forestry University, Email:surazkarkee23@gmail.com

In recent year attraction towards these rice landraces is growing due to their quality content and health benefits as their consumption has been linked to lowering the risk of diseases related to oxidative stress i.e. inhibitory effects on carcinogenesis and

Mutagenesis (Setyaningsih *et al.,* 2015). These are non-other than pigmented rice, glutinous rice, long grain rice, and scented/aromatic rice. These rice cultivars have been growing form centuries and have nutritional, cultural, and medicinal importance. The products from these cultivars have also become more widely appreciated in the current global market.

White rice (polished rice) lacks several micronutrients that cause a serious problem like hidden hunger in rice eating countries due to unbalance diet intake (Maclean *et al.,* 2002). Though landrace cultivars had potential to solve hidden hunger but their low productivity they are not preferred by farmers (Mau *et al.,* 2017). To address this nutrient demand and food demand agriculture and food scientists are focusing on increasing the production of nutritive rice that contains essential nutrients in their endosperm and are high yielding. For this they are adopting technologies as biofortification that involves enriching the modern high yielding rice with nutrients like Fe, Zn, Vitamin A, etc. Similarly, food scientists are also focused on adding antioxidant compounds in transgenic rice and antioxidant-rich rice plants have been successfully generated viz. purple rice (Zhu, 2017).

Table 1. Effect of processing on nutrient content of rice (Abbas *et al.,* 2011).

S.N.	Extraction Rate %	100 Rough	82 Brown rice	72 Milling rice
	Mineral content			
1.	Calcium (mg/g)	0.3	0.1	0.1
2.	Phosphorus (mg/g)	3.1	3.2	1.5
3.	Zinc (ppm)	2.4	3.3	18.0
4.	Iron (ppm)	38.0	8.8	4.1
5.	Copper (ppm)	2.8	2.7	2.2
	Vitamin Content			
6.	Thiamine (µg/g)	2.8	2.4	1.6
7.	Riboflavin (µg/g)	0.5	0.3	0.2
8.	Niacin (µg/g)	29.6	29.0	6.0
9.	Pyridoxine (µg/g)	5.1	5.1	1.9
10.	Biotin (µg/g)	91.0	48.0	43.0

OBJECTIVES

The objective of this paper is to review about different specialty rice cultivars including landraces that were handed by our ancestors and modern nutritive rice developed by adopting different breeding techniques. In addition, it also includes unique feature that makes these cultivars different from others.

METHODS AND MATERIALS

A number of research and reviewed articles related to White or polished rice, specialty rice cultivars and landrace have been reviewed to prepare this paper. Basically, Google Scholars, Google book, and Research gate, are main search engine to extract related articles.

CLASSIFICATION OF SPECIALTY RICE CULTIVARS (VARIETIES AND LANDRACES)

The classification is based on their special feature and the specialty content is natural or artificially induced through different breeding techniques.

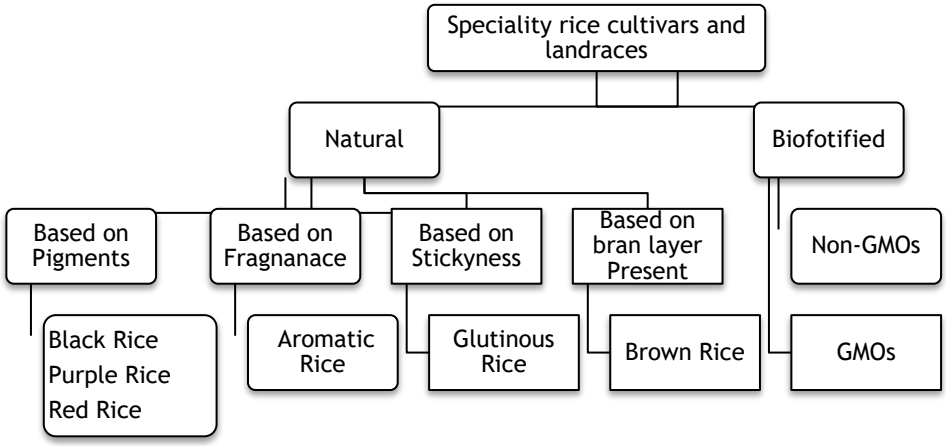

Fig 1: Classification of Special Rice cultivars and landraces on different basis

Table 2: Different specialty rice landraces and varieties with their examples (Joshi, 2017; Majumder *et. al.,* 2019)

S.N.	Basis	Special Rice cultivar	Speciality	Examples
1.	Based on color	Black rice	Pigment on bran layer	Kalo dhan
		Purple rice		
		Red rice		Wild rice
2.	Based on waxyness	Glutinous rice	Stickness	Anadi, Jumli marshi, Taichung-176, Chiure, Karange
3.	Based on fragrance	Aromatic rice		Kalomuniya, Jethobudho, Basmati Lalka Basmati, Motisar, Sali Dhan, Anadi Basnadhar Pahenle, Sunalo Sugandha

4.	Based on milling	Brown rice	Consists of bran layer	Dehusked rice (rice obtained from dhikki)
		White rice	Absent of bran layer	Milled (rice absent of bran and embryo layer)
5.	Based on fotification	Zn-Biofortifed rice	Higher Zn content	BRRI Dhan-62
		Fe-Biofortified rice	Higher Fe content	IR68144 rice
		VitA-Biofortified rice	High Vitamin A content	Golden rice

AROMATIC RICE

Aromatic or scented rice is a special group of rice recognized for their fragrance. Aroma or fragrance is one of the major qualities preferred among different other rice qualities like taste, color, nutrient, etc. Because of their aroma, flavor, and texture, aromatic varieties get a higher price in the market than do the non-aromatic rice varieties (Singh *et al.,* 2000).

Aromatic rice is native of the Indian subcontinent. Cultivation of aromatic rice is traditionally practices in the foothills of Himalayas in the Indian states of Uttar Pradesh (UP) and Bihar, and Terai region of Nepal (Singh *et al.,* 2000). The aromatic rice is mainly grown and consumed in India, Nepal, Pakistan, Thailand, Bangladesh, Afghanistan, Indonesia, Iran, and United States. Among these countries India, Pakistan, and Thailand export fine grain aromatic rice mostly to the Middle East, Europe, and USA with the annual export worth millions of dollars (Singh, 2000). It is estimated that there are over 300 aromatic rice varieties that are recognized, although the utilization and production of these varieties are limited. The popular aromatic rice of the world are Basmati rice of India, Nepal and Pakistan, Dulhabhog of Bangladesh, Khalo Dawk Mali and Leuang Hawn of Thailand, Azucena and Milfor of the Philippines, Rojolele of Indonesia, Sadri varieties of Iran, Barah of Afganistan, and Della of United States (Singh *et al.,* 2000)

The fragrance of aromatic rice is due to the presence of volatile compounds. There is no individual compound which imparts a pleasant odor to raw or cooked aromatic rice. Probably it is a blend of various volatiles and more than 114 compounds were recognized which imparts pleasant odor in aromatic rice. Among all these volatile compounds, 2-acetyl-1-pyrroline (2AP) is recognized as an important compound contributing to the aromatic odor (Buttery *et al.,* 1982). The pleasant aroma from aromatic rice is not only

associated with cooked rice, some varieties emit aroma in the field from the flowering time. They release aroma from leaves, grains, and other parts. Chewing of immature grains is one of the popular methods for the rapid identification of aromatic rice varieties. Mittal *et al.*, (1995) reveled that aroma can be determined form leaves of a crop.

PIGMENTED RICE

Pigmented rice is those varieties and landraces in which the outer bran and aleurone layer contain the accumulated different pigmented substances. Pigments are phenolic compounds that give rice grain natural color ranging from brown to red (proanthocyanidins) or from purple to black (anthocyanins) (Deng *et al.,* 2013). It is reported that a wide range of phenolic compounds including anthocyanins, proanthocyanidins, 4-hydroxycinnamic acid, 4,7-dihydroxyvanilliv acid, syringaldehyde, vanillin, the group of p-coumaric, ferulic, sinapinic acids, etc. are found in pigmented rice (Deng *et al.*, 2013). Low molecular weight phenolic are found in grains with light brown pericarp color whereas grains with red and black pericarp color contain higher molecular weight phenolics (Goffman and Bergman, 2004).

Several researches reported the health benefit of pigmented rice and its bran phytochemicals that include anti-inflammatory, antioxidant, anticancer, and anti-aging activities etc. Phenolic compounds like tocopherol and anthocyanin extracted from pigmented rice are efficient neutralizers of reactive oxygen species (Krishnanunni *et al.,* 2014). Anti-diabetes activity inhibits the activity endogenous α-amylose and α-glucosidase, thereby inhibiting the conversion of starch to glucose in the small intestine which acts as a source of resistant starch to be utilized by gut microbiota in the colon (Boue *et al.,* 2016). A bioactive compound from pigmented rice acts as an anti-cancer by reducing the viability of cancer cells, anti-mutagens, blocking the carcinogenetic cytochromes (Baek *et al.,* 2015; Insuan *et al.,* 2017). Depending upon the pigment present, pigmented (colored) rice are classified as red rice, purple rice, and black rice (Limtrakul *et al.,* 2019).

1.1. Black rice

These are pigmented rice with pericarp or kernel deep purple or black in color (Karkee *et al.,* 2019). The color of this rice is due to the accumulation of anthocyanin in a different layer of the pericarp, seed coat, and aleuronic region (Chaudhary, 2003). The origin of black rice takes place in tropical Japonica and genes attributing blackness subsequent spread to the indica subspecies (Kushwaha, 2016). This rice has a long and glorious history as it is recognized as forbidden rice, heaven rice, imperial rice, king's rice, and prized rice since the high-class family was only allowed to consume the rice. The rice worked as a treasure as it protects from aging, had nutritional importance and used in ancient medicines.

There are more than 200 types of black rice varieties globally. Only China is responsible for 62 % of the global production of black rice and it has developed more than 54 modern black rice varieties with high yield characteristics and multiple disease resistances (Kushwaha, 2016). These rice cultivars are assumed as a panacea of many culinary diseases because of its high nutritive value and curative effect. This rice is supposed to enhance the longevity of life; hence it is also known as long life rice (Bolea *et al.*, 2019). The outer pericarp or aleuronic layer of rice contains pigments like proanthocyanin, and anthocyanin. These compounds have several health benefits like antioxidant properties. Anthocyanin helps to minimize the toxic effect of free radicles (Khoo *et al.,* 2017). Despite of antioxidant property the rice contains nutrients like Fe, Zn, Cu, Fiber, and several other beneficial nutrients which are lacking in normal rice. Daily consumption of this rice protects people from the disease like diabetes, obesity, cancer, and constipation etc.

1.2. Purple rice

Purple rice is pigmented glutinous rice with characteristic purple pigment in the pericarp and husk. Pigmentation of the grain in pericarp and husk is due to deposition of huge amount of the anthocyanin, phenolic acids, and flavonoids. Concentrated amount of these compounds in different layer of grain makes rice purple to black in color (Pusadee, *et al.,* 2019). This glutinous rice is native to Thailand. In Thailand, purple rice is called "BKao Kum" or "BKao Niaw Dam" where "Kum" means purple, "Dam" means black, "Kao" means rice, and "Neow" means glutinous grain type. This rice is culturally important germplasm in Asia with a long history of cultivation in China, India and Thailand (Kong *et al.,* 2008). It is grown in China, Japan, Korea, Sri Lanka, India, Bangladesh, Thailand, Laos, Philippines, and Indonesia (Sukhonthara *et al.,* 2009).

1.3. Red rice

These are weedy rice with red colored bran layer. These are termed as weed as they appear voluntarily in rice field. Red rice is colored rice with red colored bran layer. The coloration of bran is due to proanthocyanidin pigments (Wirjahardja *et al.,* 1983). These includes polyphenols and anthocyanin, and possesses antioxidant properties. The red rice are a richer source of protein, zinc and iron than white rice (FAO, 2004). It is usually eaten unhulled or partially hulled. Rice has a nutty flavor. Compared to polished rice, it has the highest nutritional value (Table 3). The importance of this rice is mentioned in Hindu religious books Agni, Vishnu and Garuda Purana as it delays thirsty, arrests perspiration and highly restorative. In different part of India rice is consumed to cure blood pressure and fever, intake by women during lactation, used for treating leucorrhea and abortion complication, preferred for coolness and a tonic (Saxena, 2014). The red rice

yeast (prepared by fermenting yeast *Monascus purpurea* over red rice) is a popular cholesterol-lowering product over the world (Chaudhary and Tran, 2001).

Red rice can be found in different agro ecology as weeds of rice. These rice shows intermediate characteristics between wild and cultivated rice (Chen, 2001). Despite of nutrient rich the rice has great potential value as it can adapt extreme natural and versatile environment conditions and can be used as genetic material for developing new varieties in future. (Nadir, *et al.,* 2017).

Table 3: Nutrient content of red rice and white polished rice

S.N.	Parameters	White Rice	Red Rice
1.	Nutritional Parameters		
2.	Mositure content (g/100 gram)	12.75±0.15	12.7±0.13
3.	Crude Fat content (g/100 gram)	0.62±0.015	1.81±0.011
4.	Crude Fibre content (g/100 gram)	0.23±0.02	2.71±0.1
5.	Crude protein content (g/100 gram)	7.6±0.23	10.49±0.43
6.	Total Ash content (g/100 gram)	0.46±0.04	1.53±0.01
7.	Carbohydrate content (kcal/100 gram)	78.34±1.5	70.19±1.0
8.	Energy content (kcal/100 gram)	349.34±2.5	341±1.2
	Minerals and Antioxident properties		
9.	Calcium content (mg/100 gram)	7.94±0.17	8.71±0.65
10.	Iron content (mg/100 gram)	7.65±0.22	13.45±0.60
11.	Magnesium content (mg/100 gram)	46.45±0.649	192.27±5.98
12.	Zinc content (mg/100 gram)	1.49±0.039	1.91±0.036
13.	Total flavonoids content(mg/100 gm of flavonoids)	166.23±0.25	120.0 ±0.38
14.	Total phenolic content (mg GAE/100g of phenol)	24.26±1.05	143.38 ±1.5

(Source: Raghuvanshi, *et al.* 2017)

1.4. Brown

Brown rice is either un-hulled or partially hulled type of rice. It is whole grain rice which means the bran layer remains intact with grain after removal of the outer hull (Hasen *et al.,* 2012). This rice is different from usual white rice due to the presence of bran layer (Priya *et al.,* 2019). During the milling process, first of all the husk from the whole rice grain or paddy is removed to obtain the whole brown rice grain that contains the outer bran layer with commonly brown or reddish-brown color. After removal of the outer bran layer, the polished or white rice is obtained (Janet *et al.,* 2002). The bran layer consists of pericarp, aleurone, sub-aleurone layer, and germ which

contain large amounts of nutrients and bioactive compounds (Table 4 and 5) and are known to have various beneficial properties (Juliano, 1993; Janet *et al.*, 2002).

The characteristics reddish brown or dark brown color of the bran layer of brown rice is due to the deposition of pigments like proanthocyanidins, vitamins, fibers, and minerals. (Pengkumsri, *et al.*, 2015). It can be consumed as an alternative to white rice as white rice has a high glycemic index and may result in high oxidative stress and other health risks (Saleh *et al.*, 2019). Recently studies have shown that white rice increases the risk of type 2 diabetes. Consumption of brown rice lowers insulin and glycemic indices and may confer other health benefits (Setyaningsih *et al.*, 2015). Similarly, consumption of germinating brown rice may improve texture, palatability, and the amount of the bioactive molecules. Patil& Khan (2011) reported that germinated brown rice have glucose and cholesterol lowering properties. Consumption of this brown rice product instead of white rice would provide enormous benefits since it will not have the same health risks as white rice but rather will promote health and reduce disease burden.

Table 4: Nutritional profile of different rice varieties in per 100 g serving

S.N.	Parameters	Black rice	Brown rice	Red rice	White rice
1.	Carbohydrate (g)	34 ± 0.05	24 ± 0.07	23 ± 0.04	28 ± 0.03
2.	Protein (g)	8.5 ± 0.5	7.9 ± 0.07	7 ± 0.05	2.7 ± 0.04
3.	Fat (g)	2 ± 0.06	0.8 ± 0.02 1	0.8 ± 0.01	4 0.3 ± 0.01
4.	Tocopherol (mg)	12.54 ± 0.34	2.2 ± 0.76	10.77 ± 0.24	0.1 ± 0.14
5.	Thiamin (B1) (mg)	0.46 ± 0.032	0.54 ± 0.07	0.33 ± 0.15	0.7 ± 0.06
6.	Riboflavin (B2) (mg)	0.403 ± 0.04	0.1 ± 0.2	0.105 ± 0.03	0.03 ± 0.33

(Source: Kumar and Murali, 2020)

Table 5: Nutrient contents of rice varieties

Type of Rice	Protein (g/100g)	Iron (mg/100g)	Zinc (mg/100g)	Fiber (g/100g)
White(policed) rice	6.8	1.2	0.5	0.6
Brown rice	7.9	2.2	0.5	2.8
Red rice	7.0	5.5	3.3	2.0
Purple rice	8.3	3.9	2.2	1.4
Black rice	8.5	3.5	--	4.9

Source: Food and Nutrition Division, FAO (2004)

1. Glutinous rice

Glutinous rice (*Oryza sativa var. glutinosa)* has sticky characteristics when cooked. Due to stickiness, the rice is also named as sticky or waxy rice. They may be both pigmented/non pigmented. After cooking, the rice gives a sweet taste and also called sweet rice (Noomhorm *et al.,* 1997). Lao People's Democratic Republic (Lao PDR) has been recognized as a center for glutinous rice biodiversity. About 2,470 germplasm or about one-fifth of the world germplasm was found in Loas PDR (Bestari, 2006). China is the largest in both production and consumption of glutinous rice. Glutinous rice shares about 3% of the world's milled rice production (USDA, 2018).

The waxy or stickiness in rice cultivar is characterized chiefly by a lack of amylose in the starch (Bean *et al.*, 1984). Natural starch contains two polymers; amylose (10-30%) and amylopectin (70-90%) (Taghvaei *et al.*, 2010)). Non-glutinous rice contains both molecules that makeup starch: amylopectin and amylose (Panesar and Kaur, 2016). Glutinous differs from the regular (non-glutinous) rice mainly in having low (<5%) or almost no amylose in its starch but basically high in amylopectin (Setyaningsih *et al.*, 2015). Amylose is essentially long chains composed of (1-4)-linked α-D-glycopyranosyl units with few (1-6)- α-linkages branches while as amylopectin has a higher molecular weight and much shorter chains of (1-4)-linked α-D-glucose units that are highly branched through additional (1-6)- α-linkages branches (Bertoft, 2017).In general, the amylose content of rice starch varies from (0-2%), very low (3-9%), low (10-19%), intermediate (20-25%) and high (>25%) (Kumar and Khush, 1986).It has been reported that many native varieties of glutinous rice have high nutrient content such as vitamin E, antioxidant, protein, beta carotene, and folate (Ratcha and Kongkachiuchai, 2013). Despite of health importance, it has been used in preparing many kinds of Asian traditional desserts and used in making rice wine, sushi, rice balls, and cakes

3. Bio-fortified rice

According to the WHO, is the process of nutritionally enhancing food crops through agronomic practices such as managing crops to promote soil and water conservation, conventional plant breeding and modern biotechnology, which can include GMO. Biofortification is similar with fortification as both of them increase the nutritional quality of the food. The major difference between them is that bio-fortification focuses on improving the nutritional content of the food during plant growth while fortification is done manually during processing of the crops. It refers to increasing genetically the bio-available mineral content of food crops by increasing the concentration of nutrients, promoter compounds, and a decrease in anti-nutrient substances (Brinch-Pederson *et al.,* 2007).

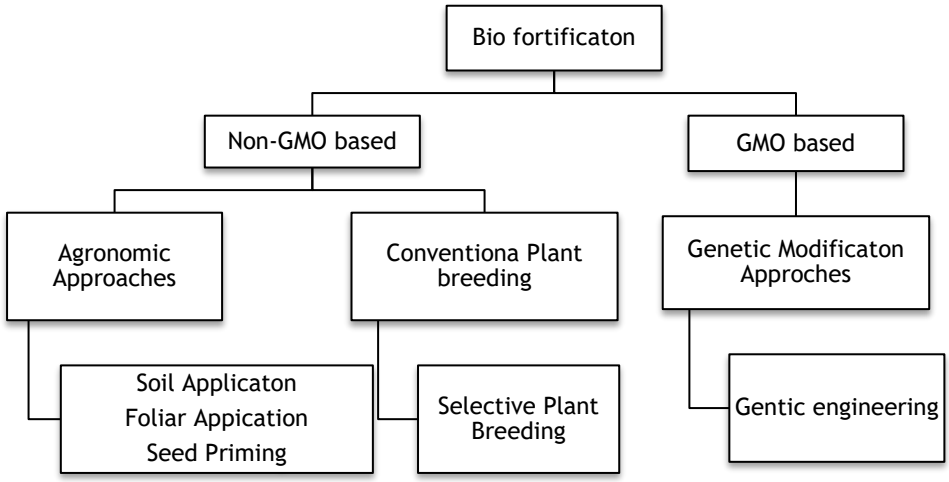

Figure 2: Different approaches of Biofortification

3.1. Biofortification through agronomic practices

This approach involves the application of minerals containing micronutrients to the plant rhizosphere, foliar application and soil inoculation with beneficial microorganism. This increase the Phyto availability of minerals in soil which is often low and gets uptake by plants and translocate to the grains and other parts. Mineral fertilization method is applicable when micro nutrients have good mobility in soil and is such as Se, I and Z but not in for Fe as it has low mobility. Prom-u-thai *et al.*, (2020), found significant higher content of Zn, I and Se in rice grains when cocktail containing Zn, I, Fe were applied as foliar spray in brown rice grain grown under wide range of environment.

3.2. Biofortification through conventional plant breeding

This is the method of enriching food crops through selective breeding. Plant breeders search seed or germplasm bank for existing varieties of crops which are naturally high in nutrients. These high-nutrient varieties are crossed with high yielding varieties of crop, to develop a progeny with high yield along with increased nutrient value.

i. Fe biofortified rice

IR68144 rice Fe biofortified rice which is developed via plant breeding by crossing between IR8 and Taichung (Native)-1 (Virmani and Ilyas-Ahmed, 2008). This rice is high in iron content and able to produce 21 µg/g (2-fold) of iron concentration in brown rice.

ii. Zn biofortified rice

BRRI Dhan-62 was the world's first Zinc fortified rice which was developed using conventional breeding methods Similarly, IET 23832 or DRR Dhan 45, the high zinc rice of India contains 22.6–24.00 ppm in polished grain.

3.3. Biofortification through genetic modification

It is an alternative approach applicable when desirable trait for enriching nutrient is not available naturally in the existing germplasm and mean while modifications cannot be achieved by adopting conventional breeding. This method is open to utilize genes from different source like plants, bacteria and other microorganisms.

i. Iron Biofortified rice

Enhanced uptake of iron, increase translocation to grain, specialization of Fe storage toward endosperm, decrease of anti-nutrition, an increase of bioavailability of iron are major steps that can be addressed for efficient and targeted genetic biofortification in rice (Mulualem, 2015). To address among these steps some of the popular approaches for facilitating iron biofortification in rice crop through molecular breeding are mentioned as:

Table 6: Different method for iron bio-fortification in rice (Majumder *et al.*, 2019).

S.N.	Biofortification strategies	Increase quantity of iron after bio fortification (brown rice)	Increase quantity of iron after bio fortification (polished rice)
1.	Improving iron storage via ferritin	1.5-2.2- fold	2.0-3.7-fold
2.	Chelation based strategy (via NAS gene)		2.3-4.0-fold
3.	Enhancing iron influx (via OsYSL2 gene)		4.4- fold
4.	Enhancing iron uptake and translocation (via IDS3 gene)	1.3- fold	1.4—fold
5.	Enhancing iron uptake and translocation (silencing OsVITs genes)	1.4- fold	1.8- fold
6.	Manipulation of iron uptakes and translocation regulatiors	2.0-3.8-fold	2.9- fold
7.	Low phytate rice(RNAi silencing of phytic acid)		1.3-1.8- fold
8.	Release of phytic acid bound iron (by phytase gene)	2.0- fold	2.0-6.3- fold
9.	Multiple transgenes combination	6.0- fold	3.4-6.0—fold

ii. Zinc biofortified rice

The molecular breeding strategies involved in zinc biofortification are similar to that of iron biofortification. Furthermore, the uptake and homeostasis of zinc and iron are closely linked in cereals. Different approaches for zinc biofortification via genetic manipulation are Overexpression of OsIRT and MxIRT genes in GM rice resulted in increased iron and zinc concentration in rice grains (Majumder, 2019). Similarly, Overexpression of NAS genes makes nicotianamine an interesting target for Zn biofortification. Moreover, biofortifying cereals with NAS alone or in combination with ferritin Over-expression of NA synthase (NAS) by introducing 35S enhancer elements led to 2–3-fold increases in Zn content in paddy (Zheng, *et.al,* 2010).

iii. Golden rice

Golden rice is a variety of rice produced through genetic engineering to biosynthesize beta carotene (Rawat *et.al*, 2013). This rice differs from normal rice as it contains extra genes that were introduced through genetic modification. The rice was invented with the objective to supply Vitamin A to the rice consuming population (Dubock, 2014). In 1999, this rice was invented by Professor Ingo Potrykus of the Institute for Plant Science, Swiss Federal Institute of Technology, Zurich, Switzerland, and Dr. Peter Beyer of the Centre for Applied Biosciences, University of Freiburg, Germany.

Golden rice is genetically modified that contains a high level of beta-carotene and other carotenoids. These are the precursors of vitamin A, beta-carotene change into vitamin A as enters in the body (Tang *et al*., 2009). It was developed using r-recombinant technology. The technology of biofortification of rice involved the introduction of three genes in rice through *Agrobacterium tumefaciens* viz. two genes from daffodil *Narcissus pseudonarcissus* (phytoene synthase and lycopene beta-cyclase) and one gene from a bacterium *Erwini auredovora* (carotene desaturase) (Beyer et.al., 2002). Golden rice can be beneficial because it serves as a source of supplementary vitamin A and ß-carotene. It can prevent Vitamin A deficiencies that cause blindness, premature death, and xerophthalmia (thickening on conjunctive) (Dubock 2014). ß-carotene is an antioxidant, therefore it helps to protect the body from harmful free-radicles (Grune *et al.,* 2010).

Golden rice provides 1.6-2.0µg ß-carotene/g of dry rice which is not enough to fulfill the recommended daily requirement of vitamin A (Ye *et al.,* 2000.). Similarly, young children are the most vulnerable to vitamin A deficiency, but they do not consume solid food (Hessler *et.al,* 2010). It is believed that as rice contains extraneous genes, it may increase toxicity, decreased nutritional value, gene transfer, and allege city (Zhang, 2016). So, from the above predictions and believes the rice might require further study and research.

CONCLUSION

Along with grain yield and nutrition, quality has also become a primary consideration in rice eating countries. White rice is deficit in several minerals, vitamins, and sometimes becomes unfit for consumption to the patient like diabetics. Consumption of some healthy natural rice like black/purple rice, brown/red rice, and glutinous rice can overcome or minimize this limitation of white rice. Mixing aromatic rice in white rice increases the palatability, fragrance of rice. These landrace cultivars have immense potential to manage the problem of nutrient deficit in rice eating countries but due to their low yielding character, rough texture and poor palatability they are being left behind. To address this limitation of specialty rice landraces there is need of improving the grain yielding character,

palatability and texture. Post-harvest processing also determines retention of important micronutrient, fiber and secondary metabolites in rice therefore minimizing the process make rice nutritive as brown rice. The nutritional quality of white/policed rice can be enhanced by the adoption of technology i.e. bio-fortification that includes Agronomic practices, conventional breeding methods and modern genetic engineering. Nutritive rice from conventional breeding methods and agronomic methods has have more scope and wider acceptance as they are away from the controversies of GMO crops. Landraces are valuable source of genetic variation for improvement of rice in future that will create a new avenue for nutritional diversification in rice at lower cost.

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AN OVERVIEW OF CHEMICAL PESTICIDE IMPORT IN NEPAL

D. Khanal[1*], S. K. Neupane[2], S.Poudel[3] and M. Shrestha[4]

ABSTRACT

In 2021, this study has attempted to analyze the trend of pesticide importover two decades in Nepal. Secondary data obtained from Plant Quarantine and Pesticide Management Center were analyzed to know the pesticide import trend. The result showed that the import of pesticides was in increasing trend and the average annual increase in import was 30.48 tons (a.i.) over the last twenty-two years. Fungicide had the highest import followed by insecticide, herbicide and these three groups comprised more than 90% of the pesticide import. The importof insecticide, fungicide, herbicide, organophosphate, mix group pesticide was in increasing trend while that of rodenticide, bactericide was in decreasing trend. The import of synthetic pyrethroid, carbamates, and some new groups like nicotinoids had been increasing in recent years. Although the import of chemical pesticides was increasing in huge amount; import of biopesticide also seems to be in increasing trend. The use of pesticide is still low in Nepal as compared to the global average or other countries however, the effects of its use are greater and hazardous which indicates the need for strong policy implementation for the safe import and use of pesticides.

Keywords: Banned-pesticides, hazardous, import, pesticide, trend

INTRODUCTION

Pesticides are substances used by human beings to kill or deter the organisms that threaten our health and wellbeing of pets and livestock or cause damage to crops (Giliomee, 2009). These are any substance or mixture of substances that prevents, destroys or controls any pests, including disease vectors, unwanted plant or animal species, causing harm during production, processing, storage, transport or marketing of food, agricultural commodities, animal feedstuffs or substances that may be administered to animals for the control of insects, arachnids or other pests in or on their bodies (FAO, 1990).

Up until the 1940s inorganic substances such as sodium chlorate, Paris green, lead arsenate, calcium arsenate, ethylene dibromide, or organic chemicals derived from natural sources were widely used in pest control worldwide (EPD, 2004; Sanchez, 2019). The growth in synthetic pesticides accelerated in

1 Institute of Agriculture and Animal Sciences, Paklihawa

* Corresponding auther's Email : dipakbabu@hotmail.com

2 Ministry of Agriculture and Livestock Development, Singhadurbar, Kathmandu

3 Institute of Agriculture and Animal Sciences, Paklihawa

4 Institute of Agriculture and Animal Sciences, Paklihawa

the 1940s with the discovery of the effects of DDT, BHC, aldrin, dieldrin, endrin, chlordane, parathion, captan, and 2,4-D. In the 1950s organophosphates and carbamates were introduced followed by synthetic pyrethroids in the 1970s (Arora, 2018). Throughout most of the 1950s, consumers and most policymakers were not overly concerned about the potential health risks of using pesticides. About two million tons of pesticides were used globally among which 45 % was consumed in Europe followed by 24 % in the USA and the remaining 25 % in the rest of the world (Abhilash and Singh, 2009). In Nepal, during the 1950s DDT was introduced for the malaria eradication program. Later on, other pesticides like Paris green, gramoxone, and nicotine sulfates were imported for the same purposes from the USA (Dahal, 1995). Gradually after some year's organophosphates, organochlorines and carbamates were introduced. To make use of pesticides, various acts were taken into enforcement that includes Pesticide Act 1991, Pesticide Regulation 1994, and enforced from 1994 July 16 (Adhikari, 2008). The Pesticide Management Act 2019 has been enacted to regulate the production, formulation, export, import, storage, sale and purchase, transportation, use and disposal of pesticides to minimize the negative effects to human, animal health and the environment (NPPO, 2020). At present, there are 253 licensed owned pesticide importers, 5 formulators, and 14,849 sellers through agro-vets in Nepal. 3,037 and 172 types of pesticide by trade name and common name respectively have been registered for use while 24 pesticides have been banned under the Pesticide Management Act 2019 till now (AITC, 2021).

METHODOLOGY

The study was based on time series secondary data for twenty-two years that were obtained from Plant Quarantine and Pesticide Management Centre, Lalitpur. It also includes reviews of different journal articles and other kinds of literature. Data were assembled and different line graphs and column graphs were generated.

RESULTS AND DISCUSSION

TOTAL PESTICIDE IMPORTIN NEPAL

Most pesticides used in Nepal are imported from India, some from China and other countries (Winrock International, cited in Kalauni and Joshi, 2019). In comparison to other countries in Asia Pacific Region, the use of chemical pesticides in Nepal is one of the lowest i.e., 0.396 kg (a.i)/ha (PPD, 2014). Pesticide use, however, is higher in vegetable and fruit production and areas having greater access to markets (Jasmine *et al.*, 2008; Sharma, 2014). Also, the survey conducted by the Department of Food Technology and Quality Control indicated that Nepalese people are at alarming threat of pesticides in their diets (Koirala *et al.*, 2009). Pesticide is imported in two forms

formulated or non-formulated. The import quantity in this article indicates total import. The trend line shows an increasing trend of pesticide import with an average annual increase of 30.48 tons (a.i.) over the last twenty-two years as shown in Figure 1. According to the latest estimate in the fiscal year 2018/19, the annual import of pesticide is 809092.9 kg (a.i.) worth of NRs. 95,89,71,910 (US$ 8093956.03) which is increased from 56172 kg (a.i.) in 1997/98, i.e., 14 folds increase in 22 years. One of the reasons behind this may be an increase in vegetable cultivated area by more than 100000 ha in the last eighteen years (AITC, 2021; Gurung *et al*., 2016) as 90% of pesticides [1.6 kg (a.i.)/ha] have been applied on vegetable crops and 0.18 kg (a.i.)/ha on cash crops (PPD, 2014). Also, 27 vegetable zones developed under Prime Minister Agriculture Modernization Project might have amplified the use of pesticides. Chemical pesticides are readily available in the local markets nowadays due to the increase in the number of agrovets. Pesticide resistance, elimination of natural enemies and pest resurgence are also increasing the amount of pesticide applied on crops (Palikhe, 2002). Pesticide import is increasing over decades however, there is fluctuation in import every year. The highest increase in the pesticide import is in the fiscal year 2007/08 by about 165% and the highest decrease is in the year 2009/10 by about 41% as shown in Figure 2. The significant increase in pesticide import is probably due to an increased application because of an increase in area for the cultivation of high-value vegetable crop replacing low-earning cereal crops in a hilly region. Also, it might be related to the increased use in the health sector because of Kalazar, Malaria control program running in 11 districts of Nepal (MOF, 2008). The slow rise or decrease from 2001 for few years is perhaps due to IPM-FFS program running intensively in Nepal.

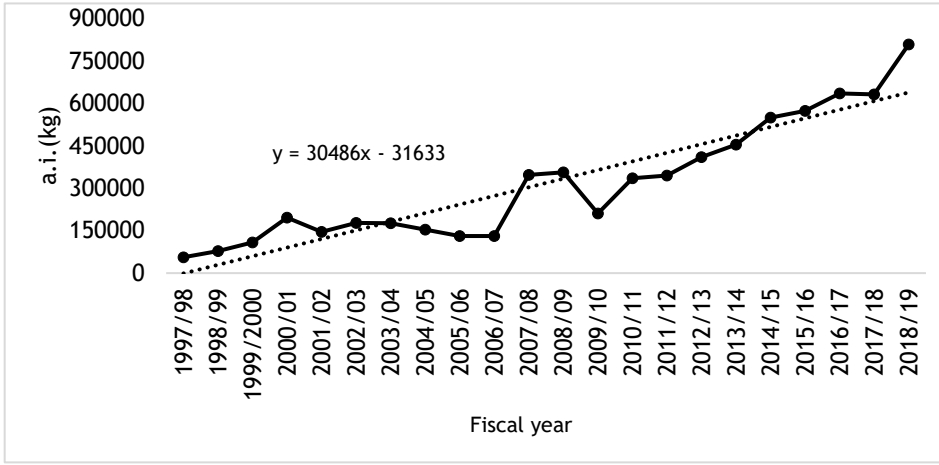

Figure1: Import trend of pesticides over twenty-two years in Nepal.

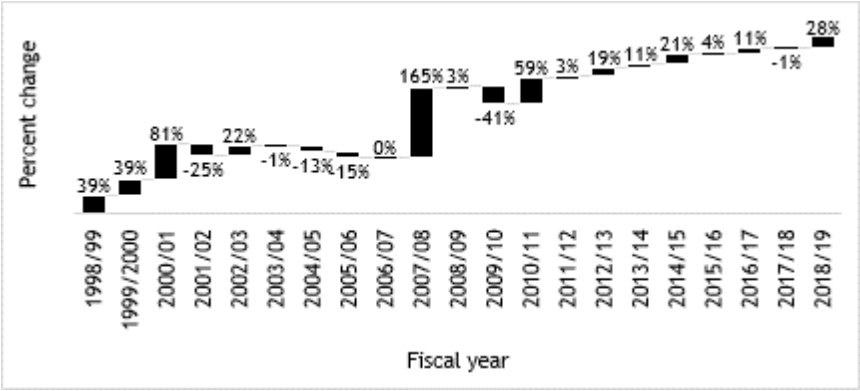

Figure 2: Percent change in pesticide import in Nepal.

IMPORT OF DIFFERENT CATEGORY OF PESTICIDES

The import of insecticides, fungicides and herbicides is in increasing trend with an average annual increase of 13.61 tons (a.i.), 17.95 tons (a.i.), 12.40 tons (a.i.) respectively while that of rodenticide is in decreasing trend with an average annual decrease of 98.51 kg (a.i.) for the last fifteen years as shown in Figure 3. Among different types of pesticides, fungicide has the highest import followed by insecticide, herbicide and rodenticide. In the latest year 2018/19, out of total pesticides imported, insecticide, fungicide, herbicide account for about 30%, 48%, 20% respectively as in Figure 4. According to the latest estimate in the fiscal year 2018/19, the annual import of fungicide, insecticide, herbicide and rodenticide is 390509.81 kg (a.i.), 246025.67 kg (a.i.), 164370.04 kg (a.i.) and 7959.06 kg (a.i.) respectively (PQPMC, 2019). The incidence of fungal disease recorded is higher than that of other disease or insect pest among samples diagnosed in the Plant Pathology Division from the year 2009 to 2018 (NARC, 2018). The import trend of bactericide and pesticides used for public health are in decreasing trend with an average annual decrease of 8.60 kg (a.i.) and 241.47 kg (a.i.) over the last fifteen years. Since 2012/13, the import of pesticides used for public health purposes had been stopped which can be seen in Figure 4. The import of bio-pesticide is in increasing trend over the last fifteen years with the highest increase in the year 2016/17 but with an abrupt decrease in the year 2018/19. The import is 4.29 kg (a.i.) in the year 2004/05 and 19.81 kg (a.i.) in 2018/19. However, the trendline in Figure 5 shows that an average annual increase in bio-pesticide importis 37.86 kg (a.i.).This is due to an increase in farmers' involvement in organic farming (Nandwani *et al.*, 2021). Prioritization of organic agriculture in the national plan since Tenth Five Years Plan and promotion by providing subsidies on organic product certification might have attracted people towards organic farming (NPC, 2002; MOALD, 2018). Also, the establishment of RBPR labs in Nepal and the

test of fresh vegetables for pesticide residue before sale might have encouraged growers to use biopesticides (CAL, 2017). Rise in demand for organic vegetables in urban settlements due to increased knowledge and understanding about the safety of organic produce, awareness about hazardous effects of chemical pesticides, increased buying power, and customers' desire to eat chemical-free foods may have contributed to the increased use of biopesticides on crops (Nandwani *et al.*, 2021). Also, IPM-FFS of the Government and FAO over the years has some role in raising awareness among vegetable growers; pesticide application reduced up to 40% in FFS implemented areas as compared with non-FFS areas (GC, 2011, cited in Kafle *et al.*, 2014). However, higher production cost, existence of market competition and a difficult certification process are some constraints in the adoption of organic farming (Nandwani *et al.*, 2021).

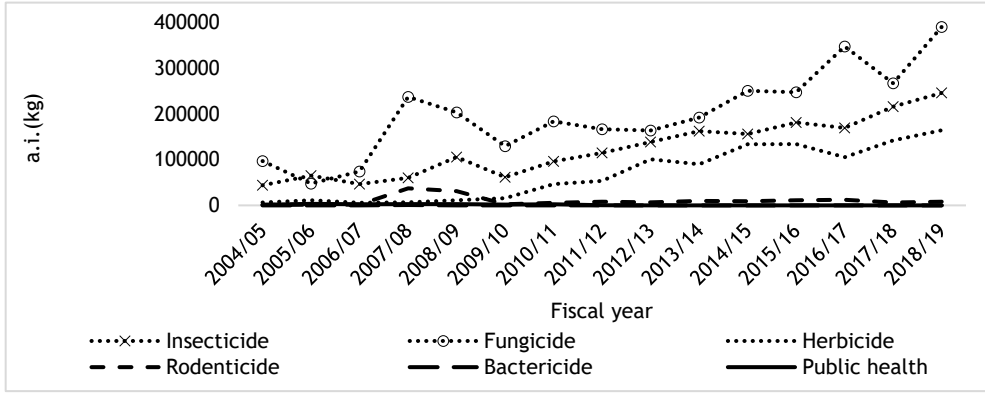

Figure 3: Import trend of different pesticide groups in Nepal.

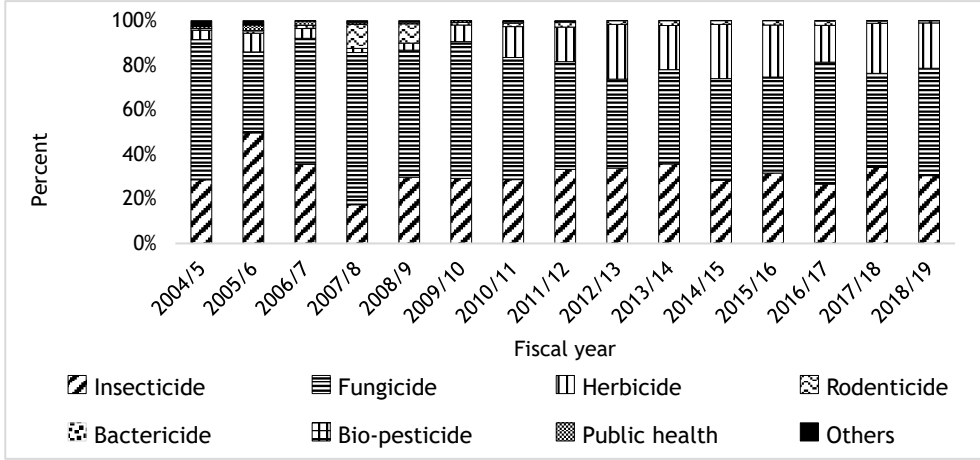

Figure 4: Percent share of different pesticides imported in Nepal

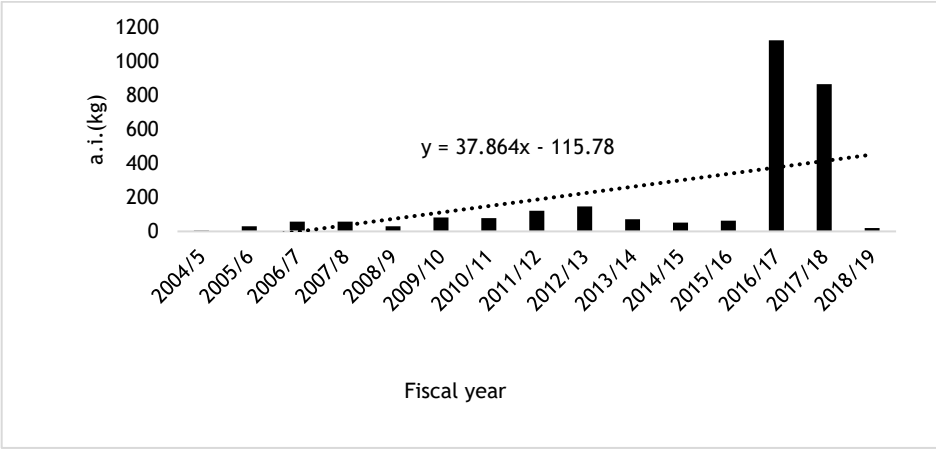

Figure 5: Import trend of bio-pesticides in Nepal.

The import of organophosphate, carbamate and synthetic pyrethroid is in increasing trend with an average annual increase of 2.19 tons (a.i.), 0.23 ton (a.i.) and 0.32 ton (a.i.) respectively whereas the import of organochlorine is in decreasing trend that has been completely stopped since 2012 as most of them are now banned in Nepal. The increase in the import of carbamate and synthetic pyrethroids might be due to their chemical nature. Carbamates can be easily degraded under a natural environment with less environmental pollution. Similarly, synthetic pyrethroids are highly toxic to insects but slightly toxic to mammals and birds. They are considered to be amongst the safest insecticides for use in food crops (Yadav and Devi, 2017). The import of organophosphate was relatively higher in past years but in recent years organophosphate and mix group are major constituents of total pesticide imported in Nepal due to their higher effectiveness which is shown in Figure 6. The import of organophosphate in 2018/19 is 79548.49 kg (a.i.). Mix pesticide group includes pesticide made by mixing two or more active ingredients. For example, a pesticide with the trade name dragon includes a mixture of chlorpyrifos 50% and cypermethrin 5%. Figure 7 shows the increasing trend of pesticide import with an average annual increase of 6.14 tons (a.i.) over the last fifteen years. According to the latest estimate in the year 2018/19, the import of mixed pesticide is 81,799 kg (a.i.). The first abrupt increase is in the year 2010/11 with an annual rise of 9.18 tons (a.i.) while the highest annual increase is in the year 2015/16 i.e., 36.02 tons (a.i.).

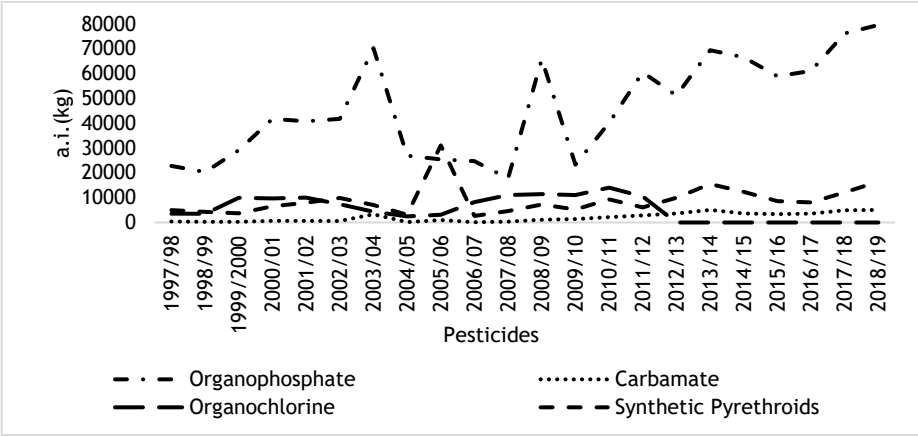

Figure 6: Import trend of different category of pesticides in Nepal.

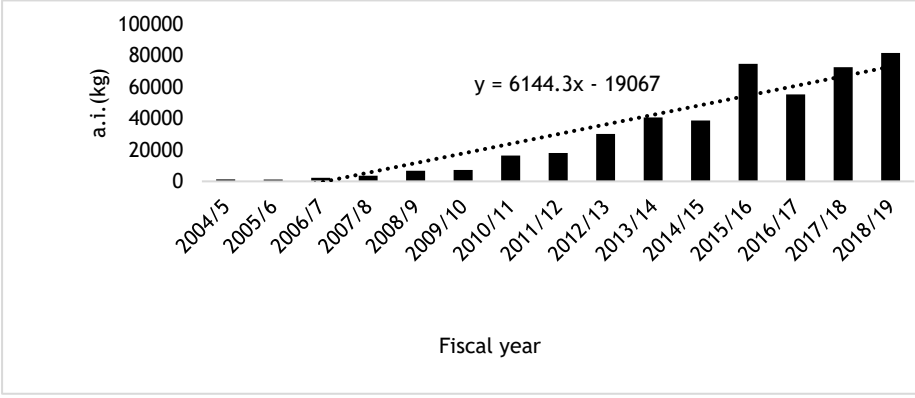

Figure 7: Import trend of mix group of pesticides in Nepal.

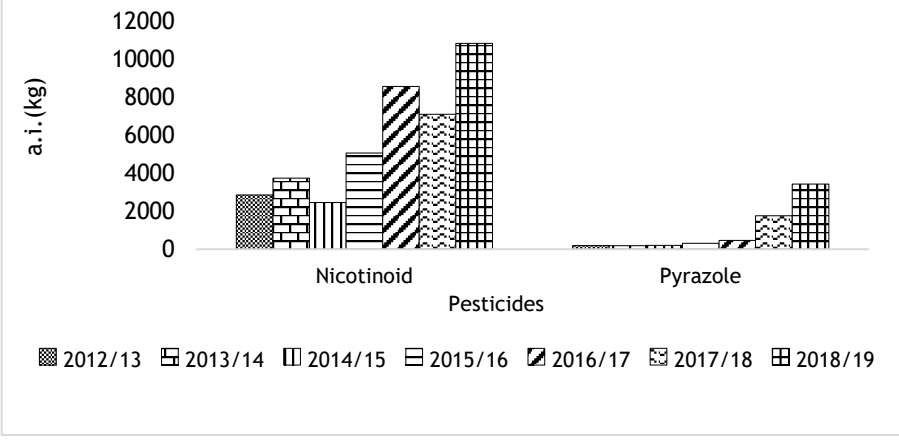

Figure 8: Import trend of some new pesticide groups imported in Nepal.

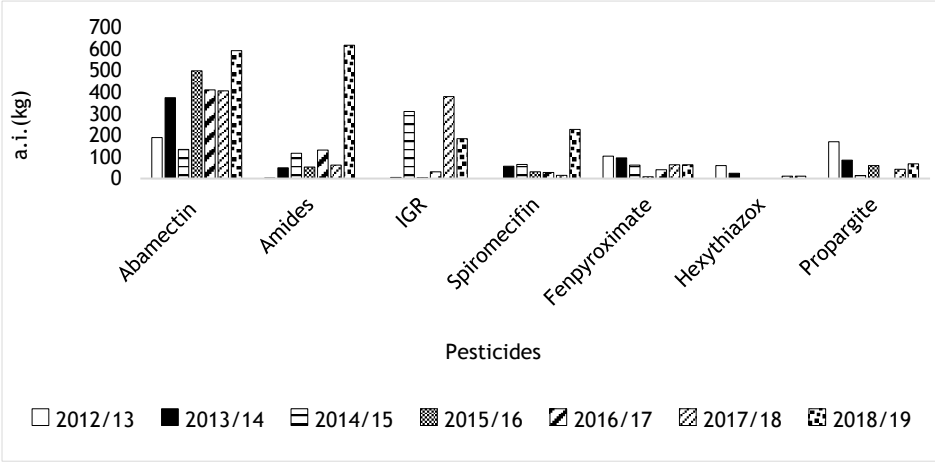

Figure 9: Importtrend of some new pesticide groups imported in Nepal.

Figure 8 shows the increasing trend in the import of nicotinoids and pyrazole in the last seven years. The annual import of nicotinoid and pyrazole in 2018/19 are 10841.21 kg (a.i.) and 3431.5 kg (a.i.) respectively. The importof abamectin, amides, IGR and spiromecifin are in increasing trend while that of fenpyroximate, hexythiazox and propargite is in decreasing trend over the last seven years as shown in Figure 9. The graph shows a higher import of abamectin on average. The annual import in the year 2018/19 of amides, abamectin, spiromecifin, and IGR are 619.32 kg (a.i.), 593.76 kg (a.i.), 227.86 kg (a.i.) and 184.65 kg (a.i) respectively. The import of propargite, fenpyroximate, and hexythiazox decrease from 171 to 68.4 kg (a.i.), 103.75 to 63.5kg (a.i.), and 60.17 to 10.9 kg (a.i) respectively from 2012/13 to 2018/19. These new pesticides are considered relatively safe for most non-target organisms, so their use and import are slowly increasing in recent years. Abamectin neither persists nor accumulates in the environment. It rapidly photolyzes in water, on soil, and both inert and biological surfaces. Its instability, strong binding to the soil, and low water solubility limit its bioavailability and prevent it from entering the aquatic environment (Wislocki *et al.*, 1989). Also, soil microorganisms degrade abamectin (Lasota and Dybas, 1990). Likewise, pyrazole does not accumulate in the abiotic environment, is relatively immobile in soil and has low potential to leach into groundwater (Tingle *et al.*, 2003).

REGISTERED AND BANNED PESTICIDES IN NEPAL

Plant Quarantine and Pesticide Management Centre (PQPMC) implements Pesticide Act/ Regulation for pesticide management in the country. It performs the role of registration, management and regulation of pesticides to minimize haphazard use of pesticides and solve pesticide problems. At

present 3037 pesticides by trade name and 172 pesticides by common name are registered in Nepal which is listed in Table 1.

Table 4: List of registered pesticides in Nepal.

S.N.	Pesticides	Trade Name	Common Name
1	Insecticide	1636	61
2	Fungicide	747	43
3	Herbicide	436	30
4	Biopesticide	113	14
5	Rodenticide	38	2
6	Acaricide	28	6
7	Bactericide	17	1
8	Molluscicide	2	1
9	Nematicide	1	1
10	Herbal	19	13
	Total	3037	172

Source: (AITC, 2021)

After the realization of the impacts of hazardous pesticides on human and the environment, the Government of Nepal first banned twelve pesticides [including 8 Persistent Organic Pollutants (POPs)], mostly organochlorines in 2001 (2057 B.S). These chemicals have low aqueous solubility, low polarity, high lipid solubility, and are volatile and stable, thus increasing their high persistence and bioaccumulation potential (Jayaraj *et al.*, 2016). Exposure to organochlorine pesticide residue is reported as a potential risk factor for type-2 diabetes (Airaksinen *et al.*, 2011), thyroid system (Freire *et al.*, 2011), gallstone disease (Su *et al.*, 2012), hormone-related cancers including breast, prostate, stomach and lung cancer (Wolff *et al.*, 1993) and neurological disorder (Forns *et al.*, 2012). Later in the year 2007, 2012, 2015, 2018 number of pesticides banned were 2, 1, 1, 5 respectively. Recently in August 2019 three pesticides were banned which can be used till 2021/8/4 and have yet to be notified in the Nepal Gazette. At present 24 pesticides are banned in Nepal which is listed below in Table 2.

Table 5: List of banned pesticides in Nepal.

S.N.	Pesticides	Banned Year	S.N.	Pesticides	Banned Year
1	Aldrin*	2001	13	Methyl parathion	2007
2	BHC	2001	14	Monocrotophos	2007
3	Chlordane*	2001	15	Endosulfan*	2012
4	DDT*	2001	16	Phorate	2015
5	Dieldrin*	2001	17	Benomyl	2018
6	Endrin*	2001	18	Carbaryl	2018
7	Heptachlor*	2001	19	Carbofuran	2018
8	Lindane*	2001	20	Dichlorvos	2018
9	Mirex*	2001	21	Triazophos	2018

10	Organo-mercury	2001	22	Aluminium phosphide 3gm tablet	2019 (can be used
11	Phosphamidon	2001	23	Carbosulfan	till
12	Toxaphene*	2001	24	Dicofol*	2021/08/04)

*= *Persistent Organic Pollutants, Source: (PQPMC, 2020)* (Secretariat of the Stockholm Convention Clearing House, 2008), (Stockholm Convention, 2004 with 2013 update)

PESTICIDE CONSUMPTION AND SAFE HANDLING OF PESTICIDE

Approximately 4.11 million tons [2.63 kg (a.i.)/ha] of pesticides was utilized annually worldwide in 2017, where China was a major contributing country, followed by the USA, Brazil, Argentina, and Canada, which is increasing rapidly (Roser, 2019). The use of chemical pesticides per area of cropland in Nepal is low as compared to other countries in the world like France [3.63 kg (a.i.)/ha], New Zealand [7.89 kg (a.i.)/ha], Japan [11.76 kg (a.i.)/ha], Israel [12.61 kg (a.i.)/ha], China [13.07 kg (a.i.]/ha) and Saint Lucia [19.6kg (a.i.)/ha] as shown in Figure 10. Among different types of pesticides consumed (kg/ha) in Nepal, fungicides shared a major part of 60%, followed by insecticide 37% (PPD, 2014). Among the pesticides used across the globe, herbicides had the highest consumption followed by insecticides, fungicides, and others (Roser, 2019). However, in Nepal fungicides are highly consumed by total active ingredient but by total quantity (kg) insecticides share a higher percentage of total consumption (PQPMC, 2019). However, Nepalese farmers are more exposed to pesticides and are at greater risk. Many farmers are still unaware of pesticide handling, pesticide label and hazard level (Atreya *et al.*, 2012). On the basis of ecological domains of Nepal, the pesticide consumption is highest in terai [0.995kg (a.i.)/ha] followed by valley [0.47 kg (a.i.)/ha], mid-hill [0.314kg (a.i.)/ha] and high hill [0.085 kg (a.i.)/ha] (PPD, 2014).Reportshows that the residue analysis of 75 samples (of 13 vegetables), 4% of samples exceed the maximum residue limit (Sharma, 2015). Overdose and frequent application of pesticides on crops have been reported. Many vegetable growers, nearly 50%, apply pesticide5-6 times in a single cropping period (Shrestha *et al.*, 2010). Most of the farmers spray pesticide up to 4 times a month (Khanal and Singh, 2016). A certain category of farmers apply pesticides without proper advice from trained personnel/agrovets and harvest their crops without considering the pre-harvest interval (PHI) or waiting period. They apply pesticides on vegetables near harvesting time and even a day before selling (PPD, 2014). Farmers do not follow safety measures during the handling and application of pesticides. Only 10% of farmers used face mask while handling or spraying pesticides (Atreya *et al.*, 2012). Half of the vegetable growers use their bare hands while mixing pesticides (Shrestha *et al.*, 2010). Farmers have been practicing unsafe disposal of pesticide containers near a water source (Khanal and Singh,

2016). Misuse of pesticides such as sales of expired, banned and counterfeit products have been reported in Nepal (Sharma *et al.*, 2012).

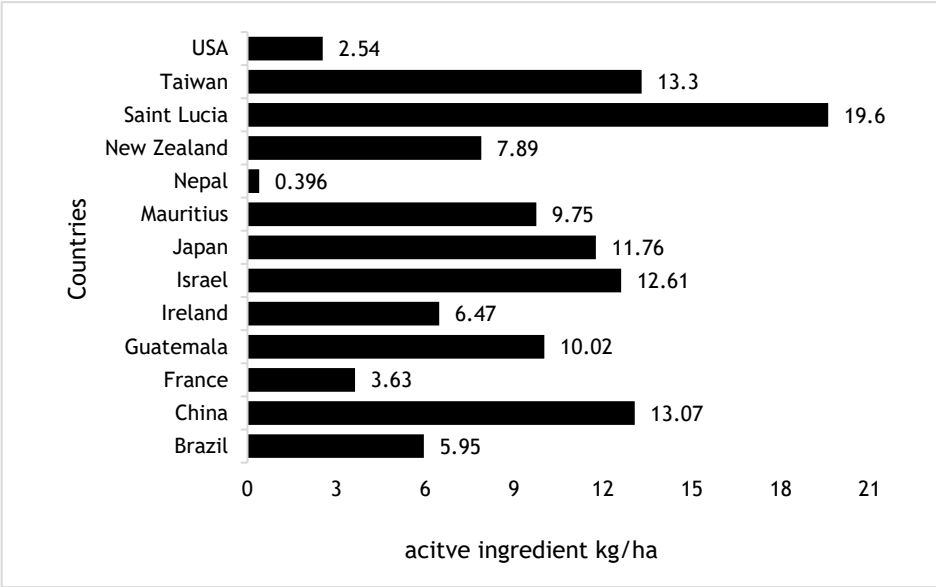

Figure 30: Pesticide consumption pattern.

Source: Roser (2019); PPD (2014)

CONCLUSION

The import of pesticides has been increasing over the decades. Organophosphate and mix group has a major share followed by synthetic pyrethroids and carbamates. Although among 172 registered pesticides, insecticides are the highest in number i.e., 61, fungicide occupies a larger quantity (a.i.) of total import among pesticide groups. In Nepal, pesticide consumption is increasing [396 gm (a.i.)/ha], though it has a low national average as compared to other countries in the world. However, the risks of chemical pesticide are higher in Nepal because of the absence of proper knowledge on their safe handling and application. Awareness campaign on harmful effects of chemical pesticides, training on safe handling of pesticides targeting agrovets, extension workers,farmers and consumers, emphasis on research and extension activity related to IPM techniques, proper implementation of Pesticide Management Act could help minimize injudicious use of pesticides and its hazard on non-targeted organism.

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GENETIC VARIABILITY STUDY OF LOCAL RICE GENOTYPES

P. Panth[1], A. Dahal[1] and K. Upadhyay[2]

ABSTRACT

Rice is a self- pollinating, major staple food crop growing in tropical and having high importance in food security and economy of the country. The study was conducted main season during first week of May to third week of September 2018 in the research field of Gokuleshwor Agriculture and Animal Science College, Baitadi of Sudurpaschim province in 3 replications in Randomized Complete Block Design with 13 local genotypes including 2 improved checks Black rice (G-60) and Sukkha Dhan-3 to evaluate performance of different local rice varieties grown in Gokuleshwor agro-environment. Phenotypic traits like plant height, tiller number, panicle number, panicle length, leaf area index and genotypic traits like thousands kernel weight, grain/panicle, productivity, biological yield and harvest index were the traits evaluated Highest grain yielding genotype was Naka Dhan (7.80ton/ha) and highest thousands kernel weight was found in Chiude (30.33 gm) . Phenotypic coefficient of variation was highest for number of unfilled grains per spike (81.39) followed by leaf area (51.37 cm^2) and lowest magnitude was exhibited by number of spike/panicle (26.16) and harvest index (19.44%). The heritability was highest for thousands kernel weight (99.07%) followed by plant height (95.23%) and panicle length (76.34%) and lowest for unfilled grains/spike (41.69%) and yield (41.36%). Correlation study suggested that productivity showed the positive significant association with biological yield (0.896) and harvest index (0.348). Most of other traits have shown positive association with productivity. Thus, Chiude and Naka dhan genotypes could further be used for breeding programmes for the environmental condition of Baitadi district, Nepal.

Keywords: Correlation, heritability, landrace, panicle, plant height, phenotypic traits.

INTRODUCTION

Rice (*Oryza sativa* L.) is one of the major stable cereal crops feeding more than 3.5 billion people worldwide (IRRI, 2017). A total of 49% calories consumed by the human population come from rice, wheat and maize of which 23% contributed by rice, 17% by wheat and 9% by maize. Thus, almost one fourth of the calories consumed by the entire world population come from rice (*Subudhi, et al., 2006*). Besides, rice also plays an important role

1. Researcher, Gokuleshwor Agriculture and Animal Science College, IAAS, TU, Baitadi, Nepal. Corresponding author: email:panthpradip2@gmail.com mobile: 977-9843696599
2. Assistant professor, Gauradaha Agriculture College, IAAS, TU, Jhapa, Nepal.

both economically and in terms of food security (*Timmer, 2010*). Its annual Rice production in world was 741.4 million ton with the yield of 4.55 t/ha (FAO, 2017). In Asia, about 90% of global rice is produced and consumed (IRRI, 2013). Rice ranks first important staple crop of Nepal followed b y maize, wheat, millet and barley. It accounts for one-fifth of total agricultural GDP of the country. Nepal is rich in rice genetic resources with 1700 rice landraces growing from 60 to 3050 masl attitude (MOAC, 2010). Rice production, production area and productivity in Nepal during fiscal year 2074/75 B.S. was 5.15 million metric ton(mt), 1.47 million hacter(ha) and 3.51 t/ha (MOALD, 2076 B.S.).

Landraces are generally named by farmers based on their phenotype and genotypic traits and sometimes it is named by the location of production area. In general these nomenclature is imperfect as different name can be given to genetically closely related populations, while the same name can be given to genetically distinct ones. However, farmers have recognized, controlled acted and have developed own descriptors of the landraces. Highly increase in cultivation of hybrid seed causes losses of landrace varieties. However, the cultivation of the landraces is shaped in part by the production environment and by the cultural and religious significance (*Joshi and Bauer*, 2006). The average area share of landraces is slightly over 10% in Nepal. By season, this accounts 10.3% during main and 8.8% during early season. The popular landraces grown in Far-West area are Kaljade, Jhimi, Thapa chini, Chiude etc. Likewise Basmati, Kalanamak, Chanamchur, Sathiya etc are the landraces cultivated in eastern terai (*Crop Development Directorate*, 2015).

Highly use of hybrid seed, food insecurity, no use of landraces in breeding program and loss of genetic diversity are the rational to study. The major objective of this research is to study genetic variability of local rice genotype in *Gokuleshwor,* Baitadi.

MATERIALS AND METHOD

This research was conducted in irrigated agronomical farm of Gokuleshwor Agriculture and Animal Science College (GAASC), Gokuleshwor Baitadi (80034'E and 29040' N). It is situated in Far-Western state (state no.7) in *Dilasaini* rural municipality of Baitadi district. The elevation of research area is 811 masl. During the research period, maximum temperature was 32 ^{0}C and average temperature was 26 ^{0} C with an average rainfall of 130mm. The experiment was carried out during first week of May to third week of September, 2018. The experimental material consisted of 13 landraces rice genotypes including 2 improved genotypes (Table 1).

Table 1: Genotypes used in research study

Genotypes	Collected Area	Collected Height
Kaljade	Dilasaini, Baitadi	811 masl
Rato Basmati	Dilasaini, Baitadi	**811 masl**
Jhimi Dhan	Dilasaini, Baitadi	**811 masl**
Shyam Jeera	Dilasaini, Baitadi	811 masl
Oskote	Dilasaini, Baitadi	811 masl
Chiude	Dilasaini, Baitadi	811 masl
Temase Dhan	Dilasaini, Baitadi	811 masl
Naka Dhan	Dilasaini, Baitadi	811 masl
Sunaulo Dhan	Dilasaini, Baitadi	811 masl
Chhoro Dhan	Dilasaini, Baitadi	811 masl
Thapa Chini Dhan	Dilasaini, Baitadi	811 masl
Black Rice(G-60)	Hardinath, Dhanusa	75 masl
Sukkha Dhan-3	Khajura, Banke	146 masl

The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. The plot size was (1.2x1.6)m^2 with spacing of 0.5 m between experimental plots and 1m between replications. The crop geometry of rice was maintained at 20cmx20cm. The cultural operation like seed sowing, land preparation, fertilizer application, transplanting, weeding, harvesting were done as per recommendation of production. Observation of phenotypic traits was taken on 5 randomly selected sample plants escaping the boarder rows of individual plots. Observation was taken through biometric technique includes plant height, panicle number, panicle length, leaf area index, number of spike/panicle, number of filled grain/spike, number of unfilled grain/spike, productivity, biological yield, harvest index. The measured data were processed on R stat and correlation study, Phenotypic Co-officient of Variance(PCV), Genetic Co-officient of Variance(GCV), heritability, Genetic Advance Mean (GAM)calculation was done by using ms excel 2007.

RESULTS AND DISCUSSION

The genotypes were studied for under phonotypic traits, yield and yield attributing traits on the experimental field of GAASC.

PHENOTYPIC TRAITS

Quantitative phenotypic traits such as plant height, number of tiller, leaf area index, panicle number, panicle length were taken and evaluated genotypes under study. There was observed a significant difference and it is tabulated below Table.2:

Table 2: Performance of different rice genotypes for various phonological traits.

Genotypes	Plant height(cm)	Tiller/ Plant	Panicle/ Plant	Panicle length(cm)	Area(cm^2)
Kaljade	102.87^{bc}	17^{b}	12^{abc}	19.67^{ab}	28.39^{abcd}
Rato Basmati	111.93^{abc}	18^{b}	13^{ab}	18.00^{b}	34.48^{abc}
Jhimi dhan	104.60^{abc}	20^{ab}	11^{abc}	20.17^{ab}	34.60^{abc}
Shyam jeera	109.80^{abc}	24^{a}	16^{a}	22.00^{a}	34.03^{abc}
Oskote dhan	117.6^{a}	19^{ab}	12^{abc}	22.05^{a}	43.79^{a}
Chiude	75.33^{d}	14^{b}	7^{c}	22.61^{a}	13.48^{d}
Temase dhan	98.67^{c}	17^{b}	9^{bc}	20.92^{ab}	30.63^{abc}
Naka dhan	107.33^{abc}	19^{ab}	12^{abc}	20.37^{ab}	26.53^{bcd}
Sunaulo dhan	114.60^{ab}	16^{b}	9^{bc}	21.57^{ab}	40.74^{ab}
Chhoro dhan	83.93^{d}	19^{ab}	10^{bc}	21.25^{ab}	26.83^{bcd}
Thapachini dhan	101.13^{c}	20^{ab}	13^{ab}	20.67^{ab}	24.98^{bcd}
Black rice (G-60)	54.93^{e}	14^{b}	8^{bc}	14.39^{c}	22.91^{cd}
Sukkha Dhan -3	104.93^{abc}	19^{ab}	13^{ab}	19.60^{ab}	38.31^{abc}
Mean	99.00513	18	11	20.25	30.74
CV %	6.997823	15.16	26.62	9.74	28.14
LSD	5.66	2.48	2.34	2.59	7.06
F test @5%	***	*	*	**	*

Significant traits are denoted * for $p<0.05$, ** for $p<0.01$, *** and for $p<0.001$.

Rice genotypes had highly significant ($p<0.001$) difference on plant height which ranged from 54.93 cm to 117.6 cm (Table-2). Significantly, highest plant height was found on *Oskote Dhan* (117.6 cm), followed by *Sunaulo Dhan* (114.60 cm) and Rato Basmati (111.93 cm), while the lowest height was observed in Black rice(G-60) (54.93 cm). The average plant height was found to be 99.01 cm.(*Ranawake*, 2013). Likewise, genotypes had significant ($p<0.05$) effect on tiller/ plant ranges from 14 to 24 (Table-2). Significantly, highest tiller/plant was found on *Shyam Jeera* (24), followed by *Thapa Chini* and *Jhimi dhan* (20) and Sukhkha-3 (19). While the lowest tiller/plant was observed in *Chiude* (14). The average tiller/plant was found to be 18. Rice genotypes had significant ($p<0.05$) effect on panicle/plant ranges from 7 to 16 (Table-2). Highest panicle/plant was found on *Shyam jeera* (16) and lowest found on *Chiude* (7). The average panicle/plant was found to be 11. Number of reproductive tiller provide useful information for the rice breeders and

those characters have direct effect on yield per plant (*Sadeghi*, 2011). Rice genotypes had significant ($p<0.01$) effect on panicle length ranges from 14.39 cm to 22.61 cm (Table-2). Significantly, highest panicle length was found on *Chiude* (22.61 cm) followed by *Oskote dhan* (22.05 cm) and *Syam jeera* (22.00 cm). While the lowest panicle length was observed on Black rice (G-60) (14.39 cm). The average panicle length was found to be 20.25 cm. Panicle length also yield attributing characters (*Beser and Genctan*,1999) as an effect of plantation technique.The effect of rice genotypes had significant ($p<0.05$) effect on leaf area index ranges from 13.48 cm^2 to 43.79 cm^2(Table-2). Highest leaf area index was observed on *Oskote dhan* (43.79 cm^2) and lowest found on *Chiude* (13.48cm^2). The average leaf area index was found to be 30.74 cm^2.

YIELD AND YIELD CONTRIBUTING ATTRIBUTES

The yield and yield attributing characters obtained is shown in Table-3.

Table 3: Performance of yield attributing traits of different rice genotypes at Gokuleshwor, Baitadi.

Genotypes	NOS/P	NOG/S	NOUG/S	NOFG/P	TKW(gm)	Yield(t/ha)	Biological yield (t/ha)	Harvest index (%)
Kaljade Rato Basmati	10^{ab}	22^{a}	1^{b}	202^{a}	17.67^{e}	7.76^{a}	16.50^{a}	47.13^{a}
Jhimi Dhan	11^{ab}	14^{abc}	3^{ab}	121^{bcd}	17.33^{e}	5.68^{a}	15.83^{ab}	35.84^{b}
Syam jeera	10^{ab}	21^{ab}	2^{ab}	183^{abc}	15.00^{f}	5.90^{a}	15.29^{ab}	39.06^{ab}
Oskote Dhan	12^{a}	19^{abc}	3^{ab}	203^{a}	14.33^{f}	7.09^{a}	16.58^{a}	42.58^{ab}
Chiude	13^{a}	14^{abc}	3^{ab}	104^{cd}	22.67^{c}	5.29^{a}	11.18^{ab}	46.70^{ab}
Temase Dhan	9^{b}	13^{bc}	3^{ab}	85^{d}	30.33^{a}	4.81^{a}	10.29^{ab}	47.21^{ab}
Naka dhan	10^{ab}	15^{abc}	4^{ab}	112^{cd}	22.00^{cd}	4.86^{a}	12.33^{ab}	39.11^{ab}
Sunaulo Dhan	10^{ab}	20^{abc}	2^{ab}	178^{abc}	25.00^{b}	7.80^{a}	15.98^{ab}	48.67^{a}
Chhoro Dhan	10^{ab}	13^{bc}	2^{ab}	104^{cd}	25.00^{b}	5.67^{a}	13.51^{ab}	43.17^{ab}
Thapa Chini Dhan	11^{ab}	13^{bc}	5^{a}	78^{d}	26.33^{b}	4.89^{a}	10.73^{ab}	44.44^{ab}
Black Rice(G-60)	11^{ab}	12^{c}	4^{ab}	80^{d}	26.00^{b}	6.17^{a}	12.57^{ab}	49.36^{a}
	10^{ab}	15^{abc}	3^{ab}	119^{bcd}	26.00^{b}	4.53^{a}	9.54^{b}	48.10^{a}

Sukhkha Dhan-3	13[a]	20[abc]	2[ab]	192[ab]	20.67[d]	7.38[a]	17.00[a]	42.59[ab]
Mean	11	16	3	136	22.18	5.99	13.64	44.07
CV%	17.12	27.04	62.08	31.18	3.69	33.04	25.56	12.77
LSD	1.51	3.55	1.48	34.51	0.67	1.61	2.85	21.15
F-test@5%	NS	.	NS	**	***	NS	*	NS

Significant traits are denoted * for p<0.05, ** for p<0.01, *** for p<0.001 and NS for Non significant.

NOS/P for number of spike/panicle, NOG/S for number of grain/spike. NOUG/S for number of unfilled grain/spike, NOFG/P for number of filled grain/panicle and TKW for thousands kernel weight.

The effect of rice genotypes had non significant effect on number of spike/panicle which ranged from 9 to 13(Table 3) highest number was observed on *Oskote dhan* (13). While the lowest number was observed in *Chiude* (9). The average number was found to be 11. The number and development of spikelets on a panicle directly affect the grain yield (*Beser and Genctan*, 1999). Rice genotypes had non significant effect on number of grain/ spike ranges from 12 to 22 (table 3). Highest number was observed on *Kaljade* (22). While the lowest number was found on *Thapa chini dhan* (12). The average number to be 16.The effect of rice genotypes had non significant effect on number of unfilled grain / spike ranges from 1 to 5 (table 3). Highest number was found on *Chhoro dhan* (5) and lowest number was found on *Kaljade* (1). The average number was found to be 3.The effect of rice genotypes had significant (p< 0.01) effect on number of filled grain/ panicle ranges from 78 to 203 (table 3). Highest number was found on *shyam jeera* (203) and lowest number number was found on *Chhoro dhan* (78). The average number was found to be 136.The effect of rice genotypes had highly significant (p< 0.001) effect on thousand kernel weight ranges from 14.33 to 30.33 gram (table 3). Highest TKW was found to be on *Chidue* (30.33) and lowest TKW was found to be on *Shyam jeera* (14.33). The average weight was found to be 22.18 gram.The effect of rice genotypes had non significant effect on yield ranges from 4.53 t/ha to 7.80 t/ha (table 3). Highest yield was found on *Naka dhan* (7.80 t/ha) followed by *Kaljade* (7.76 t/ha) and Sukkha-3 (7.38 t/ha). While the lowest yield was found on Black rice (G-60) (4.53 ton/ha). The average yield was found to be 5.99 t/ha.Rice genotypes had significant (p<0.05) effect on biological yield ranges from 9.54 to 17.00 t/ha (table 3). Highest yield was found on Sukhha-3 (17.00 t/ha) and lowest yield was found on Blackrice (G 60) (9.54 t/ha). The average biological yield was found to be 13.64 t/ha.The effect of rice genotypes had non significant effect on harvest index ranges from 35.84% to 49.36% (table 3). Highest harvest index was found on *Thapa chini dhan* (49.36%) and lowest was found on to be *Rato basmati* (35.84%). The average harvest index was found to be 44.07%.

CORRELATION STUDY:

The correlation study among different traits are shown in table.

Table 4: Relation among different traits.

	PH	Tiller no.	Panicle No.	Panicle length	Leaf area	NOS/P	NOG/S	NOFG/S	NOUG/S	NOFG/P	TKW	productivity	BY	HI
PH	1	.428**	.472**	.353*	.504**	.251	.212	.258	-.160	.213	-.503**	.343*	.443**	-.181
Tiller no.		1	.747**	.068	.349*	.322*	.268	.258	.001	.335*	-.447*	.513**	.544**	-.019
Panicle no.			1	.118	.429**	.056**	.358*	.303	.110	.333**	-.518**	.744**	.720**	.122
Panicle Length				1	.252	.127	-.095	-.112	.066	-.087	.027	.060	.041	.033
NOS/P					1	.159	.147	.045	.434**	-.237	.283	.251	.111	
NOG/S						1	.935**	-.002	.824**	-.463**	.588**	.543**	.163	
NOFG/S							1	-.354*	.863**	-.504**	.567**	.512**	.194	
NOUG/S								1	-.276	.219	-.044	-.011	-.112	
NOFG/P									1	-.576**	.597**	.566**	.154	
TKW										1	-.274	-.483**	.389*	
Productivity											1	.896**	.348*	
BY												1	-.092	
HI													1	

The result on correlation study suggested that plant height showed the positive significant association with tiller number (.428**), panicle number (.472**), panicle length (.353*), leaf area (.504**), productivity (.343*), biological yield (.443**) and positive association with number of spike./ panicle (.251), number of grain / spike (.212), number of filled grain/ spike (.258), number of filled grain / panicle (.213). the negative significant association with TKW (-.503**) and negative association with number of unfilled grain/ spike (-.160), harvest index (-.181). However, it has been reported that plant height was affected by many factors like plantation method, plant density and fertilizer application (Beser and Gentan,1999; Aide and Beighly, 2006; Gozubenli,1992).Tiller number had positive significant association with panicle number (.747**), leaf area (.349*), number of spike / panicle (.322*), number of filled grain / panicle (.335*), productivity (.513**), biological yield (.544**) and positive association with panicle length (.0680),

number of grain / spike (.268), number of filled grain / spike (.258), number of unfilled grain / spike (.001). The negative significant association with TKW (-.447**) and negative association with harvest index (-.019).Panicle number had positive significant association with leaf area (.429**), number of spike/ panicle (.506**), number of grain / spike (.358*), number of filled grain / panicle (.444**), productivity (.744**), biological yield(.720**) and positive association with panicle length (.118), number of filled grain / spike (.303), number of unfilled grain/ spike (.101), harvest index (.122) . The negative significant association with (-.518**).Panicle length had positive association with leaf area (.252), number of spike / panicle (.127), number of unfilled grain / spike (.066) , TKW (.027), productivity (.060), biological yield (.041), harvest index (.033). The negative association with number of grain / spike (-.095), number of filled grain / spike (-.112), number of filled grain / panicle (-.087). However, Ulger and Genc (1989), Beser and Genctan (2001), Surek (2002) and Ghosh *et al.*, (2004) reported that the tiller number and grain number per panicle were affected by the environmental and cultivation factors as well.Gozubenli(1992) reported that the grain weight per panicle was affected by the rate of fertilizer and plant density.Leaf area had positive significant association with number of spike / panicle (.321**), biological yield (.419**) and positive association with number of grain/ spike (.147), number of filled grain / spike (.137), number of unfilled grain/ spike (.024), number of filled grain/ panicle (.121), productivity (.281). The negative significant association with TKW (-.398*) and negative association with harvest index (-.238).Number of spike/ panicle had positive significant association with number of filed grain /panicle (.434**) and positive association with number of grain/ spike (.1590, number of filled grain / spike (.147), number of unfilled grain/ spike (.045), productivity (.283), biological yield (.251), harvest index (.111). The negative association with TKW(-.237).Number of grain / spike had positive significant association with number of filled grain/ spike (.935**), number of filled grain/ Panicle (.824**), productivity(.588**), biological yield (.543**) and positive association with harvest index (.163). The negative significant association with TKW (.463**) and negative association with number of unfilled grain/spike (-.002). Number of field grain / spike had positive significant association with number of filled grain/ panicle (.863**), productivity (.567**), biological yield (.512**) and positive association with harvest index (.194). The negative significant association with number of unfilled grain with panicle (-.354*), TKW (-.504**). Number of unfilled grain/ panicle had positive association with TKW (.219). Negative association with number of filled grain with panicle (-.276), productivity (-.044), biological yield (-.011), harvest index (-.112). Number of filled grain with panicle had positive significant association with productivity (.597**), biological yield (.566**) and positive association with harvest index (.154). The negative significant association with TKW (-.576**). TKW had positive significant

association with harvest index (.389*). The negative significant association with (-.483**) and negative association with productivity (-.274).According to Surek and Beser (1996) and Manzoor *et al.*, (2006), 1000 g weight was affected by cultivation methods. However, Aidei and Beighly (2006) reported that cultivation methods didn't have such effect on 1000-grain weight.Productivity had positive significant association with biological yield (.896**), harvest index (.348*).Biological yield had negative association with harvest index (-.092).

PHENOTYPIC GENOTYPIC COFFICIENT OF VARIATION

The value for phenotypic variance were higher than those of genotypic variance for all traits. The relative magnitudes of the phenotypic as well as genotypic variance between the traits were compared based on phenotypic and genotypic coefficient of variation.Phenotypic coefficient of variation highest for number of unfilled grain per spike (81.39117) followed by leaf area (51.37263), panicle number (45.75641). Lowest magnitude of phenotypic coefficient of variation exhibited by harvest index (19.4426) followed by number of spike per panicle (26.16054). The results are in accordance with the findings of other researchers (Bai and Tran, 1991; Chaubey and Singh, 1994. The difference of PCV and GCV is lower forthousands kernel weight, plant height and panicle length which shows there is lower environmental effect. Similarly, difference is high for number of unfilled grain per spike, yield and number of grain per spike. Similar result was observed by Anjaneyulu, Reddy(2010), Mahato, Yadav and Mohan (2009), Singh, Kumar and Machhavi Latha (2007) studied on 50 germplasm on line of rice and reported high PCV and GCV values for number of grains per panicle.

HERITABILITY

The estimation for heritability for different traits under study are presented in the table. The heritability ranged from 99.07% to 41.36%. The heritability was highest for thousands kernel weight (99.07%) followed by plant height (95.23%) and panicle length (76.34%). Lowest heritability was for number of unfilled grain per spike (41.69%) and yield (41.36%). Similar results were observed by Saravanan and Senthil for days to 50% flowering, plant height, and test weight (Ali *et al.*, 2000).

GENETIC ADVANCE

Estimates of genetic advance as percentage of mean was highest for thousands kernel weight (78.37) followed by leaf area (74.09). Lowest were observed for harvest bindex (22.74). Similar result were observed by Sabesan *et al.* (2009) for grain yield per plant, test weight and number of tiller.

Table 5: variability parameters for different quantitative traits among 13 genotypes of rice on may-sep, 2018 at Gokuleshwor, Baitadi

Traits	Gcv	pcv	H	GA	GAM
Plant height	31.26101	32.03467	0.952282	62.217113	62.844241
Tiller no.	23.9706	29.48421	0.660966	7.109746	40.14538
Panicle no.	37.2113	45.75641	0.661372	6.713367	62.33974
Panicle length	17.50265	20.03168	0.763436	6.378177	31.50339
Leaf area	42.98634	51.37263	0.70016	22.78091	74.0963
NOS/P	19.78047	26.16054	0.571715	3.325646	30.81014
NOG/S	35.39651	44.5447	0.631435	9.314725	57.94181
NOUG/S	52.55855	81.39117	0.416996	2.041547	69.916
TKW	38.22274	38.4005	0.990763	17.38265	78.37435
Yield	27.75712	43.15809	0.413642	2.203196	36.7751
Biological yield	30.71354	39.9621	0.590695	6.635175	48.62715
Harvest index	14.65263	19.4426	0.567966	10.02688	22.74804

High heritability and high genetic advance attributed to additive gene action. Khan (1990) suggested that high genetic advance and high heritability may be due to mainly additive gene action and under the circumstance advocated simple plant.

CONCLUSION

The thousands grain weight has highest on Chiude and highest yield on *Naka dhan*: yield is non significant and positively correlated with plant height, panicle length and harvest index. The traits thousands grain weight, plant height, panicle length shows lowest difference of PCV& GCV and has highest GAM. Thus, *Chiude* and *Naka dhan* genotypes can further be used for breeding programmes in the environmental condition for Baitadi district.

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EVALUATION OF BREAD WHEAT GENOTYPES FOR STRIPE RUST RESISTANCE

P.B. Magar[1]*, S.Baidya[1], D.B. Thapa[2], M. Subedi[2], R. Basnet[3] and K.R. Pant[3]

ABSTRACT

Stripe rust disease is a major problem for wheat production in the hills of Nepal. To find resistance sources against this disease, 444 and 457 wheat genotypes received from National Wheat Research Program, Bhairahawa in 2018 and 2019 respectively were evaluated at Khumaltar under inoculated high disease pressure field condition. Disease was evaluated at both seedling and adult stages. In 2018, 315 genotypes showed resistance at seedling stage while 89 genotypes were having adult plant resistance (APR). Also, 71 entries showed immune response and 191 were resistant at both stages. Similarly in 2019, 233 genotypes were resistant at seedling stage and 201 were showing APR. Likewise, 35 entries were immune and 208 were resistant at both stages. Wheat genotypes with APR gene(s) can be utilized for developing durable stripe rust resistant varieties in the future. In addition, the genotypes having both stages resistant could also be used as sources of major and minor gene(s) for stripe rust resistance genotypes development in future breeding purposes.

Key-words: Adult, resistance, seedling, stripe rust, wheat

INTRODUCTION

Wheat is the third most important cereal crop in Nepal after rice and maize. It occupied 703,992 ha areas and produced 2,005,665 tons of wheat with productivity 2.85 t/ha (MoALD, 2019) during 2018/19. The average productivity of wheat is lower than the potential yield. There are several biotic constraints for wheat production and rust diseases are the most important ones in the country. Among them, stripe rust also known as yellow rust caused by the fungus *Puccinia striiformis* f.sp. *tritici* is considered as the most important threat on wheat cultivation in the hills of Nepal. The incidence and severity of stripe rust disease varied according to the climatic condition, management practices and wheat varieties. Losses due to stripe rust was estimated to be 27% in Nepal 297 variety (Sharma *et al.*, 2013). Likewise, Upreti and Karki (1988) recorded 30% in grain yield production in a field experiment on RR21 at Kavre, Dolakha due to stripe rust disease.

1 National Plant Pathology Research Centre, Nepal Agricultural Research Council (NARC), Khumaltar, Lalitpur

* Corresponding author email: premmagar12@gmail.com & Cell No. 9851167474

2 National Plant Breeding and Genetics Research Centre, NARC, Khumaltar, Lalitpur

3 National Wheat Research Program, NARC, Bhairahawa, Rupandehi

Several resistant varieties have been developed since the last many years but due to the year round evolution of new virulent pathotypes, they become susceptible. Management by growing resistant wheat cultivars is the best method in terms of economic and environmental concern. Also, due to the evolution of new races/pathotypes of stripe rust pathogen, searching for new sources of resistance is a never ending process. This study also provides genetic materials to the breeders for developing resistance wheat cultivars against the new pathotypes in the future. So, in this experiment, we were looking for new sources of resistance against stripe rust disease against the prevailing pathotypes in the country.

MATERIALS AND METHODS

Various wheat genotypes advanced to different stages of selection viz. advanced lines, NRN, IETs and CVTs (444 genotypes in 2018 and 457 in 2019) were received from National Wheat Research Program, Bhairahawa as National Wheat Disease Screening Nursery (NWDSN) for the evaluation of stripe rust resistance level at Khumaltar, Lalitpur. They were planted in the field in a 1 m long rod row design. Fertilizer dose 100:60:40 NPK kg/ha was applied with nitrogen as two split doses, one at the time of planting and another was applied during first irrigation. First Irrigation was done at crown root initiation (CRI) i.e. 21 days after sowing. Timely weeding was also done during the crop period viz. one at tillering stage and second at booting stage. Three weeks old seedlings of Morocco (susceptible variety) grown in earthen pots were inoculated with viable rust spores for multiplication of pathogen. The spores multiplied in the earthen pots were also spread uniformly in the field for congenial environment to maintain inoculum density in the field. In the meantime, the rust spores were also sprayed in the field using ULVA sprayer in the seedlings. Border rows of susceptible variety, Morocco, were also planted around each nursery and infected pots were placed in the border rows at a distance of 10 m each for a conducive environment for rust development.

Disease scoring at seedling stage was done using the 0 – 4 scale as described in the below table.

Infection Type (IT)	Description
0	*No visible symptoms*
;	*Hypersensitive flecks*
1	*Small uredinia with necrosis*
2	*Small to medium uredinia with green islands & surrounded by necrosis or chlorosis*
3	*Medium to large sized uredinia with chlorosis*
4	*Large uredinia without chlorosis*
X	*Heterogenous ITs*

+	*Uredinia somewhat larger than normal*
-	*Uredinia somewhat smaller than normal*
C	*More than normal chlorosis*
N	*More than normal necrosis*

Source: McIntosh et al. 1995

Adult plant resistance in the field was evaluated on the basis of host response to infection (pustule type and size) (Roelfs *et al.,* 1992) and disease severity – the proportion of the possible tissue surface (%) area infected by rust following to the modified Cobb's scale (Peterson *et al.,* 1948). Field response was recorded using following letters:

Field response	Description
0	Immune; *No visible infection on plants.*
R	Resistant; *visible chlorosis or necrosis, no uredia are present.*
MR	Moderately resistant; *small uredia* are present and surrounded by either chlorotic or necrotic areas.
M	Intermediate; *variable sized uredia* are present, some with chlorosis, necrosis or both.
MS	Moderately susceptible; *medium sized uredia* are present and possibly surrounded by chlorotic areas.
S	Susceptible; *large uredia* are present, generally with little or no chlorosis and no necrosis.

Based on the disease score, wheat genotypes were categorized under different levels of resistance and genotypes which showed susceptibility at seedling stage (3 or more) and resistant reactions during the adult stage were characterized as adult plant resistance (APR).

RESULTS

In 2018, most of the wheat genotypes (#315) were resistant to stripe rust disease at seedling stage. Seventy one entries showed an immune response to the disease while only 7 genotypes were resistant at adult stage. Similarly, 162 genotypes were found moderately resistant whereas 10 were recorded to have susceptible reactions. Eighty nine genotypes showed APR to stripe rust and 191 genotypes were resistant at both stages (Figure 1). The immune reaction genotypes were BL 4812, BL 4868, BL 4908, BL 4916, BL 4945, BL 4951, BL 4952, BL 4955, NL 1307, NL 1340, NL 1311, NL 1352, NL 1364, NL 1369, WK 1204, WK 2582, Bhrikuti, Kanti, PasangLhamu, Gautam, Danphe, Bandganga, Chyakhura, Dhaulagiri etc. Likewise, seven genotypes such as NL 1343, LIVINGSTON/5/2*W15.92/4/ PASTOR//HXL7573/2*BAU/3/WBLL1, PBW65/2*PASTOR, FRANCOLIN#1//WBLL1*2/BRAMBLING, WBLL1*2/4/YACO/ PBW65/3/KAUZ*2/TRAP//KAUZ/5/KACHU#1/6/MARCHOUCH*4/SAADA/3/2*FR ET2/KUKUNA//FRET2/7/WBLL1*2/4/YACO/PBW65/3/KAUZ*2/TRAP//KAUZ/5/ KACHU#1, WBLL1*2/4/ YACO/PBW65/3/KAUZ*2/TRAP//KAUZ/5/KACHU

#1/6/MARCHOUCH*4/SAADA/3/2*FRET2/KUKUNA//FRET2/7/WBLL1*2/4/YACO /PBW65/3/KAUZ*2/TRAP//KAUZ/5/KACHU#1 and NELOKI/4/MARCHOUCH *4/SAADA/3/2*FRET2/KUKUNA//FRET2/5/PBW343*2/KUKUNA*2//FRTL/PIFED were resistant to stripe rust at adult stage. Similarly, the genotypes like BL 4708, BL 4870, BL 4871, BL 4872, BL 4875, BL 4876, BL 4905, BL 4906, BL 4863, NL 1278, NL 1288, NL 1290, NL 1298, NL 1335, NL 1337, NL 1341, NL 1342, NL 1346, NL 1347, WK 2654, WK 2787, WK 2820, WK 2550, Vinayak, Siddhartha, Nepal 251, Munal etc. were moderately resistant at Khumaltar. Some of the genotypes having APR and resistant at both seedling and adult stages in 2018 were presented in Table 1 and 2 respectively.

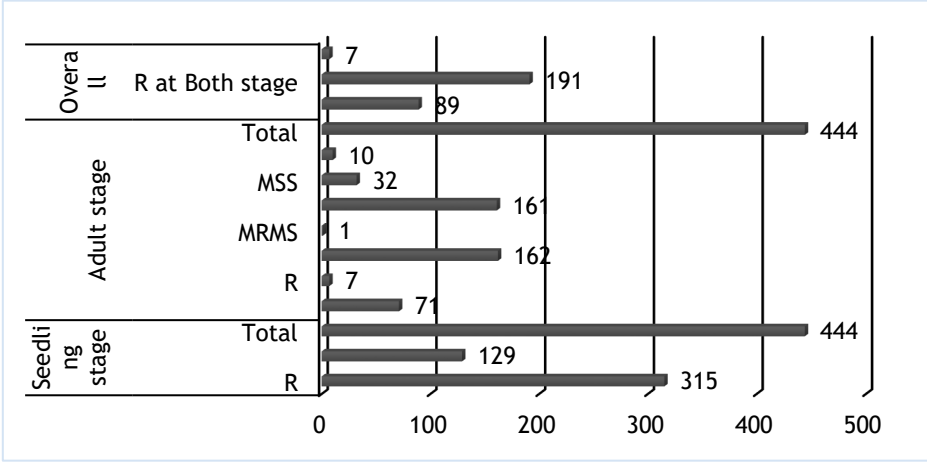

Figure 1. Wheat genotypes response to stripe rust in 2018 at Khumaltar, Lalitpur

Table 1. List of some APR genotypes from NWDSN tested at Khumaltar, Lalitpur in 2018

SN	Genotypes	Source	Seedling score	Adult score
1	BL 4872	NRN 2017-18	3	10MR
2	BL 4883	NRN 2017-18	33+	20MS
3	BL 4889	NRN 2017-18	3	20MR
4	BL 4894	NRN 2017-18	3	30MR
5	FRANCOLIN #1//WBLL1*2/BRAMBLING	NRN 2017-18	3	TR
6	HUW234+LR34/PRINIA*2//SNLG/3/BO KOTA	NRN 2017-18	33+	20MR
7	ROLF07*2/KIRITATI*2//PICAFLOR #1	NRN 2017-18	33+	10MR
8	BL 4909	NAL 2017-18	3	30MR
9	BL 4913	NAL 2017-18	33+	20MR
10	BL 4914	NAL 2017-18	33+	20MS
11	NL 1335	IET-MHH(2017-18)	33+	20MR
12	NL 1336	IET-MHH(2017-18)	3	20MS

13	NL 1347	IET-TTL(2017-18)	3	20MR
14	NL 1362	IET-TTL(2017-18)	33+	10MR
15	NL 1363	IET-TTL(2017-18)	3	10MR
16	NL 1202	CVT-TTL(2017-18)	33+	30MS
17	NL 1307	CVT-TTL(2017-18)	33+	20MS
18	NL 1298	CVT-TTL(2017-18)	33+	10MR

Table 2. List of some genotypes resistant at both seedling and adult stage in 2018 at Khumaltar, Lalitpur

SN	Genotypes	Source	Seedling score	Adult score
1	BL 4870	NRN 2017-18	2	20MR
2	BL 4904	NRN 2017-18	2	10MR
3	PBW65/2*PASTOR	NRN 2017-18	2	TR
4	BECARD #1/BAVIS	NRN 2017-18	2	10MR
5	BL 4905	NAL 2017-18	0;	10MR
6	BL 4952	NAL 2017-18	0;	0
7	BL 4953	NAL 2017-18	2	20MR
8	BL 4955	NAL 2017-18	2	0
9	PUB94.15.1.12/WBLL1	NAL 2017-18	2	10MR
10	KACHU/SAUAL*2//KINGBIRD #1	NAL 2017-18	0;	0
11	KACHU*2/CIRNO C 2008	NAL 2017-18	0;	20MR
12	WK 2820	IET-MHH(2017-18)	2	10 MR
13	WK 1204	IET-MHH(2017-18)	2	0
14	WK 2550	CVT-MHH(2017-18)	0;	10 MR
15	WK 1204	CVT-MHH(2017-18)	0;	0
16	NL 1343	IET-TTL(2017-18)	0;	TR
17	NL 1354	IET-TTL(2017-18)	2	10 MR
18	BL 4708	CVT-TTL(2017-18)	2	20 MR
19	NL 1311	CVT-TTL(2017-18)	2	0
20	NL 1317	CVT-TTL(2017-18)	2	10 MR

Out of 457 wheat genotypes, 233 were resistant and the rest were susceptible to stripe rust at seedling stage in 2019. Meanwhile, thirty five genotypes/crosses were found immune in the adult stage that means they were free from this disease. Three hundred eleven genotypes were moderately resistant to stripe rust. Similarly, 7 were resistant, 26 were moderately resistant to moderately susceptible, 62 were moderately susceptible and 16 were found susceptible to the disease. Out of 457 wheat genotypes, 201 genotypes showed APR against stripe rust disease. Two

hundred eight genotypes were resistant and only twelve genotypes were susceptible in both stages (Figure 2). Likewise, some genotypes such as Pitik 62, Annapurna-1, Annapurna-3, Bhrikuti, Kanti, Pasang Lhamu, Gautam, WK 1204, NL 971, Gaura, Dhaulagiri, Tilottoma, Chyakhura, BL 4407, NL 1307, NL 1327, NL 1179, Khajura durum 1 and Khajura durum 2 from WVD (Wheat Varietal Display) showed moderately resistant reaction to stripe rust. Some moderately resistant genotypes from NRN and advanced lines were BL3623/NL1070, BECARD/NL1128, VIJAY/NL1095, ADITYA/NL1140, BECARD/NL1128, NL1042/BL4282, BL3530/NL1129 etc. Similarly, genotypes like NL 1278, NL 1288, NL 1318, NL 1322, WK 2748, WK 2820, WK 2832, WK 2602, WK 2582, BL 4837, BL4863, BL 4879, BL 4880, NL 1330, NL 1334, NL 1335, NL 1340, NL 1342, NL 1350, NL 1362, NL 1367 etc. showed moderately resistance to yellow rust disease at Khumaltar. Some genotypes having APR and resistant at both stages in 2019 were presented in Table 3 and 4 respectively.

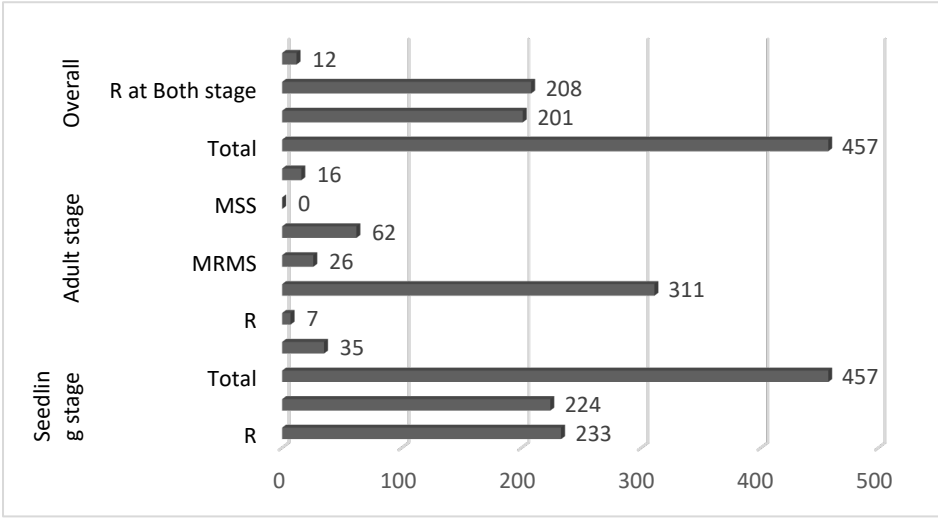

Figure 2. Wheat genotypes response to stripe rust in 2019 at Khumaltar, Lalitpur

Table 3. List of some APR genotypes from NWDSN tested at Khumaltar, Lalitpur in 2019

SN	Genotypes	Source	Seedling score	Adult score
1	VIJAY/NL1095	NRN 7	33+	20MR
2	ADITYA/NL1140	NRN 8	33+	20MR
3	UP262/KIRITATI//PRL/2*PASTOR	NRN 16	33+	TR
4	ADITYA/WAXWING/CIRCUS	NRN 21	3	20MR
5	ZINCOL/VALI	NRN 79	3	10MR
6	MUNAL*2/WESTONIA	NRN 86	33+	30MR

7	BAV92/SERI	NAL 187	33+	20MS
8	NADI/COPIO//NADI	NAL 225	33+	20MR
9	WK2832	CVTMH 18	33+	20MR-MS
10	BL4782	CVTMH 1	33+	20MS
11	WK2748	CVTMH 5	33+	20MR
12	WBLL4//OAX93.24.35/WBL L1 =NL1397	IETMH 15	3	20MR
13	WK3164	IETMH 25	33+	20MR-MS
14	WK3165	IETMH 26	3	10MR
15	BL 4928	IETTTL 2	33+	20MR
16	BL 4946	IETTTL 3	33+	30MS
17	BL 4947	IETTTL 4	33+	20MR-MS
18	BL4820	CVTTTLI 2	33+	20MR
19	NL1318	CVTTTLI 4	3	20MR
20	NL1349	CVTTTLI 12	33+	30MS

Table 4. List of some genotypes resistant at both seedling and adult stage in 2019 at Khumaltar, Lalitpur

SN	Genotypes	Source	Seedling score	Adult score
1	BL3635/NL1160	NRN 9	1	10MR
2	BL3635/NL1160	NRN 10	0	TR
3	WK1204/KINGBIRD	NRN-19	0	0
4	NL 297/NL1133	NAL 1	0	0
5	NL1055/WK2163	NAL 2	1	20MR
6	NL1097/NL971	NAL 7	2	10MR
7	BL4343/KAMB//BL4424	NAL 42	0	10MR
8	NL1340	CVTMH 13	2	10MR
9	NL1341	CVTMH 14	2	0
10	BL 4880	IETMH 3	2	10MR
11	WK2891	IETMH 21	2	10MR
12	WK3166	IETMH 27	2	10MR
13	BL 4952	IETTTL 5	1	10MR
14	NL1322	CVTTTLI 5	2	20MR
15	NL1344	CVTTTLI 10	1	20MR
16	NL1350	CVTTTLI 13	0	10MR
17	NL1362	CVTTTLI 16	2	10MR
18	NL1367	CVTTTLI 17	2	10MR

DISCUSSION

Wheat diseases commonly, leaf rust and stripe rust, foliar blight, powdery mildew, loose smut and hill bunt are the major threats to wheat production in Nepal. Various methods like chemical, cultural and resistant varieties have been used to manage these diseases. Several resistant genotypes against stripe rust disease have been developed and released during the last couple of decades. But due to the year round evolution of new races of the pathogen, those resistant genotypes became susceptible after years of adaptation like WK 1204, Dhaulagiri and Danphe which were released in 2007, 2012 and 2015 respectively now become susceptible to stripe rust in mid and far western hills of Nepal (Thapa, 2020). Both the years were favorable from a disease point of view since there was winter rain time and again. Stripe rust was very much severe in both the years. Karki and Karki (1996) also mentioned that stripe rust disease of wheat is very sensitive to environmental changes and its occurrence is not very regular. A disease becomes epidemic when susceptible variety is favored by suitable weather conditions along with virulent pathogen at specific location and time. So, regular screening of wheat genotypes against stripe rust under field conditions in different locations over the country should be given priority before releasing any varieties. Several scientists have done regular screening activities and they found some resistant lines against stripe rust disease. Two hundred ninety five entries were found resistant to stripe rust (Bhandari *et al.,* 2003). Similarly, Basnet *et al.,* 2016 revealed that 223 genotypes were resistant to stripe rust disease at Dailekh.

Genotypes such as WK 1204, Pasang Lhamu, Dhaulagiri, Bandganga, BL 4880, BL 4952, NL 1340, NL 1341, NL 1342, NL 1350, NL 1362 and WK 2787 were found resistant in both years against stripe rust disease at Khumaltar. But WK 1204 and Dhaulagiri became susceptible to stripe rust in 2020 at mid and far western hills. This might be due to the evolution of new races or prevalence of different races according to locations. Currently, we have had 4 stripe rust pathogen races viz. 46S119, 47S103, 78S84 and 110S119 prevailing in different parts of the country (PPD 2019 and NPPRC 2020) which were also used for the evaluation of wheat genotypes against this disease at Khumaltar. So, wheat genotypes showing APR and resistant at both seedling and adult stage at Khumaltar can represent the same resistance level across the country. So, we suppose that they may perform well anywhere in the country and recommend them for further varietal development processes. Also, we recorded some wheat genotypes immune at seedling stage and became susceptible at adult stage. This happens when more than one rust race was present at the same site where genotypes showed resistant reactions at seedling to one race which might become susceptible to another race at adult stage. So, wheat genotypes having APR to stripe rust can be utilized as resistant donors in

wheat breeding programs for the development of durable stripe rust resistant varieties. Similarly, we found a large number of wheat genotypes showing resistant at both stages might be the good sources of major and minor gene(s) against stripe rust disease and can be used for resistance breeding purposes.

CONCLUSION

There were abundant wheat genotypes having APR (#89 in 2018 and #201 in 2019) which can be utilized for developing durable stripe rust resistance varieties in the future. And for confirmation, those APR gene(s) should be identified by marker assisted selection (MAS). Also, genotypes which were resistant at both seedling and adult stages (#191 in 2018 and 201 in 2019) could be the source of major and minor gene(s) for stripe rust resistance and they can be used as resistant donors for breeding purposes. Similarly, genotypes like BL 4880, BL 4952, NL 1340, NL 1341, NL 1342, NL 1350, NL 1362 and WK 2787 which were resistant in both years against stripe rust disease can be selected for the varietal development process.

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FARMERS' KNOWLEDGE ON INSECT PESTS OF CITRUS (*Citrus reticulata*) AND THEIR MANAGEMENT IN GULMI DISTRICT OF NEPAL

S. Chhetri[1], S. Bhatta[2], N. Kafle[3], B. Dahal[4] and P.S. Subedi[5]

ABSTRACT

A study was carried out to assess farmers' knowledge on insect pests of citrus and Integrated Pest management in citrus zone, Gulmi district. Survey sample size of 105 was taken from Dhurkot Rural Municipality, Chatrakot Rural Municipality and Resunga Municipality of the Gulmi district. Respondents were selected using simple random sampling technique and interviewed. The primary data were collected using pretested questionnaire. The knowledge on citrus insect pest is significantly associated positively with total citrus cultivation area (p=0.1%). The average years of engagement of 23.3 years and average mandarin cultivation area of 0.35 ha gives insight to great potentiality of farmers adopting integrated pest management. The result shows insect's severity as one of the major problems with major insect pest of citrus as fruitfly, green stink bugs, white grubs, leaf miner, aphid and rent ants. Although (74.3 %) of the total respondents were found to have knowledge about term "IPM technology", only (35.2%) practiced IPM practices till date. The positive attitude and perception of citrus growers towards IPM technology in the study area depicts great scope for profitable citrus production on a sustainable basis.

Keywords: Citrus, Integrated Pest Management, Knowledge

INTRODUCTION

Fruits contribute about 7% of total Agriculture Gross Domestic Product of Nepal (MoALD, 2017). Citrus is the important cash crop for the hill farmers of Nepal contributing 26.84% of the total fresh fruits production. The total production is 2,45,176 mt. however, the average productivity is only 9.4 mt/ha. in 2017/18 (MoALD, 2019b). The history of citrus in Nepal is not well documented but commercial cultivation started only after 1970 (NCRP, 2019). At present major citrus producing district are Illam, Paanchthar, Terathum,

1 Agri-intern, Agriculture and Forestry University, Prime Minister Agriculture Modernization Project, Gulmi, Nepal, Email address: csadhana2@gmail.com Telephone no: +977 9860835003

2 Assistant professor, Agriculture and Forestry University, Rampur, Nepal

3 Senior Horticulture Development Officer, Ministry of Agriculture and Livestock Development, Nepal

4 Senior Planning Officer, Ministry of Agriculture and Livestock Development, Nepal

5 Agri-intern, Agriculture and Forestry University, Rampur, Nepal

Dhankuta, Bhojpur, Sindhuli, Ramechap, Kavre, Dhading, Gorkha, Lamjung, Tanahu, Kaski, Shyangja, Gulmi, Arghakhanchi, Dailekh, Dadeldhura ((Pokhrel, 2011). The production of citrus is increased by more than two folds in last decade which is mainly contributed with increase in area of production despite of the slow growing productivity. The mid-hill region of Nepal with altitude of 1000 to 1500 meter above sea level has a comparative advantage for citrus cultivation when compared to food grain crops like rice, wheat, maize and found to be more profitable (Gauchan, 1994). The data show a citrus production surplus of 3860 mt in Gulmi (DADO, 2017). Being a leading producer of citrus in the western hill of Nepal, Gulmi has managed productivity of 11.38 mt/ha (DADO, 2017).

Gulmi is located in the sub-tropical region characterized by temperature higher than 20-degree celcius (DSWASHP, 2016). Temperature is the single most important environmental factor influencing insect behavior, distribution, development, survival, and reproduction (Petzoldt & Seaman). Therefore, higher temperature in citrus zone of Gulmi favors the increase incidence of insect pest attack. Annual crop loss due to insect and vertebrate pests is estimated at 25% to 38% (Lamsal, 2016). Citrus industry suffers 25% yield loss due to ravages of insect pests (Dhawan, Singh, Bhullar, & Arora, 2013).

Potential productivity of Citrus at field condition in Gulmi district is expected to be higher than the productivity of 9.1 MT/ha which is less than national productivity of 10 MT/ha (MoALD, 2018). The improvement in citrus fruit production and quality that a grower can achieve through choice of scion/ rootstock combinations, good irrigation management, balanced nutrition and proper pruning may easily be overwhelmed by pests, diseases and other injuries (Zekri, December 2011). Therefore, the key to successful production of citrus lies in the effectiveness of long-term pathogen- and pest-management strategies. As with many tropical and subtropical crops, citrus is host to various pathogens and pests, but it is also one of the few crops that is susceptible to a number of destructive diseases that are continuously emerging and which can severely limit or totally decimate production (Paula, *et al.*, 2009).

The government has executed Prime Minister Agriculture Modernization Project where the area is divided into super zone, zone, block and pocket. Under PMAMP, Citrus Zone Gulmi was established in 2018. The zone includes six rural municipalities: Dhurkot, Kaligandaki, Chandrakot, Madane, Chhatrakot and Gulmidurbar and two municipalities: Resunga and Musikot.

INSECT PEST OF CITRUS

CITRUS LEAFMINER: *Phyllocnictis citrella* (LEPIDOPTERA: GRACILLARIDAE)
Leafminers generally feed on new growth (Paula, *et al.*, 2009). They can cause severe damage to the leaves of trees less than three years old. Established trees are less affected. Damage is usually worst when there is new flushing growth in early autumn, depending on temperature. Citrus leafminers are naturally controlled by small parasitic wasps. Damaged leaves can be pruned out but if chemical control is required spray new foliage with horticultural oil from summer to autumn (Lacey & Broughton).

CITRUS PSYLLID: *Diaphorina citri* (HEMIPTERA: LIVIIDAE)
Psyllids cause injury resulted from the withdrawal of sap from the foliage, and transmit the organisms that cause Huanglongbing (greening disease) and also produce copious amont of honey dew promoting sooty mould (UF/IFAS, 1998). Soil application of imidacloprid reduced thinfestation levels and densities of Diaphorina citri Kuwayama on flush shoots (Sétamou, *et al.*, 2010).

CITRUS WHITEFLY: *Dialeurodes citri* (HEMIPTERA: ALEYRODIDAE)
The whitefly injures the plant by consuming large quantities of sap, which it obtains with its sucking mouth parts. This black fungus may cover the leaves and fruit so completely that it interferes with the proper physiological activities of the trees. Heavily-infested trees become weak and produce small crops of insipid fruit. Also, fruit covered with sooty mold will be retarded in ripening and late in coloring, especially the upper part, which may remain green after the lower portion has assumed the color of ripe fruit (UF/IFAS, 1998).

CITRUS APHID: *Toxoptera citricida* (HEMIPTERA:APHIDIDAE)
Nymphs and adults both suck sap from tender leaves and shoots. Affected leaves turn yellow, get curled, deformed and dry up. Growth of young shoots is adversely affected. Shooty mould is produced on honeydew excreted by aphids. Aphids also act as the active vectors of Citrus Tristeza Virus (Dr.D.B.Ahuja & Dr.N.Sabir).

CITRUS OR LEMON BUTTERFLY: *Papilio demoleus* (PAPILIONIDAE:LEPIDOPTERA)
The caterpillars fed on young foliage at the nursery stage and also feed on young flushes of grown-up trees. Caterpillar feed voraciously on leaf lamina leaving behind only midrib. In case of severe infestation entire tree is defoliated (Kedar, K.M., & Bawaskar).

FRUIT FLIES: *Bactocera dorsalis* (TEPHRITIDAE:DIPTERA)
Fruit flies are one of the world's most destructive pests of most fruit and vegetable crops both in terms of production and trade (Adhikari & G.C, 2020). Fruit fly is a problem causing considerable loss in productivity of citrus and

cucurbits and management tactics include use of pheromone trap, application of chemical pesticides, and sanitation (Sharma, Adhikari, & Tiwari, 2015). Judicious use of insecticides, early harvest and removal of fallen fruits reduce fruit fly damage (Umeh, Olaniyan, & Andir, 2004). Fruit fly management tactics includes the use of pheromone trap, application of chemical pesticides and sanitation (D. R. Sharma, 2015).

SCALE INSECTS: (HEMIPTERA: COCCOIDEA)

The armoured scale damages the fruits and form blemishes at low levels of infestation and in severe cases they damage tree badly. The soft scale insects secrete honeydew on which sooty mould fungus grows (Frank, 2010).

GREEN STINK BUG (HEMIPTERA: PENTATOMIDAE)

Stink bug feeding on fruit trees can result in extensive damage, and feeding injury in the early developmental stage of the fruit results in the most damage. Feeding injury results in blemishes on the skin, yield loss, misshapen fruit, or catfacing (Kamminga, Koppel, Herbert, & Jr., 2012)

ROOT WEEVILS (COLEOPTERA: CURCULIONIDAE)

Adults feed on buds and young leaves. Damage to the root system of citrus plants by the larvae of the citrus root weevil usually results in reduced water and nutrient flow, which often causes wilting of the plant and subsequent reduction in fruit size (Paula, *et al*., 2009).

INTEGRATED PEST MANAGEMENT IN CITRUS

IPM is an approach which assess the pest situation, evaluates the merits of pest management options and then implements a system of complementary management actions within a defined area (H.S.Abd, De, & Jirli, 2015).

Cultural method

Cultural practices include those practices that reduce pest establishment, reproduction, dispersal and survival by using healthy production practices. It includes practices like field sanitation, crop rotation, mixed cropping, intercropping, use of pure seed, deep ploughing, use of recommended spacing, fertilizer dose, appropriate method of irrigation etc. It includes summer deep ploughing to expose soil inhabiting stages of insect, pathogen and nematode population. Only certified seeds and resistant rootstocks should be used. IPM package also recommends use of *Trichoderma* spp with organic matters to improve soil health and management of certain soil borne disease. For the management of citrus white fly and scaly bug intermingling branches should be pruned and spacing trees at closed distances should be avoided so that sunlight can reach through the canopy from all sides (Ragunathan, 2001).

Mechanical method

Mechanical methods comprise of the direct action of killing the pests or blocking the entry of the pests to the crop of interest. It includes the practices like hand picking and killing, rouging, pit digging, use of dummy, light traps, pheromone traps etc. Installation of light trap can be done to attract and kill the insects such as borers, bugs, beetles, whitefly, fruit fly etc. Spraying of 2% starch is recommended in souty mould affected orchard (Ragunathan, 2001)

Biological method

Biological method uses the natural enemies such as parasites, predators, pathogens and competitors to control pests and their damage.

- Conservation
  Conserve predators viz., *Amblyscius tetranychivorus, Chrysoperla carnea, coccinellids, Cryptolaemus montrouzieri, Mallada boninsis Menochilus sexmaculatus,* spiders and parasitoids viz., *Apanteles, Aphytes proclia Leptomastix dactylopii* etc.
- Augmentation
  Monitor the incidence of citrus black/white flies and aphids and release 10-15 eggs or first instar larvae *of Chrysoperla* or *Mallada* per plant. Avoid spraying with insecticides for at least one week after the release of bio-control agents (Ragunathan, 2001).

Chemical Method

Need based, judicious and safe applications of pesticides are the most vital triplicate segments of chemical control measures under the ambit of IPM. It involves developing IPM skills to play safe with environment by proper crop health monitoring, observing ETL and conserving natural biocontrol potential before deciding in favour of use of chemical pesticides as a last resort (Ragunathan, 2001).

Systemic and contact chemical insecticides are used to kill insects according to their feeding habit. Commonly used chemical pesticides are Malathion, Dichlrovos, Immidachloropid, Chloropyrifos which are sold in different trade names (Ragunathan, 2001).

Legislative method

Legislative method includes phyto-sanitary and quarantine measures to control the arrival of new insect pests from another infested area to the area for the interest.

This research is an attempt to picture the knowledge level of farmers regarding the insect pests of mandarin and their management practices which would help concerned stakeholders and institutions to run insect pest management technology feasible in this region. The major objective of this

study was to assess farmer's knowledge on insect pests of citrus and their management in Gulmi Specific objectives:

1. To assess various socio-demographic condition and citrus production status of citrus growers in Gulmi
2. To find out the knowledge of farmers on insect pest and analyze their relationship with various attributes of socio-demographic characters. Rape seed production,
3. To identify major citrus production constraints in Gulmi
4. To identify major insect pest of citrus in Gulmi
5. To find out the knowledge and perception of farmers on the application of IPM practices in citrus cultivation.

METHODOLOGY

SELECTION OF SITE

Gulmi is located in mid hill area of western region, province 5 surrounded by Palpa, Argakhanchi, Baglung, Parbat and Pyuthan. The area of this district is 1149 square kilometer. The district is at an altitude range of less than 1000 masl and greater than 2000 masl. The mean annual temperature ranges from 0 degree Celcius to more than 20 degree celcius (DSWASHP, 2016). Gulmi is leading district for citrus production in western hill of Nepal. It has total area of 1543 ha of citrus cultivation which majorly include mandarin, sweet orange, and lime, a productive area of 843 ha with production of 9695 Metric ton and yield of 12 Mt/ha (DADO, 2017). This study was conducted in citrus zone area of Chatrakot Rural Municipality, Resunga Municipality and Dhurkot Rural Municipality of Gulmi district, a potential area for mandarin production as prioritized as zone by PMAMP project.in year 2020. The selection was based on high citrus production and farmer's engagement in citrus cultivation and orchard management.

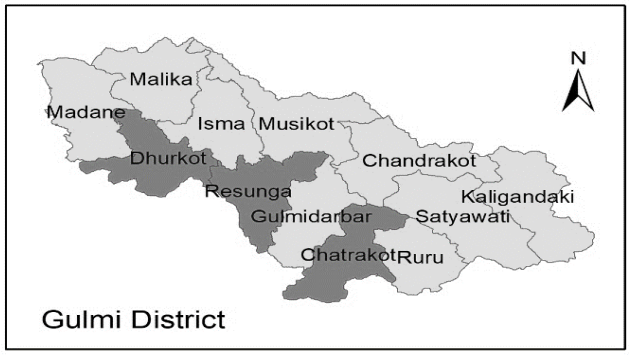

Figure 1: Study site for field survey at Gulmi District

SELECTION OF POPULATION AND SAMPLE

Sampling framework of households was prepared from preliminary field visit and data of citrus zone profile obtained from the Project Implementation Unit, Gulmi office. A total of 105 sample households were drawn from the sampling frame prepared by citrus zone using simple random sampling technique. The sampling was done using random number table in Microsoft Excel 2015. The number of the household to be surveyed is decided by using Raosoft sample size calculator, using following information:

Total number of households (Population size): 3000
Confidence level: 90%
Margin of error: 10%
Response distribution: 50%

RESEARCH DESIGN

Preliminary field visits

Preliminary field visits were conducted prior to the survey to collect information about the farming techniques, socio-cultural settings, demographic and topographic features of the study area. Five households and its citrus orchard from each municipality were visited randomly. The information collected was used while preparing the interview schedules, designing sampling framework and applying sampling techniques.

Key Informant Interview (KII)

A total of 10 concerned stakeholders like progressive farmers, members of the executive operating committee of the citrus zone, local leaders and members of the community-based organizations, etc. were selected as key informants of citrus production in the study area. The first-hand knowledge of citrus production and use of management practices to control insect pest of citrus was used for the purpose of verifying the information obtained from the household survey.

Focus Group Discussions (FGDs)

Three focus group discussion was conducted with representatives of farmers' groups and and other progressive farmers of the three municipality of citrus zone. It was conducted before designing the questionnaires to know the scenario of Integrated Pest Management adopted by farmers for various insect pest. The information was used to design questionnaire for the study.

PRE-TESTING OF QUESTIONNAIRES

The questionnaire was pre-tested before field survey for checking the reliability and validity and then necessary adjustment were made as per the requirements after administering the questionnaire to the 5% farmers of vicinity area.

QUESTIONNAIRE SURVEY

A questionnaire survey was conducted among respondents with questions seeking socio-demographic information, production status, major constraints in citrus production, and knowledge on insect pest, integrated pest management and other related information from citrus growing farmers.

SOURCES OF INFORMATION

PRIMARY DATA

Primary data was collected using research designs; questionnaire survey, focus group discussion, key informant interview and field visits. The primary method was used to collect the data and share experience and knowledge of the community.

SECONDARY DATA

Different secondary sources of data as given below were reviewed during the study for relevant information.

i. Documents and publications of MOAD, AICC, NPC, NARC, PM-AMP for area, production and productivity data.
ii. Reports and publications of various concerned NGO's and INGO's like FAO for insect pest of citrus and their management technique
iii. Journal articles of AFU, TU and other reputed national and international universities and journals

DATA ANALYSIS TECHNIQUES

The data were analyzed using Statistical Package for Social Science (SPSS) version 25, Microsoft excel 2015.

Following statistical measures were used for the data analysis

a. Frequency and percentage
b. Correlation
c. Scaling technique
    - Scale of Importance
    - Likert scale for measuring perception

SCALING TECHNIQUE

Scale of Importance

Constraints were assessed by group discussion. Respondents were asked to rank the problems in mandarin cultivation and reasons with most significant reasons followed by less significant ones. As well as they were asked to rank insects based on its severity. The data was collected and based on it, frequencies and weighted index were calculated accordingly. The reasons were ranked by using seven-point scales for problems in mandarin cultivation

and nine-point scales in insect severity. Scale value of 0.85, 0.7, 0.56, 0.42, 0.27, 0.13 and 0.012 was given to most important reasons followed by less significant for problems in mandarin cultivation. Scale value of0.89, 0.79, 0.66, 0.55, 0.44, 0.33, 0.22, 0.1 was given to most important reasons followed by less significant for insect severity. The index of importance was computed by using following formula;

- I_{imp} =$\sum\frac{SiFi}{N}$

Where I_{imp}= Index of importance

∑= Summation

S_i= i_{th}scale value

F_i= Frequency of i_{th} importance given by respondent

N= total number of respondents

Likert scale for measuring perception

Respondents were given six statements about the IPM practice and were asked to answer in five terms as strongly agree-5, agree-4, neutral-3, disagree-2 and strongly disagree-1 with code value as 5 type likert scale. The data was collected and based on it, frequencies, percentage and standard deviation were calculated accordingly. The standard deviation data corresponds to the code value and determine the perception in five above mentioned terms.

VARIABLES AND THEIR MANAGEMENT

INDEPENDENT VARIABLES

The selected socio-demographic and production status like age, gender, ethnicity, religion, family size, main occupation, education level, types of agriculture, years of engagement in citrus production and productivity were independent variables.

The respondents having different ages, family size, years of engagement in citrus production and productivity were divided into three categories for each variable using the following method.

Table 6: Method for categorizing respondents using mean and S.D.

S.N.	Categories	Range
1	Low	Less than mean – S.D.
2	Medium	in between mean ± S.D.
3	High	Above mean + S.D.

DEPENDENT VARIABLES

Knowledge and perception on insect pest and their management by farmers were taken as the primary dependent variable.

RESULTS AND DISCUSSION

SOCIO DEMOGRAPHIC CHARACTERISTICS OF RESPONDENTS

Distribution of Respondents by Gender, Age, Ethnicity and Religion

The study conducted on study area showed different data than district average with male higher (68.6 percent) and female lower (31.4 percent). However, 57 percent female and 43 percent male reside in Gulmi district (CBS, 2011). The average age of respondents was 47.28 years. Two types of religions: Hindu religion (98.1 percent) and Buddhism religion (1.9percent). The district profile also shows Hinduism (97 percent) as a major religion while Buddhism is followed by 3 percent (NepalMap, 2011). The study conducted on study area showed that majority of the respondents (48.6 percent) in the study area were Bhramin followed by Chhetri (39.4 percent), Dalit (6.7 percent) and Janjati (5.7 percent). However, the district profile shows Bhramin (25%), Chhetri (23%), Janjati (23%) and Dalit (26%) and others (3%) (NepalMap, 2011).

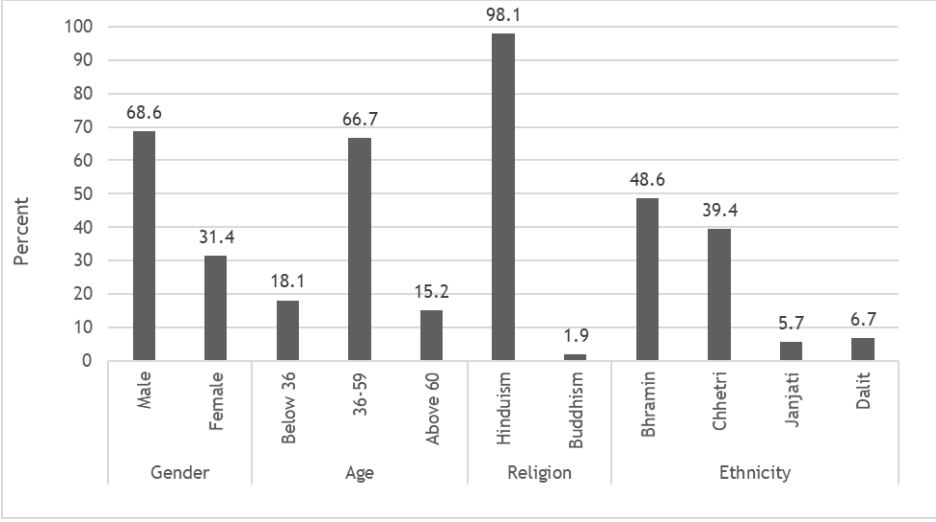

Figure 1. Distribution of respondents by gender, age, religion and ethnicity

Distribution of respondents by family size, level of education, main occupation and type of agriculture

The average family size in the study area is 5.87 whereas the district profile shows the average family size as 4.32 (NepalMap, 2011).

The study showed that majority of the respondents (32.4 percent) acquired certificate level education followed by primary level education (23.8

percent), secondary level education (21.9 percent), no education or illiterate (18.1 percent) and few (3.8 percent) acquired university level. The result shows the education level different than district education level as primary (41 percent), secondary (21 percent), certificate level (10%) and university (1%) (NepalMap, 2011).

The study showed that the major occupation of the respondents of the study site was agriculture (61 percent). The second major occupation in the study site was service (24.8 percent) followed by trade (17.1 percent). The agricultural sector provides employment opportunities to 65.6% of the total population of Nepal (AICC, 2019). This shows less adoption of agriculture as main occupation than the national data.

The study showed that type of agriculture adopted by most of the respondent is semi commercial (34.3 percent) and subsistence (34.3 percent) whereas (31.4 percent) of total respondent adopted commercial agriculture. This shows that people in the study site adopt all three types of agriculture nearly in the equal ratio.

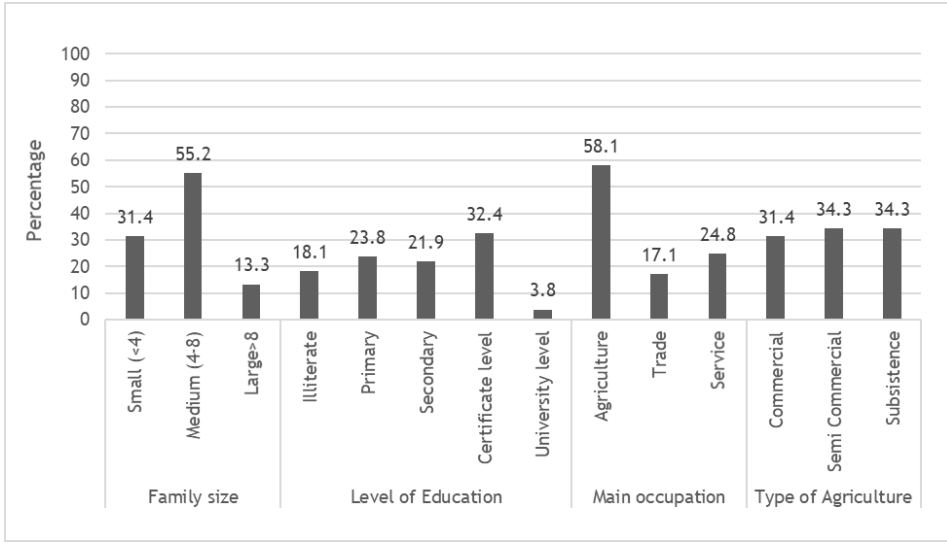

Figure 2. Distribution of respondents by family size, level of education, main occupation and type of agriculture

MANDARIN CULTIVATION STATUS

YEARS OF ENGAGEMENT IN CITRUS CULTIVATION

Results indicated that most of the respondents (64.8 percent) were engaged in mandarin cultivation for 26 years followed by engaged for less than 10 years (19 percent) and for more than 37 years (16.2 percent).

Table 1: Distribution of respondents by years of engagement in mandarin Cultivation in Gulmi district (2020)

Years engaged in Mandarin Cultivation	Frequency	Percent
Less than 10	20	19
26	68	64.8
More than 37	17	16.2
Total	105	100
Mean		23.3
Std. deviation		13.50

The average years of engagement in mandarin cultivation from field survey was 23 years.

Distribution of respondents by Mandarin cultivation area

The distribution of mandarin cultivation area of respondents was categorized into three groups as small, medium and large by using mean and standard deviation. Small size mandarin cultivation area consists of less than 0.01 ha of land; medium size farm (0.01-0.69) ha and large size farm more than 0.69 ha of land. The study showed that majority of the respondents owned medium size mandarin cultivation area (85.7 percentage) followed by large (percentage).

Farm size does have an effect on technology adoption (Urquhart, 1999). On the one hand, the intensity of management required for IPM is easier to attain on a smaller farm (Urquhart, 1999). Larger farms (of around 6000ha) in general tend to be more chemically-oriented in their approach (Urquhart, 1999). However, larger farms generally also have more resources available to implement biological control measures, although intensive management is more complicated because of their size (Urquhart, 1999).

Table 2. Distribution of respondents by mandarin cultivation area in Gulmi district (2020)

Mandarin Cultivation area (In hectare)	Frequency	Percent
>0.01 to <0.69	90	85.7
More than 0.69	15	14.3
Total	105	100
Mean		0.35
Std. Deviation		0.34

The result indicated that eighty six percent respondents had medium size land holding. The average size of mandarin cultivation area of respondents was 0.35 hectare.

PRODUCTIVITY OF MANDARIN IN THE STUDY AREA

The study showed that majority of the respondents (77.1 percent) had moderate productivity followed by high productivity (17.1 percent) and low productivity (5.7 percent). The average productivity of mandarin in the study site was 6.83 mt/ha. The average productivity of mandarin in Gulmi district is 11.38 mt/ha (DADO, 2017). This shows that the productivity of study site is less than the district's productivity.

Table 3: Distribution of respondents according to the productivity of mandarin in Gulmi district

Mandarin productivity (Mt/ha)	Frequency	Percent
Low (up to 0.23)	6	5.7
Moderate (0.23-13.46)	81	77.1
High (13.46)	18	17.1
Total	105	100
Mean		6.83 Mt/ha
Standard deviation		6.62 Mt/ha

Constraints in Mandarin production

The eight most important constraints faced by the respondents in mandarin production were insect severity of fruit fly, white grubs, red ants, green stink bugs and disease severity of root rot, citrus greening, shooty mould, lack of proper fertilization and manuring, lack of irrigation facility, higher wages, severe fruit drop and hailstones impact as shown in table. Table indicates that insect's severity was the major problem as obtained from field survey followed by disease severity and lack of irrigation facility. While hailstones impact being the least problem.

Table 4: Ranking of mandarin production constraints in Gulmi district

Problems	Rank	Index	Weighted Mean
Insect severity	I	0.895	94
Disease severity	II	0.672	70.571
lack of proper fertilization and manuring	VI	0.234	24.665
Lack of Irrigation facility	III	0.413	43.368
Higher wages	IV	0.350	46.788
Severe Fruit drop	V	0.309	32.499
Hailstones Impact	VII	0.227	23.91

FARMER'S KNOWLEDGE IN INSECT PEST OF CITRUS

KNOWLEDGE ON IDENTIFICATION OF HARMFUL AND BENEFICIAL INSECT

During the study five each of harmful insects: Citrus leafminer (*Phyllocnictis Citrella*), Citrus butterfly (*Papilio demoleus*), Fruit flies (*Bactocera dorsalis*), Green stink bug, White grubs and beneficial insects: Ladybird beetle (*Coccinella septumpunctata*), Ground Beetle, Syrphid Fly, Tiger Beetle and

Spider were shown to respondents. Respondents identifying more than three insects each of harmful and beneficial were considered able to identify them. The majority of the respondents (75.2 percent) were able to identify the harmful insects while rest of 24.8 percent respondents were unable to identify harmful insects. Whereas 53.3 percent respondents could identify the beneficial insects and 46.7 percent of the respondents could not identify the beneficial insect. This data shows that majority of the respondents had knowledge to identify the insects and pest.

KNOWLEDGE ON IDENTIFICATION OF MANDARIN INSECT PESTS DAMAGE SYMPTOMS

The study showed that 56.2 percent of the respondents could identify insect pest damage symptoms in mandarin while rests of 43.8 percent were unable to identify insect wise damage symptoms in Mandarin. This data shows that majority of the mandarin growing farmers of this study site are well acquainted with the mandarin insect pest damage symptoms of mandarin

Table 5: Knowledge on identification of insect pests and their damage and symptoms

Knowledge on Insects Pest	Coef.			Std. Err
	Harmful Insects	Beneficial Insects	Symptoms and Damage	
Age	0.174	0.174	0.260	1.925
Sex	-0.267	-0.466**	-0.540**	0.079
Ethnicity	-0.358**	-0.03	0.023	0.106
Religion	0.111	0.098	0.097	0.025
Family size	0.88	0.191	0.162	0.104
Education level	0.136	0.255	0.165	0.190
Main Occupation	0.123	-0.147	-0.163	0.128
Types of agriculture	-0.276	-0.527**	-0.552**	0.121
Years of engagement in citrus cultivation	0.280	0.240	0.193	2.333
Total citrus cultivation area	0.227	0.289	0.329*	1.206
Productivity	0.256	0.214	0.218	797.683

The knowledge on harmful insect of citrus orchard is positively influenced by age, religion, family size, education level, main occupation, years of engagement in citrus cultivation, total citrus cultivation area and productivity while negatively influenced due gender, ethnicity, types of agriculture followed by respondents. The knowledge on harmful insects of citrus orchard

is negatively influenced with ethnicity of respondents is found significant at 5% level of significance

The knowledge on beneficial insect of citrus orchard is positively influenced by age, religion, family size, education level, years of engagement in citrus cultivation, total citrus cultivation area and productivity while negatively influenced due gender, ethnicity, main occupation and types of agriculture followed by respondents. The knowledge on beneficial insects of citrus orchard is negatively influenced with gender and types of agriculture which is found significant at 5% level of significance.

The knowledge on damage and symptoms of citrus insect pest infestation in orchard is positively influenced by age, religion, ethnicity, family size, education level, years of engagement in citrus cultivation, total citrus cultivation area and productivity while negatively influenced due gender, main occupation and types of agriculture followed by respondents. The knowledge on damage and symptoms of citrus insect pest infestation of citrus orchard is negatively influenced with gender and types of agriculture which is found significant at 5% level of significance. Whereas, the knowledge on damage and symptoms of citrus insect pest infestation of citrus orchard is positively influenced with total citrus cultivation area which is found significant at 10% level of significance which must be due to larger the cultivation area more the farmers are likely to get acquainted with damage and symptoms of insect pest

MAJOR MANDARIN INSECT PESTS OF THE STUDY AREA

The major insect pest found in the study area are fruitfly, green stink bugs, white grubs, leaf miner, aphid and rent ants. The minor insect pest found were thrips, scale insects and citrus tem borer Respondents ranked fruit fly as the first and green stink bugs as the second most detrimental insect pests on mandarin field as shown in table. These were closely followed in rank by white grubs, leaf miner, aphid, red ants in descending order. Other insect pests included thrips, scale insects and least ranked being citrus stem borer. This is different from in case of Mediterranean countries as reported by survey of the situation of citrus pest management on Mediterranean countries. Major key-pests, i.e., reported as key-pests in at least 50% of the countries, include the medfly (*Ceratitis capitata)*, the citrus red scale (*Aonidiella aurantia*) the citrus leafminer (*Phyllocnistis citrella)* and the citrus mealybug (*Planococcus citri)* (Franco, Garcia-mari, Ramos, & Besri, 2006).

Table 6: Ranking of mandarin insect pests by respondents in Gulmi district (2020)

Insects	Rank	Index	Weighted Mean
Fruit Fly	I	0.775	81.43
Green stink Bugs	II	0.665	69.83
Leaf Miner	IV	0.494	51.93
White Grubs	III	0.658	69.1
Scale Insects	VIII	0.199	28.52
Aphid	V	0.487	51.19
Thrips	VII	0.227	20.98
Citrus stem borer	IX	0.021	2.26
Red ants	VI	0.396	41.59

KNOWLEDGE AND ADOPTION OF INTEGRATED MANAGEMENT OF INSECTS PEST OF CITRUS

KNOWLEDGE AND ADOPTION OF CULTURAL PRACTICES

It was observed from the study that majority of respondents adopted the cultural practices like sanitation (90.48 percent) and training and pruning (89.5 percent). The other cultural practices mostly followed were intercropping with leguminous crops like beans, soyabeans and peas (61.9 percent), timely irrigation and manuring (61 percent). Few of the respondents were found to follow summer ploughing (32.4 %), proper spacing and pit dimension (26.7%) and growing attractant plants like marigold and sunflower (24.8%). While very few used resistant stock; *Trifoliata Orange* (*Poncirus trifoliata*) (2.9 %). This is different than the study where 54% of the citrus farmers used certified sour orange rootstocks in Morrocco (Lahlali, Jaouad, Moinina, & Belabess, 2021).

Table 7: Adoption status of cultural practices to control mandarin insect pests in Gulmi district (2020)

Cultural practices	Yes	No
Sanitation	95(90.48)	10(9.52)
Training and pruning	94(89.5)	11(10.5)
Intercropping with leguminous crops	65(61.9)	40(38.1)
Timely Irrigation and Manuring	64(61)	41(39)
Summer Ploughing	34(32.4)	71(67.6)
Proper spacing (4 meter) and Pit Dimension (1*1*1 cube meter)	28(26.7)	77(73.3)
Timely Irrigation and Manuring	64(61)	41(39)
Growing attractant plants	26(24.8)	79(75.2)
Use of Resistant stock	3(2.9)	102(97.1)

KNOWLEDGE AND ADOPTION OF MECHANICAL PRACTICES

The study showed that about 88.6 percent of respondent adopted mechanical practices. The mostly used mechanical practice to control citrus insect pest was hand picking and removal of fallen fruits infected by fruit fly (84.8 percent). Whereas very few adopted other mechanical practices like use of protein bait of 1 kilogram of local jaggery, pumpkin with 5 ml of malathion for fruit fly (16.2 percent), use of pheromone traps (9.5 percent), use of sticky traps (7.6 percent) and only (1 percent) used light traps among the total respondents. The result reveals the poor use of mechanical practices to control insect pest because of unfamiliarity of practices and use of such practices.

Table 8: Adoption status of mechanical practices to control mandarin insect pests in Gulmi district (2020)

Mechanical practices	Yes	No
Hand Picking and Removal of fallen fruits infected with insects	89 (84.8)	16(15.2)
Use of Light traps	1(1)	104(99)
Yellow Sticky traps	8(7.6)	97(92.4)
Use of Protein Bait	17(16.2)	88(83.8)
Use of Pheromone Traps	10(9.5)	95(90.5)

KNOWLEDGE AND ADOPTION OF PHYSICAL PRACTICES

The study showed that 63 percent of the respondents practiced burning of old infected trees whereas only 4 percent of the respondents practiced moisture maintenance in orchard. It has been seen that almost all of the respondents do not have knowledge of physical practices like maintaining temperature and moisture in order to control insects. However, some performed such practice without knowing the benefits of them.

Table 9: Adoption status of mechanical practices to control mandarin insect pests in Gulmi district (2020)

Physical Practices	Yes	No
Burning of old Infected Trees	63 (60)	42(40)
Moisture Maintenance in Orchard	4(3.8)	101(96.2)

KNOWLEDGE AND ADOPTION OF BOTANICAL PRACTICES

The study showed that 38.1 percentage of respondents adopted Botanical practices whereas 61.9 percentage of respondents did not adopt any botanical practices. The data in the table shows the moderate adoption of botanical practices to control mandarin insect pests in the study area.

Majority of the respondents (92.5 percentage) adopted local practices like spraying cow urine around the mandarin trees, using ash to control insect pests, using smoke from the firewood used for cooking feed for cows and buffaloes to control insect pest and applying *Titepate (Artemesia dubia)* and *Asuro* (*Justicia adhatoda)* as mulch to control insect pest of citrus.

(82.5 percent of the respondents used bio pesticides like EM, a microbial consortium, and 35 percent respondents used bio-fertilizers like *Jholmol* for insect pest control.

Whereas only 27.5 percent of the respondents conserved natural enemies like pollinators by discarding the application of chemicals and protecting their nest.

Environmental benefits of a switch from chemical to biological pest management are well known and have served as a major stimulus for the development of IPM technology. They include reduced pesticide pollution of land and water, improved functioning of ecosystems, and reduced effects on land and aquatic fauna (Urquhart, 1999)

Table 10: Adoption status of biological practices to control mandarin insect pests in Gulmi district (2020)

Biological practices	Yes	No
Bio-pesticides	33(82.5)	7(17.5)
Bio-fertilizers	14(35)	26(65)
Conservation of natural enemies	11(27.5)	29(72.5)
Local practices	37(92.5)	3(7.5)

KNOWLEDGE AND ADOPTION OF CHEMICAL PRACTICES

THE STUDY SHOWED THAT ONLY 28.6 PERCENTAGE OF TOTAL RESPONDENTS ADOPT CHEMICAL METHOD FOR CONTROL OF INSECT PESTS.

Frequency of application

The study showed that most of the mandarin growers (93.3 percent) of those who adopt chemical method to control insect pest in the study site applied pesticide only at the time of insect attack and 3.3 percent of the respondents applied pesticides once a year and 3.3 percent of the respondent applied pesticides twice a year. This shows the less use of the pesticide in the study site.

Table 11: Frequency of application of chemical pesticides in Gulmi district (2020)

Pesticide application	Frequency	Percent
Once a Year	1	3.3
Twice a Year	1	3.3
At the time of insect attack (June-September)	28	93.3
Total	30	100

Protective wearing

The research revealed that none of the applicators followed all the recommended safety measures which have shown that higher number of farmers is exposed to the pesticide risks and health hazards. All of the respondents used sandals while none used spectacles. Whereas (43.33 percent) used masks, 30 percent used boots, 26.67 percent used gloves and only 16.67 percent used coverall as protecting wearing against pesticide use.

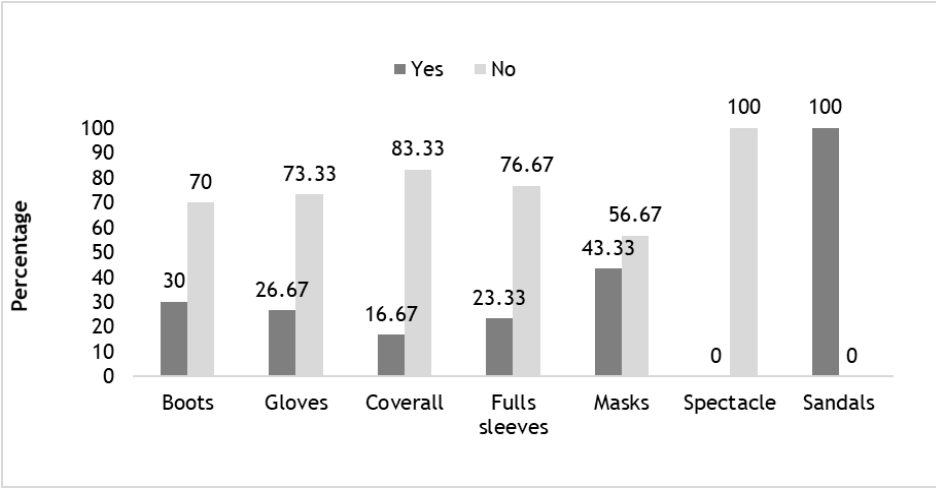

Figure 1. Use of protective wears during pesticide application in Gulmi.

Source: Field Survey 2020

Safety Measures

The field survey showed that majority of the respondent does not follow basic safety measures. 63.33 percent of the respondent shower after each spray and 86.67 percent of respondents change cloth after spray. While only 26.67 of the respondents watch label before spray. Whereas 80 percent of the respondents practice Unhealthy practices such as reuse of the containers and 20 % of the respondents consume while spraying. This showed the poor practice in pesticides handling and ignorance in following safety measures while pesticide application.

Table 12: Safety Measure followed by respondents while pesticide application in Gulmi district (2020)

Safety measures	Yes	No
Consume while spraying	6(20)	24(80)
Shower after each spray	19(63.33)	11(36.67)
Change cloth after spray	26(86.67)	4(13.33)
Reuse container	24(80)	6(20)
Watch label before spray	8(26.67)	22(73.33)

Figures in parenthesis indicate percentage

Knowledge on pesticide hazard

It was observed from the research that all respondents who use chemical methods were aware of the health hazards and environment hazards. Most of the farmers experienced health hazards like vomiting, headache, fever, dizziness, skin rashes, shortness in breath and allergies. The environmental hazards as faced by respondents were water contamination, loss in population of beneficial insects like honey bee and so on.

KNOWLEDGE ON IPM

INFORMATION ON IPM

The study showed that 74.3 percent of the respondents had heard about the IPM while 25.7 percent of the respondents had not heard about IPM. Majority of the respondents (75.6 percent) knew IPM from fellow farmers, 10.3 percent of respondents knew from leader farmers, 7.7 percent of respondents knew from relatives and rest 6.4 percent knew from different media.

Table 13: Source of information on IPM received by respondents in Gulmi district (2020)

Source of information on IPM	Frequency	Percent
Fellow farmers	59	75.6
Relatives	6	7.7
Media	5	6.4
Technicians	8	10.3
Total	78	100

TRAINING ON IPM

The study showed that (40 percent) respondents had taken training on IPM while rest of 60 percent of respondents had not taken any training on IPM. Almost everyone who had taken training on IPM is by project organized by Food and Agriculture Organization of United States.

ADOPTION STATUS OF IPM

The survey showed that 35.2 percent practice IPM strategies whereas 64.8 percent of respondents did not practice IPM strategies. The major reason behind less adoption were found to be complex strategies, poor excess to trainings and higher IPM input costs. Likewise, survey on the situation of citrus pest management in Mediterranean finds that the complex IPM strategies, the increased risk, the production costs, the lack of effective alternative tactics to pesticides and the lack of accurate and practical pest monitoring methods were among the considered major problems/constrains for the development of citrus IPM in Mediterranean countries (Franco, Garcia-mari, Ramos, & Besri, 2006). Majority of the respondents (90.5 percent) think that IPM practices are relevant and effective while only 9.5 percent think that IPM practices are not relevant and effective.

PERCEPTION ON IPM

Respondents were given several statements about IPM as:

Statement 1: Following IPM practices is efficient in reducing pest infestation.

Statement 2: IPM protects environment and maintains balanced ecosystem.

Statement 3: IPM increases farmers income and reduce the cost in buying pesticides.

Statement 4: IPM produces quality fruit with no chemical residue.

Statement 5: IPM practices are difficult and time and energy consuming.

Statement 6: IPM practices require more resources.

Table 15: Respondent's degree of perception on various statement of IPM

Statement	Strongly agree	Agree	Neutral	Disagree	Strongly Disagree	Mean1	Mean2	St Deviation
1	43%	43%	4%	10%	1%	4.17	18.30	3.76
2	64%	26%	6%	5%	0%	4.49	20.77	4.04
3	16%	39%	31%	13%	0%	3.58	13.66	3.17
4	29%	61%	10%	0%	0%	4.18	17.84	3.70
5	17%	39%	30%	13%	0%	3.60	13.81	3.20
6	8%	65%	26%	2%	0%	3.78	14.66	3.3

The standard deviation is more inclined towards code value 3.2 to 4.04 that represents neutral to agree side of statement. The agreement on statement shows the positive perception of farmers towards the statements.

CONCLUSION

The knowledge of insect pest of citrus is greatly affected by the citrus cultivation area of farmers because farmer is more likely to get acquainted with types of insects and their damage symptoms in larger area than smaller area. The average years of engagement of 23.3 years and average mandarin cultivation area of 0.35 ha gives insight to great potentiality of farmers adopting integrated pest management. It is because, based on local experience and the intensity of management IPM is much easier to attain on a smaller farm. This study concludes that insect severity is one of the prominent factors that affect the citrus production significantly whereas fruitfly (*Bactocera dorsalis)* is more prominent in terms of infestation in Gulmi. Other major insect pest of citrus in the study area includes green stink bugs, white grubs, leaf miner, aphid and rent ants. (74.3 %) of the total respondents were found to have knowledge about term "IPM technology" but only (35.2%) practiced IPM practices till date. Although the knowledge among c growing citrus farmers on the insect pest of citrus was found to be satisfactory, there is immaculate need of knowledge on IPM technology. Use of improved varieties, propagation by grafting using *Trifoliate* rootstock, use of pheromone trap, protein bait that has been less applied in the field should be enhanced by making the IPM inputs easily available. Farmers should be encouraged to substitute chemical practices by integration of cultural practices like proper spacing and pit dimension and use of grafted plants and biological practices like use of biopesticides *Beauveria* spp. and *Metarhizium* spp with various awareness programs, demonstration programs through FFS. The positive attitude and perception of citrus growers towards IPM technology found through this research depicts great scope of application of IPM technology in increasing production on a sustainable basis.

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ASSESSMENT AND MANAGEMENT OF TOMATO DISEASES UNDER PLASTIC HOUSE CONDITIONS IN LAMJUNG

S.K. Neupane[1], G.B. K.C.[2], S.M. Shrestha[3] and A. C. Neupane[4]

ABSTRACT

An experiment was conducted under plastic houses at three farmers' field, each farmer as a replication, in Tarku and Banhjakhet VDCs in Lamjung district during July to December 2010, to identify and manage major fungal diseases of tomato (variety Srijana) using chemicals and bio-pesticides. The treatments Bio-cure-F (Trichoderma viride, bio-fungicide), carbendazim (Bavistin, systemic fungicide) and Dithane M-45 (Mancozeb, contact fungicide) were applied as foliar spray. Control plot was maintained without application of any treatment. Mainly four fungal diseases, early blight (Alternaria solani), late blight (Phytophthora infestans), powdery mildew (Leveillula taurica) and septoria leaf spot (Septoria lycopersici) were recorded. Dithane M-45 appeared the best to control early blight, late blight and septoria leaf spot, followed by Bavistin and Bio-cure-F over control. Bavistin performed the best to control powdery mildew, followed by Dithane M-45 and Bio-cure F over control. Severity of fungal diseases appeared high on tomato in plastic house. Based on type of disease, Dithane M-45 or Bavistin is suggested to spray for the management.

Key words: tomato, plastic house, fungal diseases, control measures.

INTRODUCTION

Tomato (*Lycopersicon esculentum* Mill) belongs to family Solanaceae and is one of the most remunerable and widely grown vegetables in the world. The world annual production of tomato during 2003 was 113.3 million tons covering an area of 4.3 million hectare with the productivity of 26.34 tons per hectare. Tomato is one of the important vegetable crops in Nepal and is grown commercially in plains and hills for fresh consumption and processing to some extent. In Nepal, tomato stands in third position after cauliflower and cabbage in terms of area (21,389 ha) and production (400,674 tons) (MOALD, 2018). It is also known as poor man's apple in Nepal. Although the Terai region produces and sells more vegetables, vegetables grown in the hilly region have greater value; these vegetables are produced during the rainy season when prices are higher (NEAT, 2011). Tomatoes, which are actually a fruit vegetable, are loaded with all kinds of health benefits for the body.

1 Ministry of Agriculture and Livestock Development, Singhadurbar, Kathmandu

∗ Corresponding Author's Email: shree.neupane2000@gmail.com

2 Nepal Academy of Science and Technology (NAST), Khumaltar, Lalitpur

3 Agriculture and Forestry University, Rampur Chitwan

4 CIMMYT International, Nepal

Tomato contains a very powerful antioxidant called lycopene which purportedly fights the free radicals that can interfere with normal cell growth and activity. These free radicals can potentially lead to cancer, heart disease and premature aging. Introduction of tomato cultivation under plastic house conditions favored the off season production making possible availability of tomato in all the seasons in the market.

There are several diseases on tomato caused by fungi, bacteria, viruses, nematodes and abiotic factors (Balanchard, 1992) that are limiting its production and productivity. Early blight caused by *Alternaria solani*, late blight caused by *Phytophthora infestans* and septoria leaf spot caused by *Septoria lycopersici* are the major fungal foliar diseases. Powdery mildew caused by *Leveillula taurica* and *Oidium* spp.is another foliar disease generally appearing in late season. To combat with diseases growers/farmers are using chemical fungicides haphazardly, but still satisfactory level of diseases control are not achieved by them. At the same time, the ultimate results of haphazard use of chemicals create health related problems, increase environmental pollution and yield loss also due to non- target fungicides application resulting in fungicide induced disease resurgence, the whole natural ecosystem is adversely affected and also financial burden increased to the poor farmers (Palikhe, 2006). Therefore, the objective of the study was to find out the effectiveness of most commonly used chemical fungicides and bio-fungicide for the management of major, foliar fungal diseases of tomato grown under plastic houses.

METHODOLOGY

An experiment was conducted in three plastic houses on three farmers' fields at two VDCs in Lamjung (Tarku and Banhjakhet) during July to December, 2010. Mean area of each plastic house was 50 sq m (10 m x 5 m). Two plastic houses were selected, from Banjhakhet, one from the village an altitude of 900 masl, situated north- east from Beshisahar and Marshyangdi river, and the other at Kupling village, a pocket region of vegetable production in Lamjung, at an altitude of 1,150 masl, on the southern face of a hill, and the third plastic house was taken from Thakle village of Tarku VDC, situated at 800 masl in southern side of Lamjung district on the bed of Paudi Khola. A nursery bed of 5 m^2 size was prepared, applying 18 kg well decomposed FYM, at one corner inside the plastic house at Tarku. After seed bed preparation, 5 gram seeds of "Srijana F1 hybrid" tomato were sown continuously in row in 1 cm depth with row to row spacing of 10 cm on 18th June, 2010. Twelve days old seedlings were uprooted and transplanted on the same bed for hardening. Each plastic house was taken as a replication where there were 4 plots/plastic house with a size of 5m x 2m and inter plot spacing 40 cm. The plots were slightly raised to avoid the water logging and flooding. Twenty five

days old, 20 seedlings per plot and 80 seedlings per plastic house were transplanted on 12th July, 2010 in all the plastic houses. There were two rows/plot and planting distance was 80 cm row to row and 50 cm plant to plant.

TREATMENTS

There were 4 treatments as below in the study, which were replicated 3 times. Treatments details are presented below.

T1 = Bio-cure-F (*Trichoderma viride*)

T2 = Bavistin (carbendazim)

T3 = Dithane M-45 (mancozeb)

T4 = Control

Application of treatments

The bio-pesticide, Bio-cure-F @ 5 g/l, Bavistin at the concentration of 2 g/l and Dithane M 45 @ 2 g/l water were sprayed five times at seven days intervals after the appearance of any of the fungal diseases.

OBSERVATION

Observations on plant height, leaf numbers, yield, disease incidence and severity were taken. Plant height and leaf number were recorded two times, first 10 days after transplanting and the second 15 days after the first observation. Disease scoring was done from the central four plants of each plot after the appearance of the disease. Each 3rd plant from both the ends among the 10 plants in a row is selected for the observation. Disease scoring of infected plants was done using the following standard scales.

Scale used for assessment of late blight (Mayee and Datar, 1986)

0= No symptoms, 1 = 1 - 10% leaf area infected, 2 = 11 - 25% leaf area infected, 3 = 26 - 50% leaf area infected, 4 = 51 - 75% leaf area infected and 5 = >75% area infected.

Scale used for assessment of early blight (Mayee and Datar, 1986)

0 = no symptoms, 1 = 1-9% plant parts infected, 2 = 10-24% plant parts infected, 3 = 25-49% plant parts infected, 4 = 50-74% plant parts infected and 5 = 75-100% plant parts infected.

Scale used for assessment of powdery mildew (Thayerand Stall, 1962)

0 = no appearance, 1 = <25% leaf area infected, 2 = 50% leaf area infected, 3 = >75% leaf area infected and 4 = 100% leaf area infected.

Scale used for assessment of septoria leaf spot (Emua, 1980)

1 = Disease free leaf, 2 = Few lesions on leaf 3 = large number of lesions but with little coalescence. 4 = Large number of lesions with yellowing, 5 = leaf completely destroyed.

Disease incidence and severity were calculated by using the following formulae

$$\text{Disease Incidence (\%)} = \frac{\text{Number of infected plant units}}{\text{Total number of plant units}} \times 100$$

$$\text{Disease severity (\%)} = \frac{\text{Sum of all numerical value in each category}}{\text{Total no. of samples x maximum scale value}} \times 100$$

$$\text{Disease Index (\%)} = \frac{\text{Sum of all disease ratings}}{\text{Total no. of samples x maximum scale value}} \times 100$$

These formulae were applied to all the numerical scales.

AUDPC was calculated by using the following formula (Das *et al.,* 1992).

$$\text{AUDPC} = \sum_{i=1}^{n-1}\left[\left(\frac{X_{(i+1)} + X_i}{2}\right)\right]\left(T_{(i+1)} - T_i\right)$$

Where,

X_i = Disease intensity on the i^{th} date. T_i = Days from transplanting to the date of disease scoring

n = number of dates on which disease was scored

LABORATORY WORK

Preparation of Potato Dextrose Agar and *Trichoderma* Selective Media

Potato Dextrose Agar (PDA) and *Trichoderma* selective media (Table 1 and 2) were prepared in the laboratory of IAAS, Rampur, Chitwan, for the confirmation of potato diseases from the research plots and to check the viability of the commercial product of *Trichoderma viride*.

Table 1. Composition of potato dextrose agar medium

Constituents	Quantity
Potato (Peeled)	200.0 g
Dextrose	20.0 g
Agar	20.0 g
Dicrysticin	0.1 g
Distilled water	1000.0 ml

Table 2. Compositions of *Trichoderma* selective medium

Contents	Quantity
Potato	200.0 g
Dextrose	20.0 g
Agar	20.0 g
Dicrysticin	0.1 g
Vitavex	0.1 g
Distilled water	1000.0 ml

Statistical analysis

Data entry was done in MS-excel and analyzed using SPSS, MSTATC (MSTAT, Michigan State University, USA). Mean values were compared by using analysis of variance, Duncan's Multiple Range Test and descriptive analysis.

RESULTS AND DISCUSSION

Mainly four major diseases were observed in tomato plants under plastic house during experimental period. They were early blight, late blight, septoria leaf spot and powdery mildew. Powdery mildew appeared in late season of cropping period. All the treatments were significantly different from untreated control as shown in the tables 3, 4 and 5 below.

EARLY BLIGHT

Initial symptoms of early blight were appeared on 26th September, 2010. The disease was identified by the appearance of brown to dark, leathery, necrotic spots first on leaflets in a target board pattern. The pathogen was identified as *Alternaria solani* by its typical conidiophores and conidia under microscope. Older leaves of tomato were affected first and the disease progressed upwards. Finally the leaves dried up and dropped down. Walker (1952) reported that the spots were oval or angular in shape up to 0.3 or 0.4 cm diameter and there was usually a narrow chlorotic zone around the spot which later faded into the normal green color.

Effect of treatments

The results of the experiment revealed that the least disease incidence and severity of early blight were recorded in Dithane M-45 treated plots (27.0% and 6.6%), followed by Bavistin (30.0% and 11.67%) and Bio-cure-F (35.33% and 16.67%) as compared to Control (45.33% and 30.0%) respectively (Table 3 and 4). Choulwar and Datar (1992) reported also similar results. Among the tested fungicides, copper oxychloride, mancozeb, carbendazim and captafol against early blight of tomato, mancozeb was the most effective in reducing disease intensity and increasing the yield in cultivar Pusa Ruby.

LATE BLIGHT

Symptoms of late blight caused by *Phytophthora infestans* were noticed on October 5, 2010, which were at the base of the petiole as water soaked lesions with ash or green colour in later days. The symptoms were also seen in green fruits which were rotted in late stage. The pathogen was identified with papillate lemon shaped sporangia developed in the lesions under moist conditions.

Effect of treatments

The least incidence and severity of late blight was shown by Mancozeb (18.0% and 11.25%), followed by Bavistin (22.33% and 13.67%), respectively (Table 3 and 4). As reported by Gisi *et al*. (1983) mancozeb was more effective in controlling *Phytopthora infestans* on potato and *Plasmopara viticola* on grapes than the other systemic fungicides used alone.

POWDERY MILDEW

The symptoms of powdery mildew caused by *Leveillula taurica* were appeared on November 3, 2010. The fungus produced a white talcum like covering on the lower leaves first and progressed toward upper leaves. The infected leaves became yellow and prematurely dried up. Correll (2014), stated that three fungal species *(Leveillula taurica*, *Oidium lycopersici* and *Oidium neolycopersici)* cause powdery mildew in tomato.

Effect of treatments

The least disease incidence of powdery mildew was observed in Bavistin treated plots (10.67%) followed by Dithane M-5 (12.0%) and Bio-cure-F (15.0%). Similarly, the least disease severity of powdery mildew was recorded in Bavistin (5.83%), and followed by Dithane M-45 (10.43%) and Bio-cure F (12.50%) as compared to control (20.56%) (Table 3 and 4). Germination of powdery mildew fungi may distinguish from other fungi is the manner in which water is bound with in the conidia (Somers. and Horsfall, 1966).

SEPTORIA LEAF SPOT

The initial symptoms of septoria leaf spot caused by *Septoria lycopersici* appeared on September 26, 2010. The symptoms were minute to small brownish spots on the lower leaves. As the spots grew larger, they became more or less circular in outline and showed definite brown colored margin with grey centre in which minute fruiting bodies, pycnidia, were appeared and black circular spots were appeared on the fruits.

Effect of treatments*:*

The least disease incidence of septoria leaf spot was observed in Dithane M-45 treated plots (24.0%), followed by Bavistin (29.45%) and Bio-cure-F (33.33%). Similarly, the least disease severity of septoria leaf spot was

observed in Dithane M-45 (24.0%), followed by Bavistin (29.39%) and Bio-cure-F (33.33%) as compared to control (40.0%). respectively.

Table 3. Effect of treatments on incidence of fungal diseases in tomato under plastic house during July to November, 2010 at Lamjung.

	Incidence (%)			
Treatments	EB	LB	PM	SLS
Bio-cure-F	35.33b	27.67b	15.00b	33.33b
Bavistin	30.00c	22.33c	10.67d	29.45c
Dithane M-45	27.00d	18.00d	12.00c	24.00d
Control	45.33a	38.00a	21.00a	40.00a
SEM (±)	1.014	1.280	0.645	1.054
LSD (= 0.05)	2.025	2.558	1.29	2.106
Probability	<.01**	<.01**	<.01**	<.01**
CV (%)	2.9	4.8	4.4	3.3

Treatment means followed by the same letter in a column are not significantly different by DMRT at 5% level of significance. LSD = Least Significant Difference, SEM = Standard error of mean. CV = Coefficient of variation, **significant at 1% level.

Table 4. Effect of treatments on severity of fungal diseases in tomato under plastic house during July to November, 2010 at Lamjung.

	Severity (%)			
	EB	LB	PM	SLS
Bio-cure-F	16.67b	16.25b	12.50b	33.33b
Bavistin	11.67c	13.67c	5.83d	29.33c
Dithane M-45	6.66d	11.25d	10.43c	24.00d
Control	30.00a	29.58a	20.56a	40.00a
SEM (±)	1.443	0.859	2.45	1.054
LSD (=0.05)	1.104	1.716	4.995	2.106
Probability	<.01**	<.01**	0.02**	<.01**
CV (%)	8.9	2.9	12.4	3.3

Figures in the column with the same letter are not significantly different (p=0.05) according to DMRT, LSD =Least Significance Difference, SEM =Standard Error of mean difference, CV= Coefficient of variation, EB =Early blight, LB = Late blight, PM = Powdery mildew, SLS= Septorial leaf spot. ** Significant at 1%.

EFFECT OF TREATMENTS ON AUDPC VALUES OF DIFFERENT FUNGAL DISEASES OF TOMATO

Table 5. Effect of treatments in AUDPC values of major fungal diseases of tomato under plastic house during July to November, 2010 at Lamjung

	AUDPC			
Treatments	EB	LB	PM	SLS
Bio-cure-F	870.00 b	1325.00 b	198.27 b	1597.00 b
Bavistin	604.00 c	1120.00 c	95.56 c	1381.45 c
Dithane M-45	339.00 d	890.80 d	172.34 d	1146.00 d
Control	1167.00 a	1685.80 a	328.76 a	1888.00 a
SEm (±)	44.6	31.43	38.8	40.50
LSD (=0.05)	89.1	62.80	77.40	80.90
Probability	<.01**	<.01**	0.002**	<.01**
CV (%)	6.0	2.5	19.5	2.7

Figures in the column with the same letter are not significantly different (p=0.05) according to DMRT, LSD =Least Significance Difference, SEM = Standard Error of Mean difference, CV= Coefficient of variation, EB =Early blight, LB = Late blight, PM = Powdery mildew, SLS= Septorial leaf spot. ** Significant at 1%.

EFFECT OF TREATMENTS ON YIELD OF TOMATO

Dithane M-45 treated plots showed the highest yield (52.35 ton/ha), which was significantly highest than other treatments, and it was followed by Bavistin (48.40 ton/ha), Bio-cure F (46.24 ton/ha) and control (41.47 ton/ha).

CONCLUSIONS

Dithane M-45 (mancozeb) can be used as foliar application To manage early blight, late blight and septoria leaf spot in tomato under plastic house at Lamjung and similar conditions. Similarly, foliar application of Bavistin (carbendazim) can be used to reduce powdery mildew disease in tomato. As powdery mildew appeared late in the season, early planting might be one of the best management tools to reduce this disease, which seemed to be an important area for future research work to find a potential measure for the proper management of the disease.

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MORPHOMETRICS AND LIFE CYCLE STUDY OF CABBAGE BUTTERFLY, *Pieris brassicae nepalensis* (DOUBLEDAY) IN ILAM, NEPAL

A. Subedi[1] and S.Tiwari [2]

ABSTRACT

Cabbage butterfly, Pieris brassicae nepalensis is an economic pest of crucifer crops. Morphometrics and life cycle study of P. brassicae was carried out in room condition at Barhabasti, Ilam, Nepal to understand their general morphology and life cycle. Based on the results of morphometric parameters, the mean length of egg, larva (I - V instars), pre-pupa, pupa and adult was measured 1.28 mm, 3.97 mm, 8.50 mm, 20.78 mm, 33.6 mm, 38.72 mm, 39.32 mm, 26.04 mm, and 24.08, respectively. The adult wingspan of female was greater than male wingspan. The adult butterflies were pale white with dense hairs and the females contain two small (black) dots in the central area of each forewing and one (black) dot in males. Egg, larval (I to V instars), pre-pupa and pupal life durations were 4 to 5 days, 3-5 days, 4-6 days, 4-5 days, 4-5 days, 4-6 days, 1-2 days, 8-10 days, respectively. The total development period from egg to adult was 32 to 44 days. This information's are useful for ecologist and to develop an integrated pest management protocol.

Keywords: Cabbage butterfly, life cycle, morphometrics, *Pieris brassicae nepalensis*

INTRODUCTION

Insect pests are the major crop limiting factors in crucifers (Bhavani et al., 2009). Insect herbivores alone can cause 40 % of the yield loss annually (Ali & Rizvi, 2007; Hasan & Ansari, 2010; Sood & Bhalla, 1996). *Pieris brassicae nepalensis* (Doubleday) are commonly known as cabbage white, cabbage moth, large cabbage white, or large white butterfly, is the most widely dispersed lepidopteran pest of crucifers (Ansari et al., 2012). The common name cabbage white butterflies are designated to these butterflies owing to the colour of their wings, and cabbage as their main host (Wilbur, 2011). The pest is responsible for causing serious damages at all the growing stages of the crucifers crops from seedling to flowering stages (Bhandari et al., 2009). Loss from this pest ranges from 27 to 41% in various conditions (Ali & Rizvi, 2007; Atalay & Hincal, 199; Eichler, 1948; Shapiro, 1975). This pest is distributed worldwide from Asia, Europe and North Africa to the North America (Scudder, 1887; Howe, 1975). *Pieris brassicae nepalensis* is also

1 Instructor, Karfok Vidya Mandir Secondary School, Suryodaya, Ilam, Nepal
Corresponding author: email: anupasubedi55@gmail.com,

2 Associate Professor, Department of Entomology, Agriculture and Forestry University, Bharatpur, Chitwan, Nepal

abundantly present crucifer crops from January to May in India, Bhutan, and Nepal and in other Asian countries (Piya & Khatiwada, 2004; Joshi, 1994; Thapa, 1987).

According to the morphological parameters as suggested by Wilbur (2011), the eggs were spindle-shaped with length and width of 1.23 and 0.61 mm, respectively. The mean length of I to V instars larvae was 4.4 ± 1.20 mm, 12.3 ± 0.38 mm, 15.9 ± 1.07 mm, 27.6 ± 2.47 mm, 39.74 ± 1.98 mm, respectively (Bhubaneshwari et al. 2012). The pupal length was measured as 20.0 - 25.0 mm as suggested by Bhowmik and Gupta (2017) while the adult male mean length was 20.7 mm and female length 24.98 mm, respectively (Bhubaneshwari et al. 2012).

The development period of *P. brassicae nepalensis* consists of four stages which include the egg, larval, pupal, and adult where the larval stages include five instars and the pupal stage includes a pre-pupa and pupa (Bhowmik & Gupta, 2017). The adult *P. brassicae nepalensis* butterflies are non-damaging, and are attractive with pale white wings and smoky shade on the dorsal side of the body (Bhowmik & Gupta, 2017). The caterpillars are the damaging stage that feeds glucosinolate rich crucifers such as cabbage, cauliflower, and mustards (Hopkins et al., 2009). They feed gregariously during the early instars and disperse as they mature, leading to the severe economic losses (Bhandari et al. 2009; Moore & Bill, 2010). At the curd formation stage, late instars *P. brassicae nepalensis* damages the curd that reduces the yield and quality of cabbage head (Lal & Ram, 2004). Moiseeva (1984) reported that a single larva can consume 74-80 cm^2 of leaf area during the development stage, 80 to 87% can consume by the fifth instar. Morphometric and life cycle of insect species can be influenced by the location, environmental parameters as well as their potential host. Here, morphometric and life cycle study of *P. brassicae nepalensis* is conducted in the eastern hill sides of Nepal. These findings are useful to the ecologist as well general biologist to compare the *P. brassicae nepalensis* found in eastern hill regions to the other ecological regions of Nepal in future. Also, life cycle study can be useful to develop an integrated pest management strategy in crucifer crops.

METHODOLOGY

Morphometric observations such as length of the larval instars, pre-pupa, pupa & adult were measured using a simple measuring ruler (10 mm scale size). Morphometric observations of eggs were taken for the filed collected eggs. Individual egg was carefully observed keeping them in Petri dishes (9 cm diameter) and under stereo microscope. All observations were based on 50 individuals (n = 50). The newly emerged adults were differentiated as male and female and the length of the adult wingspan of both males and females

were recorded. There were 10 number of observations to study adult morphometric (n = 10).

Biology study was carried out at a room condition at Barhabasti, Ilam (26.9094° N latitude and 87.9282° E longitude and an altitude of 1020 m from the mean sea level). The leaves with freshly hatched larval masses and part of unhatched eggs were collected from farmer's field. Ten rearing plastic containers (23 cm height and 12 cm diameter) were used and cleaned properly keeping the moist cotton ball (3 cm diameter) on the bottom of each container. The mouth of the jar was covered using a muslin cloth. The newly hatched larvae were then transferred to the plastic containers using camel hair brush and fresh cauliflower leaves were supplied in each container. Each plastic jar contained 5 first instar larvae. The containers were cleaned and food residues were removed daily and replaced with new cauliflower leaves for the initial instars (I, II & III) and twice a day for subsequent instars (IV and V) to maintain hygienic conditions and this was continued until pupation.

The larvae kept in the rearing containers were carefully observed each day. The morphological change of instars was noted in each molt. Any changes in the shape, size, and color during different life stages were noted. The maximum and minimum room temperature during study period was 21.8°C and 3.8 °C, respectively, with a relative humidity of 75-80%.

RESULTS AND DISCUSSION

A. MORPHOMETRICS OF *PIERIS BRASSICAE NEPALENSIS* VARIOUS LIFE STAGES

Egg, larva and pupa

The length (mm) of eggs varied from 1.25 -1.3 mm with a mean of 1.28 mm (Table 1). The first, second, third, fourth and fifth instar larvae were measured at range of 3-5 mm (mean 3.97 mm), 6.5 - 9.5 mm (mean 8.50 mm), 17 – 24 mm (mean 20.78 mm), 29 – 37 mm (mean 33.60 mm), 37 – 41 mm (mean 38.72 mm) respectively. The length of the pupa was smaller than the larvae, and measured 26.04 mm (Table 1). These findings are similar with the result proposed by Bhowmik & Gupta, 2017.

Adult

The wingspan of female butterflies was measured 57.1 ± 0.95 mm and male butterflies measured 52.5 ± 0.4 mm while they had the body length of 24.08 ± 0.26 mm (Table 2). The female has two dots in the central area of each forewing and one in the case of males. These findings are similar with the findings reported by Bhubaneshwari et al. (2012).

Table 1: Morphometric of various life stages *of P. brassicae nepalensis*

Life stages	Length (mm)	
	Mean (mm) ± SE	Range (mm)
Egg	1.28 ± 0.03	1.25 - 1.30
I instar larva	3.97 ± 0.06	3.00 – 5.00
II instar larva	8.50 ± 0.09	6.50 - 9.50
III instar larva	20.78 ± 0.25	17.00 – 24.00
IV instar larva	33.6 ± 0.27	29.00 -37.00
V instar larva	38.72 ± 0.17	37.00 – 41.00
Pre pupa	39.32 ± 0.02	37.00 - 43.00
Pupa	26.04 ± 0.22	23.00 – 30.00
Adult	24.08 ± 0.26	21.00 – 27.00

Measurement of the larval stage to the adult stage is the means of 50 observations.

Table 2. Size of wingspan of adult *P. brassicae nepalensis*

	Mean (mm) ± SE	Range (mm)
adult wingspan (female)	57.1 ± 0.95	53 - 62
adult wingspan (male)	52.5 ± 0.4	51 - 55

Measurement of adult wingspan are the means of 10 observations each.

B. *PIERIS BRASSICAE NEPALENSIS* LIFE CYCLE OBSERVATIONS

Eggs

Pieris brassicae nepalensis eggs are yellowish during hatching and they change their color to darker yellow within twenty-four hours of oviposition (Das et al., 2018). The female butterfly laid eggs in masses, the smallest egg mass with 2-3 eggs and the biggest consisting of 116 eggs firmly glued to the leaf surface which turned greyish before hatching. Similar observation was also noted by Das et al. (2018) and Hasan et al. (2008).

Larva (I, II, III, IV and V instars)

The eggs soon after hatching developed first instars which were yellowish-green in color with dark green bands. The larva underwent four moultings developing five instars which grew in length and width, became cylindrical, robust, and fed gregariously on the leaves. Similar results were also reported by Hasan et al. (2008) and Gupta et al. (1984). All the larval stages except the first instar had a narrow yellow line running along the center of the back along with a broken yellow line or a series of yellow spots on each side. Similar findings were also reported by the study conducted by Das et al., 2018.

Pre-pupa and pupa

The fully matured larva stopped feeding and moved to the walls of glass jars. Similar behavior also reported by Hasan et al. (2008). They are slightly fattened and measured about 37- 43 mm in length and turned into a pupa. The pupa is sharply angled consisting of keel like projection dorsally on the thorax and dorso-laterally on each side of the abdomen. This non-feeding stage are yellow, grey, green, and speckled brown in color. Same observations are also observed by Bhubaneshwari et al. (2012) and Wilbur (2011).

Adult (male and female)

The adult emergence from the pupa usually takes place in about 8-9 am from the anterior end by protruding the legs first and gradually pushing itself out of the pupal skin. Similar morphological changes are also reported by Chahil & Kular (2013). The adult butterflies are pale white covered by dense hairs with a black spot on the anterior edge of the hind wings. The male can be differentiated from the female due to the dots present on the forewing. These various male and female morphological features are explained by Wilbur (2011).

Life duration

In the present studies, the egg incubation period varied from 4 to 5 days (4.60 days) whereas the duration of the first, second, third, fourth, and fifth instar larva varied from 3-5 days (3.7 days), 4-6 days (4.48 days), 4-5 days (4.48 days), 4-5 days (4.54 days), 4-6 days (4.92 days) respectively (Figure 1). The pre-pupal period lasted for 1-2 days (1.52) and the pupal period for 8-10 days (8.7 days). So the total development period from egg to adult was found to vary from 32 to 44 days. This result is supported by Pandey et al. (2015) who reported that the duration of the first, second, third, fourth, and fifth instar larva was 3.70 days, 3.34 days, 3.74 days, 3.79 days, and 4.09 days, respectively. The studies also support the findings of Hasan et al. (2008) who reported that the pre-pupal period lasted for 1-2 days (1.6 days) and the pupal period for 9- 10 days (9.4 days). Bhowmik and Gupta (2017) in their laboratory life cycle study reported that the duration of the first, second, third, fourth, and fifth instars ranged from 4-6 days (5.40 days), 4-5days (4.40 days), 4-5 days (4.60 days), 4-5days (4.60 days) & 6-7 days (6.60 days), respectively, with the total pupal period of 7-9 days (7.90 days). The total development period was found to vary from 32- 44 days (Figure 1).

Most of the results of the present studies are in agreement with the studies carried out by many workers; however slight variations in different parameters have also been noted. This could be due to the difference in the host plants, the difference in their nutrient content, their growing conditions, or due to the variations in temperature at the time of rearing (Das et al., 2018; Hasan et al., 2010; Slansky, 1990; Singh & Sandhu, 2016).

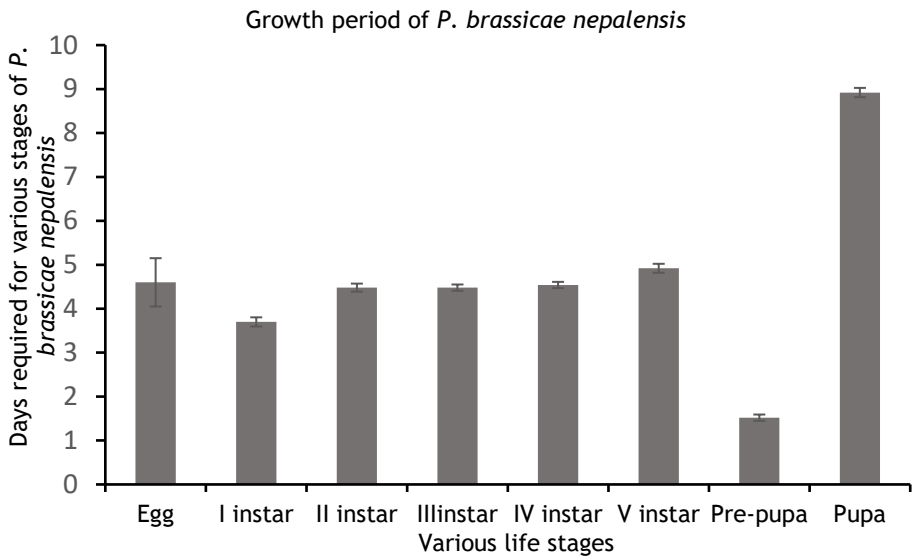

Figure 1. Life duration of various life stages of *P. brassicae nepalensis*.

CONCLUSION

Cabbage butterfly, *P. brassicae nepalensis* is one of the serious economic pests of crucifers attacking all their growth stages and cause a severe yield loss. The life cycle is completed consisting of the egg, larval, pupal, and adult stages where the larval stage includes five instars, and the pupal stage include a pre-pupa and pupa. It takes about 32 to 44 days from egg to adult development. The larval stage is the damaging stage that affects the plant at all stages of growth. The first instars larva feed the cabbage leaf by scraping the leaf surface and the gregarious feeding nature increases in subsequent larval instars. This morphometrics and life cycle study can be helpful for their proper identification of species and also support to develop an appropriate pest management strategy.

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SAFE FOOD PRODUCTION REGIMES AND POTENTIALITY OF INTEGRATED MULTI-LEVEL FOOD CERTIFICATION SYSTEM IN NEPAL

J. Pandit[1], Y.K. Karki[2], D. Gauchan[3] and B. Paudel[4]

ABSTRACT

There is continuum of agricultural production systems between highly agrochemical intensive farming and pure organic system. The current certification system in Nepal involve two levels – organic and good agriculture practice (GAP). Other middle-way alternatives for safe food like traditional and pesticide-free systems have not been considered for certification. This paper analyses various safe-food production regimes and explore potential for integrated multi-label food-safety certification system. Taking four typologies with varied levels of food safety i.e. traditional, good agriculture practice (GAP), pesticide-free and organic products as alternatives to input-intensive production systems, this paper concludes that the integrated multi-label food safety certification system would provide choice for consumers to make price and food-safety trade-off. Labelled safer food alternatives would enable consumers to choose and pay for their safe-food need and increase consumption of safer food contributing to sustainable growth of agriculture sector.

Key Words: Certification, Nepal, Organic, Pesticide-free, Safe-food, Traditional

INTRODUCTION

Finding a balance between increasing agricultural productions and maintaining food safety has been a challenging act for policy makers in developing countries. Introduction of agro-chemicals, including pesticides, has increased food availability by enhancing crop yields by reducing critical growth constraints and protecting crops from pests, it has also increased the risk of food-safety challenges such as pesticide-toxicity (Lamichhane *et al.*, 2016; Carvalho, 2006). Nepal also emphasized on increasing application of agro-chemicals for increasing agricultural production based on the assumption of green revolution (Thapa, 2010). Consequently, high pesticide residues in food products, and resulted potential health risks is an important food safety issue in country (Bhandari *et al.*, 2019).

Nepal's formal effort on 'Food Safety' can be dated back to 1966 with enactment of Food Act (1967). Regulations about food safety, however, were under broad umbrella of three laws: Food Act (1967), Plant Protection Act (1972) and Animal Health and Livestock Services Act (1998). While food safety

1 Januka Pandit, M.Sc. Agriculture, Institute of Agriculture and Animal Science, Tribhuvan University, Nepal

2 Yogendra Kumar Karki, Ph.D., Ministry of Agriculture and Livestock Development, Nepal

3 Devendra Gauchan, Ph.D., Alliance of Bioversity International and CIAT

4 Bikash Paudel, Ph.D., Agriculture Economist, Nepal

targets needs to be achieved by adopting safe methods during production, handling, preparing and storing food, historically, less attention has been paid on how farmers produce food/food ingredients. Food safety efforts in country were focused on inspecting and analysing end products. Realizing this gap, lately, National Food Safety Policy (2019) emphasized on the need for "Total Quality Management" – adopting the 'farm to fork' approach - to give due emphasis throughout food-chain including production level (MoALD, 2019a). Despite that, food safety agenda rarely reflected in the agriculture development agenda. Instead, agricultural development paradigm promoted green revolution which increased the use of agrochemicals including fertilizer and pesticides often leading to production of unsafe food. Nepal's average pesticide use in agriculture is 0.27 kg/ha which is still low compared to other countries such as India (0.37 kg/ha), China (14.84 kg/ha) and Japan (12.63 kg/ha) (FAOSTAT, 2021).

The knowledge about harmful impacts of agrochemicals has increased in recent years. Due to this, some notable efforts have been made to address negative impacts of agrochemicals. Some of them include – introduction and promotion of Integrated Pest Management (IPM) since 1997; promotion of organic agriculture; introduction of Good Agriculture Practice (GAP), and implementation of Organic Agriculture Promotion Program (OAPP) since 2018. Nepal's traditional production system is '*de facto*" organic or naturally astute form of the organic farming. Nepalese farmers are practicing this traditional system for production of agriculture commodities for centuries without using any agrochemicals and harnessing the biological and cultural diversity.

Despite availability of these alternative production methods, food certification/labelling practice has not recognised these diverse production methods. Nepal Food Regulation (1970) was the first legislation about food labelling in Nepal which asked the producers to mandatorily put essential information like processing batch number, manufacturing date, weight, and preservatives (HMGN, 1970). The regulation established the Department of Food Technology and Quality Control (DFTQC) with mandate to ensure and enhance the quality and safety of food and feed products. DFTQC plays greater role in food processing and post-harvest issues related to food safety. Food safety issues at farmers level has seldom been priority agenda for DFTQC as some of these issues are seconded to agriculture and livestock sector departments.

Thanks to the efforts from promoters of organic and GAP, Nepal has established the provisions for labelling organic as well as GAP products. OAPP has been implemented since 2018, has recognised four typologies of production systems i.e. Traditional, Pesticide-free, Organic in Conversion and Organic (MoALD, 2020). However, due to lack of integrated multi-layered certification system, these intermediate safer-food production regimes have

been overlooked in the certification/labelling mechanism despite their potential to serve as safer-food alternative to wider consumers. This indicates towards the need for integrated certification system with multiple levels of food safety between pure organic and input-intensive production system. This paper reviews status of available safer-food production regimes, related policy and legal provisions and discuss the potential for integrated multi-level food-safety certification/labelling systems for Nepal.

OBJECTIVES

The specific objectives of this paper are:

1. Assessment of status of various typologies of safe-food production regimes in Nepal
2. To review the policy and legal framework for traditional agriculture, pesticide-free, Good Agriculture Practice (GAP) and organic systems
3. To assess the need for integrated certification system for organic, traditional, pesticide-free and GAP labelling for promoting healthy and safe food production in Nepal

METHODOLOGIES

This study examines the existing literature on diverse food production systems (traditional, organic, conventional chemical based) and policies, periodic plans, perspective plans, legal mechanism, focusing on pesticide safe vegetable production, and discusses the gap in these literature and policy measures. For first objective, the assessment of status of various typologies of safe-food production regimes was done through review of literatures about various typologies of healthy and safe-food production, analysis of secondary data regarding the status of those regimes and reviewing the constraints and problems identified for promotion of those regimes. For second objective, various policies, strategies and legal documents were reviewed and analysed to note the existing policy and legal frameworks relevant for promotion of various safe-food production regimes and discussions were made on policy gaps. Finally, for third objective, the need for the integrated multi-level safe-food certification and labelling system were assessed by reviewing different national and international practices for food-safety certification.

DISCUSSIONS

TYPOLOGIES OF SAFE-FOOD PRODUCTION SYSTEMS AND THEIR STATUS IN NEPAL

Various terminologies, often overlapping with fuzzy difference, are used to denote various safer production regimes in the continuum between pure organic and input-intensive paradigm (Table 1). Some of these systems call for rationalization of agrochemicals (e.g. GAP, integrated farming system, biological farming) or do not allow agrochemicals (e.g. traditional, organic

agriculture, permaculture and ecological agriculture). Production derived from these production systems are safer compared to the conventional system because they either do not have or have tolerable level of chemical residue in food. Despite these typologies being available, the area coverage and the market share of these systems remain low.

Table 1: Typologies of safe-food production paradigm

Typologies	Focus	Use of fertilizers	Use of pesticides	Status in Nepal
Traditional Agriculture	Application of indigenous knowledge, tools, resources, and cultural beliefs	Not used	Not used	Majority of farmers still practice traditional system without visible differentiation of production from traditional methods to other farm products (Pokhrel and Pant, 2009)
Biological Farming	System which minimizes the use of 'chemicals' for pest control (Farrell *et al.*, 2017)	Not used	promote biological pest control	Biological pest control has been promoted in few crops as part of IPM initiative, but the adoption is still low
Good Agricultural Practices (GAP)	Safe and quality food and non-food agricultural products; locally developed optimal practices	Rational use	Rational use	NepalGAP Implementation Directive has been approved in 2018 (MoALD, 2018). The area under GAP is 7.99 ha (DFTQC, 2021)
Integrated Farming Systems	Farms and the food production system as an integrated whole, synergies and complementarities (Soni *et al.*, 2014)	Rational use	Rational use	Nepal's traditional farming system is like integrated crop-livestock-agroforestry system (Paudel *et al.*, 2011)
Organic Farming	Avoids use of synthetic fertilizers, and agrochemicals including GMO free targeting to getting	Not allowed	Not allowed	Being promoted through policies and strategies since The tenth plan. The country has 11,851 ha

	official certification for marketing			land and 1,622 organic producers covering about 0.23% of agricultural land (Willer and Lernoud, 2019).
Pesticide-free or Zero Pesticide Residue	Avoids the use of toxic chemicals and pesticides targeting food safety (Nazarko *et al.*, 2003)	Allowed	Not allowed	There are areas and crops where fertilizers are used but pesticides are not used but they are not documented.
Permaculture	Low-maintenance integration of plants, animals, people and structure (Holmgren, 2020)	Not allowed	Not allowed	Viewed like organic farming, not widely adopted
Ecological agriculture / Agroecological farming system	Harmony with nature, harness natural process like nutrient cycling, biodiversity without using agrochemicals (Lacombe *et al.*, 2018)	Not used	Not used	Nepal's traditional subsistence farming system, particularly in high mountains and hills is ecological agriculture, however, not widely recognized

Source: Compiled by author

Among these typologies, we can observe Traditional, Integrated Farming System, Permaculture or Agroecological farming system in Nepal, often without knowing it's literary definition. However, outputs derived from them are not differentiated in market. Nepal's certification system only consists 'organic' product and 'all others', except recent addition of GAP, failing to reward the producers who adopt traditional or agro-ecological systems and limiting consumers of the diversity of certified safer-food alternatives.

Traditional agriculture, GAP, pesticide-free and organic production regimes merits attention for Nepal due to their historical significance, area coverage, policy preference and potential to meet Nepal's food safety requirements. Globally, organic agriculture is most promoted safe-food production regime mainly due to its success in penetrating the market. Despite notable promotion of modern organic agriculture by government and private sector in Nepal only 11,851 ha of land (about 0.23%) was under certified organic agriculture, and only 1,622 farmers practiced it (Willer and Lernoud, 2019). A

high initial investment, long waiting period, shortages of labour, lack of organized market, high price of product, costlier and cumbersome process of third-party certification, lack of technical knowhow, complexity of certification, lack of consumer awareness, unclear product standards, and poor quality assurance are frequently cited reasons behind low adoption of organic agriculture (Bhatta *et al.*, 2009; Banjara, 2016). It is not possible to get information about the extent of coverage and adoption of other safe-food production systems. Traditional agriculture, which is closest to astute form of organic farming, is practiced for centuries, but is declining year after year. About 96% of agriculture land in mountain (high-hill), 80% of land in mid-hill and 41% of land in Terai are still pesticide-free in Nepal; however, due to lack of any certification and labelling, the agriculture products derived from these lands are treated as common unsafe food (PPD, 2014). There is some effort for GAP; however, it is in infant stage with almost negligible adoption at country level.

POLICY AND LEGAL FRAMEWORK FOR SAFE-FOOD PRODUCTION SYSTEMS

Policy Framework: Table 2 shows notable policies promoting organic and safe-food production regimes in Nepal. Starting from Agriculture Perspective Plan (1995) (NPC, 1995) to Agriculture Development Strategy (2015-2035) (ADS) there is notable progress in devising policies to address safe-food production issues and quality assurance issues of agricultural products through standardization, certification, accreditation, GAPs and SPS measures. National Fertilizer Policy (2002) emphasised on minimizing the negative impacts of chemical fertilizer, National Agricultural Policy (2004) emphasised on organic farming, promoting organic certification and conservation biodiversity and environment. Agribusiness Policy (2006) included the provision for establishing organic/pesticide free production areas, and registration of indigenous knowledge and technologies to promote traditional productions. Policies like National Coffee Policy (2003), Agricultural Biodiversity Policy (2014), Trade policy (2009), Nepal Trade Integration Strategy (2016) has supportive provisions for organic system. The recently introduced National Food Safety Policy (2019) has taken vision of ensuring food safety and quality in all stages of food chain. The OAPP Implementation Procedure has acknowledged the need to promote different types of safer-food production typologies (MoALD, 2020).

Recognition of these issues in policies is also paralleled with the inclusion of activities to promote safe-food production regimes in periodic plans – mainly promoting organic system and regulation of agrochemicals. For initial decades, agricultural sector plans were heavily focused on promoting green revolution technologies. The Eighth plan (1992-1997) was the first to recognize the need to rationing pesticide (NPC, 1992) as Pesticide Act 1991 (HMGN, 1991) was enforced with provision of controlled use of pesticide.

Table 2: Notable policies related to promotion of safer-food production regimes

Policy framework	Focus on safe food production	Potential Provisions and Options
Agriculture Development Strategy (2015-2035)	Standardization, Certification, Accreditation, GAPs and SPS measures	Provisions of GAPs and SPS measures can be used to refine standards and guidelines for certification for traditional and pesticide free products (MoAD, 2015)
National Agricultural Policy (2004)	Organic farming, organic certification, conservation of natural resources and biodiversity	Provisions to promote integrated farming and pesticide free farming in the new revision of the Policy (MoAC, 2004)
National Fertilizer Policy (2002)	Integrated Plant Nutrient System Management (IPNSM) to minimize the negative impacts of chemical fertilizer	Production and promotion of organic inputs for crop production (MoAC, 2002)
Agribusiness Policy (2006)	Establishing organic/pesticide free production areas, registration of indigenous knowledge and technologies	Organic/pesticide free certification of agricultural products (MoAC, 2006)
National Coffee Policy (2003)	Promotion of organic coffee	Development of national logo for coffee (NTCDB, 2003)
Agricultural Biodiversity Policy (2007), Amendment (2014)	Conservation and use of agro-biodiversity with traditional production system	Develop of Action plans, guidelines and legislation to promote traditional and pesticide free system for agrobiodiversity (MoAC, 2007)
Trade Policy (2009)	Production of organic, fresh and dried vegetables, certificates for organic products	Support to value addition and export (MoCS, 2009)
Nepal Trade Integration Strategy (2016)	Recognized organic products like large cardamom, ginger, tea, and medicinal and aromatic plants	Support to value addition and export (NTIS, 2016)
National Food Safety Policy (2019)	Ensuring food safety and quality in all stages of food chain and facilitate food trading	Adoption of risk-based food-safety and quality control mechanism, promotion of GAP and GVP certification (MoALD, 2019a)

Source: compiled by author

The Ninth plan (1997-2002) stressed on promoting Integrated Plant Nutrient Management Services (IPNMS) for rationing the use of chemical fertilizer and called for Integrated Plant Protection Services (IPPS) for minimizing the use of pesticides. The Tenth plan (2002-2007) promoted organic farming and Integrated Pest Management (NPC, 2002). All succeeding periodic plans after that have provisions, programs for promoting the organic production and paved ways to pilot innovative certification methods like Participatory Guarantee System (PGS) for organic certification and marketing. The Fourteenth Plan (2016/17-2018/19) gave strong attention to pesticide residue and risk analysis in vegetables (NPC, 2017). The Fifteenth plan (2019/20-2023/24) has called for development and dissemination of organic agricultural technologies and plans to identify and promote exportable Nepalese special production and facility of branding to these products, establish accredited laboratories to regulate and manage in pesticide use, certification, branding and marketing of organic products (NPC, 2019).

Legal Framework: Table 3 shows notable laws in Nepal related to food safety issues. Nepal's Constitution, 2015 has expressed 'consumer right' as fundamental right and stressed on right 'to obtain quality goods and services' (GoN, 2015). Accordingly, The Consumer Protection Act (2018) was enacted to assure consumer with quality products and services at reasonable price. The Food act (1967) was already there to maintain purity in foodstuffs and prohibiting production, sale and distribution of adulterated foodstuffs, prohibit on sale of foodstuffs by lying or misleading (HMGN, 1967). Since previous version of The Consumer Protection Act (1997), it has stressed on labelling of products with adequate information. There are provisions in Environment Protection Rule (1997), Pesticide Act (1991) and Pesticide Rules (1994), Pesticide Management Act (2019), although not directly mentioning food safety issues but interwoven to favor safe food production system. Recently enacted The Right to Food and Food Sovereignty Act (2018) is closely attracted to the cause of safe-food system as it emphasizes to protect traditional foods, promote traditional agricultural products and markets.

Table 3: Major legal framework in agriculture and food production in Nepal

Legal framework	Connection to safe food production	Provisions
Consumer Protection Act (2018)	Quality products and services at reasonable price	Develop by laws (rules), guidelines and directives to develop standards for food products (GoN, 2018a)
Food Act (1967)	Prohibition in production, sale and distribution of adulterated food stuffs	Specify quality standards, power to withhold, licence (HMGN, 1967)

Consumer Protection Act (1998)	Protection of the rights and interests of consumers	Formation of Consumer Protection Council, Provision of inspection officer, compensation of loss (HMGN, 1998)
Environment Protection Rule (1997)	Environmental protection, safe-food production, mandatory provision of environmental assessments for activities involving handling of chemical fertilizer and pesticide	Develop guidelines, standards and promoting environmentally friendly technologies (MoWSS, 1997)
Pesticide Management Act (2019)	Safe import, export, sale, use of pesticides and reduce negative impact	Formulation of pesticide management regulation, directives and standards, promotion of bio-pesticides (MoALD, 2019b)
Right to Food and Food Sovereignty Act (2018)	Right to protect traditional foods, farmers rights, promote traditional agricultural products and markets	Develop by laws(rules), guidelines and directives to develop standards for certification of traditional & pesticide free production system (GoN, 2018b)

Source: Compiled by author

There are several standards and guidelines like National Technical Standards of Organic Agriculture Production and Processing (2007) developed in Nepal which are also supportive for food safety causes however most of efforts are concentrated on promoting organic agriculture as the only alternative. Recently adopted NepalGAP has provided another mid-way alternative for safe food but it is in juvenile stage until now. OAPP has accepted the traditional as well as pesticide-free typologies while promoting organic agriculture in country (MoALD, 2020).

NEED FOR INTEGRATED MULTI-LEVEL FOOD SAFETY CERTIFICATION MECHANISMS

Nepal has certification system for organic and GAP which are alternative to product from unsafe input-intensive system. Since GAP is just initiated, consumer face binary choice – either buy pure organic or not. Consumers do not get to choose anything between these two ends in the spectrum. Mid-way alternatives are available in various countries like in USA, the label 'organic' is given to any product with 100% organic ingredients, whereas "made with organic" is label to products with 70% organic ingredients (Parker *et al.*, 2021; USDA, 2021). GAP is a compromise between fully organic and

conventional system as it does not exclude but encourage safe use of agro-chemicals. Even with full functional organic and GAP systems, however, they do not cover products from traditional farming and as well as any other pesticide-free production regimes which has huge potential in Nepal.

Certification of 'Traditional Production'

Although modern organic agriculture including formal certification has a relatively short history in Nepal, Traditional farming in the country was always like modern organic farming, ecological farming or permaculture. It can be argued that the traditional agriculture practiced in high-mountains and hills of Nepal for centuries was the astute form of organic agriculture. The products derived from the traditional production system in many areas of country are still free of agrochemicals (Gurung *et al.*, 2016; Parajuli *et al.*, 2016; Palikhey *et al.*, 2016); hence, they are safe for human and environmental health. Majority of traditional farmers in high mountains and hills have not received any benefit from ongoing efforts to promote organic agriculture. In fact, the production derived from traditional production system, which by default organic in nature, is not differentiated and promoted in market. Recently, OAPP has identified 'Traditional' as separate typology within organic agriculture continuum; however, this is not supported by certification practice. However, there is opportunity to differentiate the products derived from traditional production practices, agro-chemicals are largely applied to few field crops like rice, wheat, maize and the high value horticultural crops (Pokhrel and Pant, 2009; Takeshima *et al.,* 2016) mostly for modern varieties in favourable irrigated production pockets of Terai and accessible river valleys in the hills.

It is reasonable to expect that consumers are willing to pay premium price for traditionally recognized products. The traditional products with geographical identity like beans from Humla and Jumla, black gram from Gorkha, traditional varieties of rice from various places (e.g. Marsi from Jumla, Jethobudo from Pokhara, Kalo nuniya from Jhapa, Tilki from Dang, Jorayl from Doti) are sold with higher price in market. There is opportunity to provide price-premium to many traditional, neglected and underutilized crops/varieties grown in high mountains and hills as well as crops/varieties maintained and cultivated by ethnic groups, tribal people and minorities (Gauchan *et al.*, 2020). However, due to lack of proper differentiation and product tracing, there is widespread misinformation and adulteration in marketing of these products. Due to lack of appropriate standards and quality assurance, retailors falsely claim traditional production methods to other products, which gradually reduce the authenticity in the market. The process of organic certification is not suitable for certifying farm products derived from traditional farming practices. The traditional agriculture is bio-diverse and practiced in complex crop-livestock-agroforestry system which involves

diverse crops and heterogeneous production technologies, which makes it very difficult to meet the standards and homogeneity requirement of organic certification (Gauchan *et al.*, 2020; Tibério and Francisco, 2012). In addition, the organic certification process also requires paying high price and need special knowledge which cannot be afforded by smallholders. Therefore, it is reasonable to consider a different process for certifying 'traditional production', which needs to be easier and affordable yet giving authenticity to consumers. There are examples of such certification/labelling practices to differentiate traditional production such as Traditional Speciality Guaranteed (TSG) for process and Protected Designation of Origin (PDO) for place in European Union (Tosato, 2013).

Certification of Pesticide-free Production

Farmers who apply chemical fertilizer but avoid pesticide are also common in Nepal for field crops like rice, wheat and maize, fruits and vegetables. Although chemical fertilizers also have negative environmental impacts, it is not as hazardous to human health compared to pesticide. While 'organic' or 'traditional' products are the most safe-food, many consumers cannot always afford the price-premium to pay for these products. In a study conducted in Kathmandu valley, it is reported that that only 13% consumers were willing to pay up to 50% premium price whereas majority (58%) were willing to pay 6-20% premium price (Aryal *et al.,* 2009). Another study indicated that consumers in Kathmandu were willing to pay average of about 31% premium price on vegetables (Rai and Adhikari, 2016). High price of organic products is often most reported constraints among the consumers to consume safe food (Bardhan *et al.*, 2019; Bhatta *et al.*, 2009; Sharma *et al.*, 2016). A higher price for organic products is due to lower yield and higher transaction costs (Knapp and Van, 2018; Manida and Nedumaran 2021). In this regard, some suggests that if organic regulations are modified to allow restricted use of mineral nitrogen fertilisers it can increase the yield (Röös *et al.*, 2018). Though it challenges the basic principle of organic farming, products derived from such methods will be safer than conventional system and affordable than organic system. Such products can be marketed with label of 'pesticide-free' rather than 'organic'. A sizable segment of the consumers may be willing to buy the 'pesticide-free' products without considering whether it has been produced 'with' or 'without' inorganic fertilizer. Worldwide, there are examples that countries and companies use the 'pesticide-free' label to the food products to assure that the product is produced without use of any pesticide (e.g. 'Zero Pesticide Residue' or ZPR Label in France; 'Certified Pesticide Residue Free' label (Food Print, 2021) 'Certified Pesticide Free' label (Clean Label Project, 2019); 'Pesticide Free' label by Greener Choices (Oscar, 2021). Studies have suggested that consumers believe that products labelled 'Pesticide free' are with higher quality, greater value and possess

higher purchase intention than those without the label (Grebitus *et al.*, 2018). In Nepal, OAPP has recognised 'Pesticide-Free' typologies which allow use of fertilizer but not pesticide (MoALD, 2020). Therefore, a new 'pesticide-free' label is worth considering providing consumers a reliable choice between organic and unsafe products.

Integrated Multi-Level Safe-Food Certification/Labelling Regime

Considering the potential of promoting traditional agriculture which already has large area coverage in Nepal and pesticide-free label which may be relevant for producing affordable safe-food, it is worthwhile to consider multi-level food-safety certification mechanism where the food products are provided with mandatory labels indicating one production regimes among various levels of food safety. This integrated mechanism can be built on the existing mechanism for organic and GAP certification by including 'traditional production' and 'pesticide-free' labels in the spectrum of safe-food (Figure 1). Different levels of food-safety labels can be assigned by a single authority like DFTQC, which is already regulating organic and GAP certification. Necessary guidelines, standards and mechanism for certification and labelling of traditional system and pesticide-free systems have to be developed and integrated to single multi-label certification system.

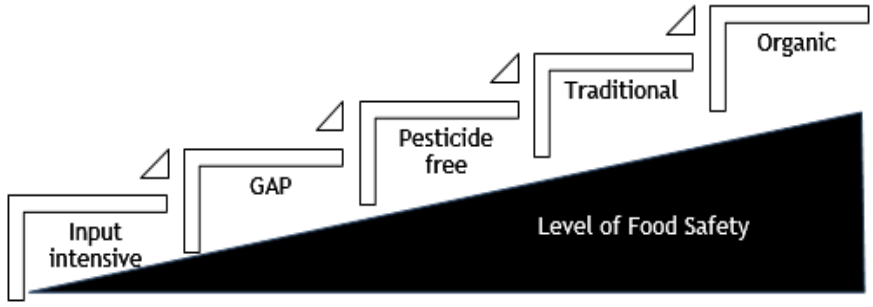

Figure 4 Continuum of multiple labels for different levels of safe food

Such an integrated certification system is aligned with the outlook of national policy framework for food safety. The Food Safety Policy 2019 also plans to establish one independent food safety and quality control authority which establishes horizontal and vertical standards for all food products in coordination with national CODEX committee (Article 11.1.2 & 11.1.3) (MoALD, 2019a). This provision paves the ways for the establishment of multi-level integrated labelling system including different typologies of safe-food production regimes in Nepal. Being a member of CODEX, Nepal has already harmonized some food standards with those laid down by Codex (WHO, 2012). While developing the standards for multi-level food-safety certification system

can be done without compromising CODEX standards. Labelling of pesticide-free and traditional systems can be targeted to national consumers in line with the Participatory Guarantee System (PGS) of quality assurance.

CONCLUSION

The increased consumer awareness on food-safety issues in Nepal has increased the demand for safe-food in country. However, due to low purchasing power of people, consumers are forced to consume unsafe pesticide-laden food products. There are various relatively safer-food production systems with potential to provider safer and affordable food. However, existing food certification and labelling system has limited mid-way choice to consumers. Food derived from traditional and pesticide-free production systems has strong potential to be mid-way choice for consumers. Therefore, this paper discussed on the potential for increasing categories in food labelling system so that consumers can make greater informed choice. By reviewing policies and legal provisions as well as national/international practices, paper makes case for implementation of integrated multi-level food-safety certification and labelling system in Nepal. It makes special emphasis to integrate traditional and pesticide-free regimes as cheaper alternatives for organic and GAP labels to meet dual goals of increasing food production and enhancing food safety. Integration of diverse relatively-safer production system in labelling is proposed for improving affordability for safe-food as well as linking millions of smallholder farmers practicing traditional agricultural systems to market, eventually contributing to both food-safety and sustainable agricultural development of the country.

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MAINSTREAMING THE CONSERVATION AGRICULTURE IN NEPAL

T.B. Karki[1] and R. Acharya[2]

ABSTRACT

Conservation agriculture (CA) system involves minimum soil disturbance, permanent soil cover, and crop rotations. In Nepal, efforts to develop, refine and disseminate conservation-based agricultural technologies started since the rice-wheat consortium in Terai in the 1990s. There are more payoffs than tradeoffs for the adoption of CA. Nepal Agricultural Research Council (NARC) with CIMMYT and IRRI has been working on it under various ecologies. Studies revealed that it reduces the production cost, saves water and nutrients, increases yields, improves soil health, mitigates global warming and improves resource use efficiency. However, there are many bottlenecks for its promotion; like lack of appropriate CA machineries, trade-offs of using crop residue in crop-livestock systems, crop residue burnings, unavailability of skilled manpower and peoples' mindset. Therefore, there is an urgent need to develop strategies to mainstream the CA in Nepal. The paper highlights on strengths, weaknesses, opportunities, and threats of CA for promotion and the way forward.

Key Words: Productivity, conservation agriculture, constraints, mainstreaming, way-forward

INTRODUCTION

To meet the global food, feed, fiber, and bioenergy demand and to reduce hunger and poverty, there is no alternative to increase agricultural productivity. This can be achieved by increasing the efficiency of total and individual factor productivities. However, until now, agricultural intensification from intensive tillage-based production systems generally has had a negative effect on the quality of many of the essential natural resources such as soil, water, terrain, biodiversity, and the associated ecosystem services provided by nature. This degradation of the land resource base has caused crop yields and factor productivities to decline and has forced farmers, scientists and development stakeholders to search for an alternative paradigm that is ecologically sustainable as well as profitable. Another challenge for agriculture is its environmental footprint and climate change. Agriculture is responsible for about 30% of the total greenhouse gas emissions of CO_2, N_2O, and CH_4 while being directly affected by the consequences of a changing climate (IPCC, 2007).

1 National Agronomy Research Centre, Khumaltar

2 Directorate of Agricultural Research, Lumle, Kaski

A set of soil-crop-nutrient-water-landscape system management practices known as Conservation Agriculture (CA) has the potential to deliver all of these goals. CA saves energy input and mineral nitrogen use in farming and thus reduces emissions; it enhances biological activity in soils, resulting in the long-term yield and factor productivity increases. While tilling the soil is not a necessity, but CA itself doesn't provide the optimum conditions for truly sustainable and productive agriculture, it has to be complemented with other techniques, such as integrated pest management, plant nutrient management, and weed and water management (FAO, 2012).

CA is the resource-saving agricultural production system that aims to achieve production intensification and high yields while enhancing the natural resource base through compliance with three interrelated principles, along with other good production practices of plant nutrition and pest management (Abrol and Sangar, 2006).

CONSERVATION AGRICULTURE

Conservation agriculture is a management system that maintains a soil cover through surface retention of crop residues with no/zero till and reduced tillage. CA is described by FAO (http://www.fao.org.ag/ca) as a concept for resource-saving agricultural crop production which is based on enhancing the natural and biological processes above and below the ground. As per Dumanski *et al*. (2006) conservation agriculture (CA) is not "business as usual", based on maximizing yields while exploiting the soil and agro-ecosystem resources, rather CA is based on optimizing yields and profits, to achieve a balance of agricultural, economic and environmental benefits. With CA, farming communities become providers of more healthy living environments for the wider community through reduced use of fossil fuels, pesticides, and other pollutants, and through conservation of environmental integrity and services. As per FAO definition CA is i) to achieve acceptable profits, ii) high and sustained production levels, and iii) conserve the environment. It aims at reversing the process of degradation intrinsic to conventional agricultural practices like intensive agriculture, burning, or removal of crop residues from the field.

It aims to conserve, improve and make more efficient use of natural resources through integrated management of available soil, water, and biological resources combined with external inputs, hence can also be referred to as resource-efficient agriculture.

Conservation agriculture systems require a total paradigm shift from conventional agriculture with regard to management of crops, soil, water, nutrients, weeds, and farm machinery (Table 1).

Table 1. Some distinguishing features between conventional and conservation agriculture.

Particulars	Conventional agriculture	Conservation agriculture
Closeness to nature	Cultivating the land, using science and technology to exploit nature	Least interference with natural processes
Soil movement	Excessive mechanical tillage and soil erosion	No-till or drastically reduced tillage
Erosion	High wind and soil erosion	Low wind and soil erosion
Residue management	Residue burning or removal (bare surface)	Surface retention of residues (permanently covered)
Water infiltration	Low	High
Use of FYM/composts	*Ex-situ* management	*In-situ* management
Bio-manuring	Green manuring (incorporated)	Brown manuring/cover crops (surface retention)
Weed management	Kills established weeds but also stimulates more weed seeds to germinate	Weeds are a problem in the early stages of adoption, but residue retention reduces the weeds
Soil compaction	Free-wheeling of farm machinery, increased soil compaction	Controlled traffic, compaction in tramline, no compaction in crop area
Cropping system/pattern	Mono cropping/culture, less efficient rotations	Diversified and more efficient rotations
Field operations	Heavy reliance on manual labor, uncertainty of operations	Mechanized operations, ensure timeliness of operations
Productivity	Productivity gains in long-run are in declining	Productivity gains in long-run are in incremental order
Economic benefit	Less	Higher
Energy use	High	Low
Labor use	High	Low

PRINCIPLES OF CONSERVATION AGRICULTURE

Conservation agriculture (CA) practices are built on ecological principles making the sustainable use of land (Lal, 2013). Adoption of CA for enhancing resource use efficiency (RUE) and crop productivity is the need of the time as a dominant tool for the management of natural resources. CA consists of 3 interconnected principles:

Minimal mechanical soil disturbance

Minimum soil disturbance provides/maintains optimum proportions of aeration in the rooting zone; moderate the process of oxidation of organic matter, porosity for soil moisture movement, retention, and release and limits the weed seeds for germination (Kassam and Friedrich, 2009).

Soil cover/residue retention

A soil cover is important to save from the harmful effects of rain and sun, to nourish the micro and macro organisms in the soil and plant roots. In turn, it improves soil aggregation, soil biological activity and soil biodiversity and enhances carbon sequestration (Ghosh et al., 2015).

Crop rotations

The rotation of crops is not only necessary for feeding the soil microorganisms, but also for exploring different soil layers for recycling by the crops in rotation. It also enriches the diverse soil flora and fauna. Cropping rotations involving legumes help in minimal rates of a build-up of a population of pest species through life cycle disruption, biological nitrogen fixation, control of off-site pollution, and enhancing biodiversity (Friedrich and Kassam, 2009; Dumanski et. al., 2006).

Table 2. Strength, weakness, opportunity and threats of CA in Nepal

Strengths	Weaknesses
• Evidence-based scientific knowledge generated to solve the multiple complex problems • Availability of resource conservation technology (RCT) based farm machineries (laser land leveler, zero-till seed cum fertilizer drills, bailing machines, boom sprayers • Availability of herbicides and weeding tools • Weather forecasting systems • International collaborations (CG centers, R-W consortium, CASI-Platform, CSISA, SRFSI, CIMMYT	• CA systems are much more complex than conventional systems. (Derpsch, 2001). • Intensive tillage-based mindset among the farmers, agricultural technicians and policy makers, • No data on the actual area under various CA based practices and responsible agency to estimate it, • Knowledge gap among the stakeholders, • Inadequate scale-neutral types of equipment and machineries, • Inadequate knowledge-intensive CA

• Curriculum of RCT in academic institutions, Critical manpower in universities, NARC, and Nepal based Consultative Group for International Agriculture Research (CGIAR) centers	based Package of Practices (POPs), • Infestation of weeds and their management, • Changes in pest dynamics, • Government policies are not CA friendly, • Land use systems (a problem in land consolidation), • Poor marketing system, • Inadequate research thrusts on CA in research institutions, • Extensive areas under sloppy hill agriculture-poor accessibility, • No specific technologies under maize-based relay/intercropping systems (maize/millet) in the hills
Opportunities	Threats
• Nepal have now three levels of governments (Federal, Provincial and Local) and the federal government develops the policy, provincial monitor and local governments are to plan and execute as per their own needs, • People are accepting that residue burning and repeated tillage are harmful to the farm, community and regional level, • CA-based farm machineries are now being available in the Nepalese markets. • Academic courses on CA in graduate and postgraduate programs of Agriculture and Forestry University (AFU) and Tribhuvan University (TU), Nepal since 2012, • Nepal Agricultural Research Council (NARC) in close collaboration with CIMMYT and IRRI have generated convincing CA-based technologies under various cropping systems in the past and data on the impact of CA in soil, crop performance and economics have been generated. It has 61 different research stations across the country stretching	• Adopting CA may, in the short term, involve costs, and risks. • Crop might be failed to produce the yield at par with conventional agriculture in initial years/seasons, • Many non-conventional biotic factors might be emerging like soil-borne pathogens (grey leaf pot disease) in maize due to infected stubbles kept as crop residue. • Weather and climatic condition might not be favorable as expected like direct seeded rice (DSR) and heavy flooding after rainfall. • More dependency on herbicides in the initial years/seasons. • Discontinuation.

from East to West and South to North,
- FAO has been giving high priorities to scale out the CA across the globe,
- International communities have very positive learning from their long-term experimentation on CA especially in South and North America, Europe, and Middle East,
- International trusts and foundations like BMG are also focusing their development thrusts towards CA,
- The momentum has been taken place in neighboring countries like China, India, and Pakistan and Nepal shares similar agro-ecologies with them.

Potential benefits of CA

(1) Reduction in cost of production

Table 3. The economics of various studies carried out by various authors in Nepal.

References	Economic analysis (benefit cost ratio)		Remarks
	Conventional tillage without residue	No tillage with residue	
Karki *et al.,* (2014)	1.7	2.5	Hills (maize-wheat/tori)
Paudel *et al.,* (2014)	2.3	2.5	Terai (maize + soybean-wheat)
Khatri and Karki (2015)	2.42	2.53	Terai: (maize + soybean-wheat)
Karki *et al.,* (2015a)	2.43	3.3	Terai (maize - maize)
Karki *et al.,* (2015b)	1.18	1.36	Hill (maize - wheat/tori)

(2) Enhancement of soil quality (Gathala *et al.*, 2011b). In rice-wheat cropping system of Nepal, 22% higher carbon content of soil in zero tilled residue retained plot was recorded over conventionally tilled plots (Paudel *et al.,* 2014).

(3) Enhancement, in the long-term C sequestration and build-up in soil organic matter to mitigate Green House Gas emissions and impart greater resilience to production systems to climate change related aberrations (Saharawat *et al.,* 2012).

(4) Reduction of the incidence of weeds, such as Phalaris minor in wheat (Malik *et al.,* 2005)

(5) No-tillage system along with site-specific approaches for nutrient management can increase yield, nutrient use efficiency and profitability while decreasing greenhouse gas (GHG) from wheat production in NW India (Sapkota *et al.,* 2014).

(6) Enhancement of production and productivity (Pariyar *et al.*, 2019).

(7) Reduces seeding time by about 6 days on small farms to over 17 days on large farms (CSISA, 2018).

(8) Reduction in greenhouse gas emission and improved environmental sustainability (Marasini *et al.*, 2018).

(9) Avoiding crop residue burning reduces loss of nutrients, and environmental pollution, which reduces a serious health hazard (Sidhu *et al.,* 2007).

(10) Providing opportunities for crop diversification and intensification-for example in sugarcane-based systems, mustard, chickpea, pigeonpea etc. (Jat *et al.,* 2005).

(11) Improvement of resource use efficiency through residue decomposition, soil structural improvement, increased recycling and availability of plant nutrients (Jat *et al.,* 2009).

(12) Surface residues as mulch to control weeds, moderate soil temperature, reduce evaporation, and improve biological activity (Gathala *et al.,* 2011b).

(13) Energy saving: Savings of energy in conservation-tillage treatments were attributed to reduced energy use in land preparation (69–100%) and irrigation (23–27%), which consumed a large amount of fuel energy (Nandan *et al.,* 2021).

(14) Conservation agriculture conserves the moisture ensuring timely sowing and emergence of crops (Acharya *et al.*, 2017).

(15) Low risk (Laborde, 2018).

KEY CA TECHNOLOGIES IN NEPAL

(1) Direct-Seeded Rice (DSR)

DSR is an alternative rice establishment method in which rice seeds are broadcast or directly seeded in the dry tillage or wet tillage (puddled) field instead of transplanting the seedlings in the puddled field. The common DSR technologies in Nepal are:

*(*i) Wet direct-seeded rice (WDSR): This method is common in Jhapa and Morang and high rainfall areas of other Terai districts. In this method, rice seeds soaked for 24-72-hours and sprouted are broadcast or sown in lines using drum seeder under wet tillage and puddled soil (Bedari *et al.,* 2020).

(ii) Dry direct-seeded rice (DSR): This is an ancient method of rice establishment in the hill districts of Nepal, especially in the western mid-hill districts: Gorkha, Lamjung, Tanahun, Parbat, Syangja, Palpa. It is known as Ghaiya Dhan, grown mostly in rainfed upland unbunded terraces with seeding in March-April. Terai receives adequate rainfall (>1300 mm) during rice season, even under rainfed condition and without supplementary irrigation, performance of DSR can be good and this technology seems promisig in high rainfall areas (Devkota *et al.,* 2019).

(2) Zero tillage (ZT) in maize

An on-station replicated experiment conducted by Karki *et al.,* (2014) in maize-wheat system during 2011-2013 in Rampur, Chitwan found that ZT sole maize without residue retention in field was counter-productive to the farmers, where ZT maize with retained residue had 6% higher yield than CT maize without residue retention, indicating ZT can replace CT in maize, which saves labor and the production costs related to field preparation and crop establishment.

(3) Surface seeding in wheat

No land preparation is needed in his method and the sprouted wheat seeds are broadcast onto the saturated soil either in standing rice crop before its harvest (relay surface seeding) or after harvest (Hobbs 2001). In Nepal, surface seeding of wheat, lentil, and lathyrus is mostly used in the areas where long-duration rice varieties are cultivated and difficult to timely drain out water from the field to allow timely field preparation and seeding. This system offers advantageous in terms of timely sowing, reduced risk of bird attacks, and low production cost. Tripathi (2010) reported that benefits of surface seeding of wheat are even more pronounced in terms of cost savings and returns compared to when it is sown under ZT or RT after draining the saturated soil. The saving in cultivation cost with surface seeding in wheat was more than 150% compared to CT wheat.

(4) Zero tillage in wheat (ZTW)

Pandey et al, (2020) in an experiment at Bhairahawa, Nepal find out that ZTW out-yielded (3.44 tha^{-1}) the conventionally tilled (CT) wheat (3.22 tha^{-1}). They reported the benefit: cost ratio of 2.38 in ZT compared to 1.81 in CT and wheat seeding can be done at least 15 days earlier than CT.

(5) Brown manuring using Dhaincha in DSR field

Brown manuring is a technique of growing green manuring crops viz., *Sesbania* sp. or *Crotolaria* juncea @20-30 kg/ha together as an inter or mixed crop when DSR is sown and killing them at 30 days after rice

seeding through the application of selective post-emergence herbicides for manuring. Co-cultured *Sesbania or Crotolaria* crop is knocked down and dried by spraying 2,4-D ethyl ester @ 0.5 kg a.i. ha^{-1} as revealed by Gaire *et al.,* (2019).

(6) No-till garlic production

The garlic seeds are planted directly into untilled soil having the rice residues anchored on the surface immediately after the harvest of rice. It is being practiced in the terai districts of mid to far western Nepal. It has multiples advantages of reduced cost of production, timely sowing and yields at par with conventional practice of land preparation (ICIMOD, 2013).

SCALING-UP OF CONSERVATION AGRICULTURE

Conservation agriculture implies a radical change from traditional agriculture. There is need for policy analysis to understand how CA technologies integrate with other technologies, and how policy instruments and institutional arrangements promote or deter CA:

(1) Research and development: Greater support from stakeholders including policy and decision makers at the local, national and regional levels will facilitate research and development on expansion of CA. On-station research should be backed by farmers' participatory on-farm research. Adaptive research on selection of crop species and their package of practices (sowing to post harvest operations), selection of cover crop and rotations, maintenance of soil cover and CA equipment need to be carried-out in the field.

(2) Diversification: CA offers opportunities for diversified cropping systems in different agro-ecological regions. The government policies affect crop diversification are pricing policy, tax and tariff policies, trade policies and policies on public expenditure and agrarian reforms (Behera *et al.,* 2007).

(3) Strengthening farmer's capacity: Training on CA to farmers, service providers and field technicians should be at all levels. In the long term, CA should be included in curricula from primary school to university levels.

(4) Institutionalization: Institutionalizing CA into local, provincial, national and regional policy and decision makers could spearhead and support the formulation and development of strategies and mechanisms for scaling up the technology.

(5) Agricultural mechanization: The new machineries, viz. happy seeder, turbo seeder, laser land leveler etc. found useful for CA are more suitable for plain areas and medium to large farm. Hill farmers

having small to marginal farms need smaller versions of the machines at the local level. Up-scaling of mechanized CA can be achieved through custom hiring centers, private entrepreneurs, and cooperatives and farmer's organizations, especially for small and marginal farmers.

(6) Champions: Identify the champion farmers, capacitate and reward them which have a great impact on the quality of life for all.

(7) Building partnership: A system perspective where scientists, farmers, extension agents, policy makers and other stakeholders' partnership are needed in developing and promoting technologies. Instead of using a top-down approach, a more participatory system is required to experiment and find out the solutions.

(8) Soft loans and no custom duties: Soft loans to buy the equipment, machinery, and inputs through banks and credit agencies at lower interest rates and provide no custom duties for the introduction of such equipment from abroad. Chinese government in recent years adopted a series of policy and economic measures to push CA techniques in the Yellow River Basin and is providing a subsidy on CA machinery and imparting effective training to farmers (Yan et al., 2009). Currently in Shanxi, Shandong and Henan provinces over 80% area under maize cultivation depends on no till seeder.

CONCLUSION

A paradigm shift has become a necessity in present context of widespread problems of resource degradation and declining factors productivity. Improving productivity, conservation of scarce resources along with soil quality, protecting environment and improvement of livelihood are the key concerns. Developing and promoting CA systems can be an option to address the issues and will call for CA friendly policies and greatly enhance the capacity of scientists working with farming communities, policy makers, extension personnel, academicians, service providers and other key stakeholders in a system perspective. Similarly, the success stories of CA across the globe can also be taken into consideration. A task force consisting of all stakeholders need to be formed in order to formulate the CA friendly agricultural policies. Thus, short, medium and long-term strategies for research and development on CA can be formulated and implemented in Nepal.

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ASSESSMENT OF DESIRED CORE COMPETENCIES AND ITS ACQUISITION BARRIERS OF AGRICULTURAL EXTENSION ADVISORS IN NEPAL

R.K. Mehta[1], O.P. Singh[2], U.P. Sigdel[3] and N.R. Joshi[4]

ABSTRACT

Modern agriculture is the era of 21st century. Competency is an indispensable in every aspect of delivering services to their ultimate users. Competency is integration of skills, knowledge, attitude and behavior that trigger to perform the delegated services in precise and methodical manner. The objective of this study was to identify important core competency required and its acquisition barrier for extension advisors of Nepalese agriculture extension service. Data were obtained using survey questionnaire from officers working at federal, state and local government offices of the selected 18 districts. The questionnaire was composed of open and close-ended questions based on 56 indicators of the nine core competencies. The descriptive statistics were used to analyze the responses. The findings indicated respondent perceptions on its all nine core competencies- program planning, program implementation, communication skills, extension education and information technology, program evaluation, personal and professional development, diversity, subject matter expertise and emotional intelligence from important to very important ranges. Subject matter expertise was perceived most important and communication skills as least one. Subject matter expertise, extension education and information technology skills positively correlate with education. The limited training opportunities and high cost for acquiring training personally are major barriers to gain competencies

Key words: acquisition barrier, Core competency, extension advisor

INTRODUCTION

Nepal is agrarian country with 27.6% contribution of agriculture sector to Gross Domestic Product (GDP) of nation. The development situation is weak even majority people are involved (MoALD, 2018). The national data shows increasing rate of foodstuff import to meet the national food demand, as 15 percent (4.6 million) of population are food insecure (FAO, 2019).There are some promising sectors within agriculture domains like milk production, poultry, tea, vegetables, seed and fisheries (MoALD, 2019). Besides this,

1 PMAMP, PIU, Morang, MoALD, Nepal

2 FoA, Agriculture and Forestry University, Rampur, Chitwan, Nepal

3 FoA, Agriculture and Forestry University, Rampur, Chitwan, Nepal

4 FoA, Agriculture and Forestry University, Rampur, Chitwan, Nepal

poverty reduction, malnutrition and food security are the major challenges for extension workers to combat for better future.

After the people movements for more than one decade, Nepal is admired by three tier of government as one central, 7 provinces with 753 local governments. At federal government, the Ministry of Agriculture and Livestock Development (MoALD) is leading body for overall agriculture development in nations (MoALD, 2019). It has three departments namely Department of Agriculture (DOA), Department of Livestock Services (DLS) and Department of Food Technology and Quality Control (DFTQC). The major agriculture extension and development services perform through Department of Agriculture (DOA) and some central level program and projects. In province level, agricultural development is governing through the Ministry of Land Management, Agriculture and Cooperatives (MoLMAC). The province ministry provides extension and development grant service through Agriculture Knowledge Centre (AKC) at district level and laboratory service as divisional office. One AKC covers one or more districts according to coverage authority. Similarly, the agriculture section is primary and front line office for Nepalese farmer providing service at local level. The agriculture officer is chief of municipal level agriculture section, which is under the chief administrative officer of municipality, who perform all the primary work of section from planning to implementation and monitored by chief of municipality (MoALD, 2019).

Extension advisors are the front-line extension workers who provide the services to farmers. The extension advisors may be Agriculture Technician (AT) or Agriculture Officers (AO). The front-line extension advisors are AT or AO working at municipality level. The Extension agents at AKCs or federal government are in second and third tier of service provider respectively (MoALD, 2019). The Nepalese agriculture is still facing the acute shortage of trained human resources. One technician is responsible for an average of 1500 farmers whereas in developed countries the ratio is one technician for 400 farmers (The New Humanitarian, 2013).In such context, to deliver service to farmer's extension advisor must be skillful to perform all task in field.

Competencies are the set of skills that individual possesses to perform certain task. It is combinations of knowledge, skills, attitude and behaviors (Maddy *et al.,* 2002). The determination of required core competence for extension agent is very crucial for planning of technical human resource development. Core competencies are important for managing the need of organization for maintaining the competitive environment (Vakola *et. al.*, 2007). There are various competencies required for extension workers to perform their jobs in field. The competencies requirements depend upon the working conditions, farmer's situations and policy of implementation in field.

There are various competency areas pointed by different researchers. According to Ghimire *et al.,* (2016) there are eight core competencies necessary in Nepalese extension service. The area of competencies are program planning, communication, program implementation, personal and professional development, extension education and informational technology, diversity, program evaluation, and technical subject matter expertise. Similarly, Lakai *et al.,* (2014) segregate the six core competencies are for extension advisor for successful in North Carolina Cooperative extension. The technical human resources have been divided in three layer of government. There were single office (DADO) to deliver all the service with all faculty members but there is one section of agriculture in each municipality with only 1-5 work forces. This deployment of human resources has made more challenging job of extension workers to deliver all the services from single service point. At the mean time, technician to farmer ratio is 1: 1500, which is very tough and challenging for service (IRIN, 2013).

The rewards and barriers are very critical for the competency acquisition among extension advisors. The rewards support much in moving towards personal satisfaction, professional respect and colleague recognition (Shinn & Smith, 1999). A panel of experts identified that in 12 barriers of acquiring the competencies for extension agents, which were majorly organization linked (Boyd, 2003).The major barriers were lack of pleasure time for personal and social activities, increased workload, and higher cost for attainment of skills, lack of monetary supports. The government needs to offer the incentives and rewards to staff for professional development. The extension advisors are responsible for their own professional development the government must make enabling environment for learning to support in job performance (Liles & Mustian, 2004). Similarly, the study of extension advisors in Florida showed financial costs and limited time and job commitments were barrier for the competency development (Harder *et. al.*, 2010).

In the era of globalization, a skilled and knowledgeable person can play crucial role for success. According to Severs *et al.,* (2007), the future extension advisors must be skilled and optimist to deliver the diverse need of farmers. To address forthcoming demand of farmers, extension worker must possess latest knowledge and skills to be acquainted with creative and in recent developments prospective. In Nepal, 753 local governments through agriculture section with officer level at municipal level, 7 provinces through AKC with SMS level and 1 federal government through DOA with up to SMS level extension agents deliver service to farmers. It is very important to identify the extension agents' current level of competency to determine

whether there is any competency gap in order to deliver the quality agricultural extension services. Moreover, identification of required competency is essential for the extension agent as an indispensable element of their serving. These competencies are important for extension agents, in order to deliver day-to-day advisory service to their clients.

A good understanding of competencies required by existing and newly appointed extension advisors is important for overall agriculture development (Owen, 2004). With the vision, this research focused to determine the important and current level of competencies of extension advisors in the Nepalese extension service. It also focused on the barriers of desired competencies development and ways of acquiring it. It is very important to determine additional life skills for successful in extension delivery in the changing context.

The objectives of the study were to determine the important (desired) core competencies and its acquisition barrier for extension advisors in current situation of federal Nepal.

MATERIALS AND METHODS

The data were collected in October to December 2019 in Nepal. The researcher requested the extension agents for voluntarily participation to fill survey questionnaire. Altogether, 72 responses from 18 districts were received covering all provinces.

SURVEY INSTRUMENT

The competency assessment questionnaire comprised of 56 indicators with 9 core competencies. The program planning and communication skills consist of six competencies in each while program implementation, education and informational technology and program evaluation had seven competencies. Similarly, personal and professional development, diversity and subject matter expertise had five competencies each and last emotional intelligence had eight competencies which made total 56 statements of competences. Responses were rated over five-point Likert-type scales designed to examine respondent perceptions. For the importance purpose, 1 equated as “not important”, 2 as “somewhat important”, 3 as “average”, 4 as “important” and 5 as “very important”. Similarly, for competency level, one equated as “very low”, 2 as “low”, 3 as “moderate”, 4 as “high” and 5 as “very high". The data were analyzed using the descriptive.

VALIDITY AND RELIABILITY

Content validity was established with advice and suggestions from experts, which was incorporated in final questionnaire to make all the necessary changes were made to establish the desired level of reliability of

questionnaire. The question was piloted in Sunsari district with 5 extension advisors. Data from the pretesting was analyzed to access the reliability of instrument using the Statistical Package for Social Science 16 (SPSS 16). It was found that Cronbach alfa was 0.92 for 56-item extension competency recording scale.

POPULATION SAMPLING AND DATA COLLECTION

The researcher purposively selected to cover all provinces districts and representatives samples from all over the Nepal to make research wider validity and representatives for whole country. The study population consisted of extension advisors (from Level 6 to 8 & Class III Officers) working in local level agriculture section, province government and its different offices like AKCs, federal government, DoA and different projects. Altogether 72 responses were received from the 18 districts covering all provinces of Nepal.

RESULTS AND DISCUSSIONS

DEMOGRAPHIC CHARACTERISTICS OF RESPONDENTS

The survey questionnaire respondents were 84.72% male and 15.28 % female (as in table no. 1). The age ranged from 25 to 57.11 years with an average age of 37 years. The grouping of the age was done in three groups, which is below 35 years, 36 to 50 and above 51 years. The divisions of the respondent were 58 %, 23 % and 18 % respectively.

Table no 1 demographic characteristic of the respondents

Demographics	Frequency	Percent
Sex		
Female	11	15.28
Male	61	84.72
Educational level		
TSLC	9	12.50
Diploma/I.Sc.Ag.	11	15.28
B.Sc.Ag.	20	27.78
M.Sc.Ag.	32	44.44
Age group		
< 35 years	42	58.33
36-50 year	17	23.61
>50 years	13	18.06
Total service duration (Year)		

< 5 year	25	34.72
6 -10 year	21	29.17
10-15 year	6	8.33
16-20	6	8.33
21-25	1	1.39
26-30	8	11.11
31-35	2	2.78
> 36 year	3	4.17
Current post service (year)		
< 5 year	42	58.33
6-10 year	26	36.11
> 10 year	4	5.56
Organizations		
Local level Ag.section	3	4.17
State Gov/AKC	43	59.72
Federal Gov/Projects	26	36.11
Current job position		
Officer L6	15	20.83
Officer L7	19	26.39
Officer L8	13	18.06
Officer Class III	25	34.72
Specialization area		
Ag extension	27	37.5
Agronomy	7	9.72
Horticulture	11	15.28
Plant protection	11	15.28
Planning	14	19.44
Soil science	1	1.39
Fisheries	1	1.39
Total	72	100.00

The majority of the extension advisor (44.44%) has masters' degree or equivalent. Similarly, 27.78% has obtained the Bachelor level. Similarly, 15 percent have Diploma level degree and only 12.5 % have TSLC level degree. The age group composition shows that the average age of extension advisors is 36.97 years. The minimum age of respondents was 25 years while the maximum age was 57.11 years. The major extension agents are below 35 years with 58%. About 24 % of the Extension agent is in 35-50 years age and

18% more than 51 years age. The respondent's average job experience is 11.46 years. The service duration ranges from 1 to 38 years. The majority of the respondents belong to less than 10 years of service duration, which is about 64%. At the same time current service post, average year of experience is 4.7 years. The minimum current post service year range from 0.25 year to 11 years.

The finding showed the 35% of class three officers as majority of participation. Similarly, Officer Level 6, 7 & 8 are 20.83%, 26.39% and 18%. Major respondents was from extension advisor belongs to Agri-extension area with 37.5% shows more than one third of staff composition. The second group belongs to planning 19.44%. Similarly, the other is, plant protection 15.28%, horticulture 15.28% and agronomy with 9.72% as staff composition. The fisheries and soil science have very few in extension services. The majority of the survey participants are from state governments with 59.72% of the total respondent. Secondly, federal government or different projects of it are 36.11%. There were very few respondents from the local level agriculture section of about 4.17%. The major respondents are form state governments, while very few from local level government. Extension advisors in study districts found to be of middle-aged (average age of 37 Year) with male majority (84.72%) which is high to the percentage of female extension workers in Nepal- 6.9% (Ghimire *et. al.*, 2016), -7.7% (worldwide Extension, 2011).Result showed professionals had on having more than decade of experience (M=11.46) While Malaysia and Ethiopia, average was seven years' experience (Belay & Abebaw, 2004) but it was less than-20 years (Ghimire et al., 2016). The current post (officer level) experience of extension advisors shows 4.7 years. This fact indicated that Nepalese extension service is with majority of young officers or promoted from Junior Technicians (JT).Nepal can explore the experience of extension advisors to strengthen the extension delivery service. The perceptions of respondents were all core competences with important to very important to their daily work. The demographics of respondents shows increase in female (15.28%) extension advisors,

PERCEPTION ON IMPORTANT (DESIRED) COMPETENCIES FOR EXTENSION ADVISORS

There are nine area of core competency determined for the Nepalese Extension System based on the previous study (Lakai *et. al.*, 2014); (Ghimire *et. al.*, 2016). The core competency areas are program planning, program implementation, communication skills, extension education and information technology, program evaluation, personal and professional development, pluralism, subject matter expertise and emotional intelligence. There are six unique competencies for each program planning and communication skill, seven unique competency for each program implementation skills, extension

education and information technology, program evaluation, five unique competency for each personal and professional development, pluralism in agriculture, subject matter expertise/technical competency and eight competency for emotional intelligence, which total made 56 competency for 9 core competency.

The top five highest important competency (shown in table no. 2) were basic knowledge about subject matter specialization (M=4.61), ability for need assessment and prioritize (M=4.60), practice of doing monitoring and evaluation (M=4.58), encouragement and motivation to perform work (M=4.57), basic principles of transfers of technology (M=4.56). At the same time, top five lowest important competencies were MS-Excel for data analysis/management (M=4.13), writing success story and lessons learned (M=4.13), cultural respect for communication (M=4.13), pluralism (information about multiple organization giving service to farmers) (M=4.15), knowledge of government administrative and financial rules (M=4.17) information about budget allocation process (M=4.17).

Table 2. Overall competency importance (desired level) by respondents (5 Most and Least important competencies only)

S.N.	Competency	Mean	SD
1	Basic Knowledge about Subject Matter Specialization	4.61	0.57
2	Ability for Need Assessment and Prioritize	4.60	0.69
3	Practice of Doing Monitoring and Evaluation	4.58	0.60
4	Encouragement and motivation to perform work	4.57	0.62
5	Basic Principles of Transfers of Technology	4.56	0.60
6	knowledge of Government administrative and Financial rules	4.17	0.92
7	Information about Multiple Organization giving service to farmers	4.15	0.73
8	Cultural respect for communication	4.13	0.73
9	Writing Success Story and Lessons learned	4.13	0.84
10	MS Excel for Data Analysis/Management	4.13	0.96

Note: Scale:1=Very low; 2=Low; 3=Moderate; 4= High; 5= Very high

PERCEPTION OF OVERALL IMPORTANCE (DESIRED LEVEL) OF CORE COMPETENCY

Table 3. Perception of overall importance (desired level) of core competencies

S.N.	Core competencies	No. of statements used to compute mean	Mean	SD
1	Program planning	6	4.35	0.81
2	Program implementation skills	7	4.36	0.69
3	Communication skills	6	4.23	0.80
4	Extension education and IT skills	7	4.32	0.73
5	Program evaluation	7	4.38	0.67

6	Personal and professional development	5	4.31	0.71
7	Pluralism	5	4.27	0.72
8	Subject matter expertise	5	4.44	0.68
9	Emotional intelligence	8	4.37	0.66

Note: Scale:1=Very low; 2=Low; 3=Moderate; 4= High; 5= Very high

Table no. 3 showed, Nepalese extension advisors perceived each core competency (desired level) found more than 4 as high importance to extension work.

Table 4.Overall importance (desired level) of core competency by sex

S.N.	Core competencies	Number of statement used	Overall Importance (Desired)				Mean difference (Male-Female)
			Male		Female		
			Mean	Mean	Mean	SD	
1	Program planning	6	4.38	0.94	4.18	0.78	0.20
2	Program implementation skills	7	4.39	0.77	4.21	0.67	0.18
3	Communication skills	6	4.30	0.81	3.83	0.78	0.46
4	Extension education and IT skills	7	4.37	0.69	4.05	0.73	0.31
5	Program evaluation	7	4.45	0.73	3.99	0.63	0.47
6	Personal and professional development	5	4.38	0.66	3.89	0.69	0.49
7	Pluralism	5	4.31	0.65	4.02	0.72	0.29
8	Subject matter expertise	5	4.48	0.63	4.22	0.68	0.26
9	Emotional intelligence	8	4.42	0.65	4.06	0.65	0.37

Note: Scale:1=Very low; 2=Low; 3=Moderate; 4= High; 5= Very high

The study (table no. 4) showed that male and female respondents have similar perception on overall importance (desired level) core competency. The male participants have rated subject matter expertise (M=4.48) as most important as same as female respondents (M=4.22). Similarly, both (male and female) respondents rated communication skills as least important (M=4.30 and M=3.83) respectively. The highest variation of male and female respondent's perception on overall importance is in personal and professional development (MD=0.49) and least in program implementation (MD=0.18).

Table 5. Overall importance (desired level) by educational level of respondents

S.N.	Core competencies	No. of statement used	Overall Importance Valued by different educational Level							
			TSLC		Diploma/I.Sc. Ag.		B.Sc.Ag.		M.Sc.Ag.	
			Mean	SD	Mean	SD	Mean	SD	Mean	SD
1	Program planning	6	4.26	0.76	3.86	0.84	4.44	0.82	4.49	0.74
2	Program implementation skills	7	4.27	0.70	4.01	0.75	4.44	0.72	4.46	0.61
3	Communication skills	6	4.09	0.71	4.29	0.74	4.14	0.93	4.30	0.75
4	Extension education and IT skills	7	4.14	0.50	4.30	0.84	4.42	0.69	4.31	0.77
5	Program evaluation	7	3.90	0.53	4.32	0.68	4.54	0.71	4.44	0.60
6	Personal and professional development	5	4.27	0.45	4.18	0.77	4.32	0.83	4.35	0.67
7	Pluralism	5	4.18	0.53	3.98	0.89	4.31	0.77	4.36	0.63
8	Subject matter expertise	5	4.07	0.58	3.98	0.89	4.67	0.62	4.55	0.54
9	Emotional intelligence	8	4.24	0.46	4.20	0.78	4.47	0.67	4.39	0.65

Note: Scale:1=Very low; 2=Low; 3=Moderate; 4= High; 5= Very high

The study (table no.5) found that subject matter expertise was rated most important core competency (desired level) by extension advisors having M. Sc. Ag degree (M=4.55) while least the communication skills (M=4.30). Similarly respondents with TSLC qualification rated program implementation and personal and Professional development (M=4.27) as most important and program evaluation (M=3.90) as least. Respondents having B.Sc. Ag degree rated the program evaluation (M=4.54) as high and pluralism (M=4.31) as low importance.

Table 6. Overall Importance (desired level) by working organization of respondents

S. N.	Core Competencies	No. of statement used	Overall importance valued by organization					
			Local level Ag section		State Gov/AKC		Federal Gov/Offices	
			Mean	SD	Mean	SD	Mean	SD
1	Program planning	6	3.83	1.42	4.28	0.83	4.53	0.63
2	Program implementation	7	4.24	0.94	4.32	0.69	4.44	0.66
3	Communication skills	6	2.78	0.88	4.23	0.72	4.39	0.75
4	Extension education and IT skills	7	4.33	0.66	4.34	0.74	4.28	0.73
5	Program evaluation	7	3.62	1.16	4.32	0.64	4.58	0.55
6	Personal and professional development	5	3.47	1.41	4.29	0.66	4.42	0.61
7	Pluralism	5	3.60	1.24	4.22	0.69	4.42	0.62
8	Subject matter expertise	5	4.20	0.94	4.34	0.72	4.62	0.52
9	Emotional intelligence	8	3.92	0.97	4.35	0.62	4.44	0.67

Note: Scale:1=Very low; 2=Low; 3=Moderate; 4= High; 5= Very high

The overall importance (desired level as in table no. 6) rating was in ascending order from local level (agriculture section) extension advisors to federal government extension advisors excepting in extension education and IT skills. The least rated core competency was communication skills (M=2.78) and most to program implementation (M=4.24) by local level extension advisors. At state level, pluralism (M=4.22) was least and emotional intelligence (M=4.35) as most important one. At federal government, extension education (M=4.28) was least and subject matter expertise (M=4.62) as highest rating of importance (desired level).

Table 7. Overall importance (desired level) by job level of respondents

S.N.	Core Competencies	No. of statement used	Overall Importance (desired level) by different job level							
			Level 6		Level 7		Level 8		Class III	
			Mean	SD	Mean	SD	Mean	SD	Mean	SD
1	Program planning	6	4.06	0.96	4.48	0.84	4.19	0.77	4.51	0.62
2	Program implementation	7	4.18	0.79	4.53	0.61	4.21	0.68	4.42	0.66
3	Communication skills	6	3.93	0.99	4.16	0.76	4.22	0.62	4.46	0.72
4	Extension education and IT skills	7	4.18	0.69	4.32	0.82	4.37	0.69	4.37	0.71

5	Program evaluation	7	4.04	0.82	4.48	0.61	4.29	0.60	4.57	0.54
6	Personal and professional development	5	4.03	0.87	4.44	0.71	4.28	0.65	4.38	0.58
7	Pluralism	5	3.96	0.86	4.47	0.60	4.05	0.76	4.41	0.58
8	Subject matter expertise	5	4.09	0.77	4.68	0.55	4.18	0.77	4.58	0.53
9	Emotional intelligence	8	4.16	0.69	4.60	0.57	4.26	0.65	4.37	0.67

Note: Scale:1=Very low; 2=Low; 3=Moderate; 4= High; 5= Very high

The study (table no. 7) showed that there was increasing trends of overall importance (desired level) for communication skills (M=3.39>4.16>4.22>4.46) for level 6 to 8 and most by class III extension officers and extension education and IT skills (M=4.18>4.32> 4.37=4.37) increased from level 6 to 8 and class III officer rated equal to level 8 officers. The study found program planning (M=4.51), communication skills (M=4.46), program evaluation (M=4.57) by class III officer, program implementation (M=4.53), personal and professional development (M=4.44), pluralism (4.47), subject matter expertise (M=4.68) and emotional intelligence (M=4.60) rated highest by officer level 7 staffs. The extension education and IT skills (M=4.37) were highest rated by level 8 and class III officer.

Table 8. Overall importance (desired level) by age group of respondents

S. N.	Core competencies	No. of statement used	Overall importance (desired level) by age group					
			<35 years		36-50 Years		>50 years	
			Mean	SD	Mean	SD	Mean	SD
1	Program planning	6	4.40	0.81	4.51	0.67	3.99	0.88
2	Program implementation	7	4.41	0.67	4.43	0.65	4.10	0.75
3	Communication skills	6	4.22	0.86	4.24	0.72	4.23	0.72
4	Extension education and IT skills	7	4.30	0.76	4.44	0.59	4.23	0.79
5	Program evaluation	7	4.42	0.68	4.37	0.64	4.27	0.67
6	Personal and professional development	5	4.28	0.75	4.45	0.55	4.22	0.74
7	Pluralism	5	4.35	0.68	4.14	0.62	4.15	0.89
8	Subject matter expertise	5	4.58	0.59	4.40	0.60	4.03	0.87
9	Emotional intelligence	8	4.39	0.69	4.41	0.54	4.22	0.71

Note: Scale:1=Very low; 2=Low; 3=Moderate; 4= High; 5= Very high

The study (table no. 8) found that the program evaluation (M=4.42>4.24>4.23) and subject matter expertise skills (M=4.58>4.40>4.03) overall importance

(desired level) decreased over the increase in age group. Program planning, program implementation, communication skills, extension education and IT skills, personal and professional development skills importance increased with increase in age, as rating was higher by 36-50 years age group than < 35 years age group.

Table 9. Overall importance (desired level) by job experience of respondents

S.N.	Core competencies	No. of statement used	Overall importance (desired level) by total job experience					
			<15 years		15-30 Years		>30 years	
			Mean	SD	Mean	SD	Mean	SD
1	Program planning	6	4.44	0.80	4.18	0.82	4.07	0.78
2	Program implementation	7	4.43	0.65	4.18	0.79	4.24	0.66
3	Communication skills	6	4.22	0.83	4.20	0.75	4.31	0.68
4	Extension teaching and IT skills	7	4.34	0.75	4.20	0.73	4.41	0.64
5	Program evaluation	7	4.44	0.67	4.21	0.63	4.35	0.66
6	Personal and professional development	5	4.33	0.73	4.28	0.61	4.20	0.76
7	Pluralism	5	4.29	0.69	4.27	0.66	4.09	0.95
8	Subject matter expertise	5	4.60	0.57	4.08	0.71	4.06	0.87
9	Emotional intelligence	8	4.44	0.64	4.26	0.64	4.11	0.78

Note: Scale:1=Very low; 2=Low; 3=Moderate; 4= High; 5= Very high

The study (table no. 9) found that the overall importance (desired level) rating of program planning (M=4.44>4.18>4.07), personal and professional development (M=4.33>4.28>4.20), pluralism (M=4.29>4.27>4.09), subject matter expertise (M=4.60>4.08>4.06) and emotional intelligence (M=4.44>4.26>4.11) decreased with increase in year of experience. Program implementation, extension education and IT skills, program evaluation was rated more important by <15 years of experience group than 15-30 years of experience group.

BARRIER FOR COMPETENCIES ACQUISITION

Segregating commonly cited barriers by different researchers, 11 barriers were short-listed for the competencies acquisition (Lakai *et. al.,* 2014). The respondents were provided to rate them on a four-point Likert scale from one being "not at all", two for "A little Extent", 3 for "Some Extent" and four as "Great Extent". The mean values close to four that are greatly hampering while less value showed lower level.

Lack of training opportunities (M=3.32), high cost for acquiring the training personally (M=3.26), lack of organizational motivation (M=3.22) and lack of truth information (M=3.21) were identified as most important barriers for competencies acquisition. The lack of time for study (M=2.72), excess program workload (M=2.85) and lack of related reading materials (M=3.00) were the least important barriers for competencies acquisition.

Table 10.Respondents identified barriers for competencies acquisitions

Barriers	Mean	SD
Lack of time for study	2.72	0.89
Excess program work load	2.85	0.90
Lack of organizational motivation	3.22	0.77
Lack of personal motivation	3.07	0.89
Lack of training opportunities	3.32	0.82
Not use of effective training methods	3.10	0.72
Lack of related reading materials	3.00	0.79
No additional financial incentives for additional skilled	3.11	0.86
Lack of truth /reliable information	3.21	0.75
No financial support for gaining skills	3.10	0.75
High cost for acquiring the training personally	3.26	0.82
Overall	33.96	8.97

Note. 1= Not at All; 2=A little Extent; 3=Some Extent; 4= Great Extent

Lack of training opportunities was defined as the major barrier that hinders extension advisor's ability to desired competency acquisition. Other important barriers limiting the desired competency are high cost for acquiring the training personally, lack of organization motivation and lack of truth information, no additional financial incentives for additional skilled. Excepting the high cost for acquiring the training personally, all the three major barriers are (lack of training opportunities, lack of organization motivation and lack of truth information) are part of organizational culture or behavior i.e. it seems poor within the organization.

Lack of time for study, excess program workload and lack of related reading materials are the three least affecting barriers for competency acquisition, which is contrast to finding of adult learners constantly acknowledged lack of

time, but similar as lack of money as barrier (Merriam *et.al.*, 2007). A finding of Shinn & Smith (1990) shorted that increasing the job responsibility and personal cost are barrier to competency acquisition for agriculture and natural resource agent in Texas.

Lack of organization motivation prohibit competency acquisition among extension advisors, which is similar to finding of, organization should consider extension advisors acquisition of competency as important part for their accomplishment (Boyd, 2003).

RELATIONSHIP BETWEEN OVERALL IMPORTANCE (DESIRED LEVEL) AND DEMOGRAPHIC CHARACTERISTICS

The analysis of responses indicated that male and female respondents have similar perception on overall importance (desired level) core competency. The male and female participants have rated subject matter expertise as most important and communication skills as least important. The findings of similar in perception of gender support Burke (2002) but counter (Okwoche et al., 2011 & Ghimire et. al., 2017). The highest variation of male and female respondent's perception on overall importance is in personal and professional development and least in program implementation.

Subject matter expertise was rated most important core competency (desired level) by extension advisors having M. Sc. Ag degree while communication skills as least. Respondents with TSLC qualification rated program implementation, personal and Professional development as most important and program evaluation as least. Such finding is similar to Ghimire (2016) but contrast to Burke (2002). Excepting in extension education and information technology skills, overall importance (desired level) rating was low from local level (agriculture section) and high from federal government extension advisors. All level extension advisors rated communication skill least important. Subject matter expertise is still most important for all extension advisors.

There was increasing trends of overall importance (desired level) for communication skills for level 6 to 8 and most by class III extension officers. Program planning, communication skills and program evaluation rated high by class III officer while program implementation, personal and Professional development, pluralism, subject matter expertise and Emotional intelligence rated highest by officer level 7 . The extension education and information technology skills were highest rated by level 8 and class III officer. It is similar to Namdar *et al.,* 2010 & Ghimire *et al.,* 2017 but contrasts with Burke, (2002) as reported no difference in competency rating by extension workers positions.

Program evaluation and subject matter expertise skills overall importance (desired level) decreased over the increase in age group. Program planning, program implementation, communication skills, extension education and information technology skills, personal and professional development skills importance increased with increase in age, as rating was higher by 36-50 years age group than < 35 years age group. Overall importance (desired level) rating of program planning, personal and professional development, pluralism, subject matter expertise and emotional intelligence decreased with increase in year of experience. Program implementation, extension education and information technology skills, program evaluation is important for younger extension advisors. Brodeur *et al.,* (2011), support the finding who indicated that extension advisors perception of core competencies change with age and experience.

Conclusions

Nepalese extension advisors are in middle age having more than decade of professional experience with majority having master's degree. The result indicated that subject matter expertise as most and communication skills as least important core competency. Overall importance (desired level) core competency of program planning, personal and professional development, pluralism, subject matter expertise and emotional intelligence decreased with increase in year of experience. Overall importance (desired level) core competency of program evaluation and subject matter expertise skills decreased over the increase in age group.

Lack of training opportunities, high cost for acquiring the training personally, lack of organization motivation and lack of truth information are major barriers for competency development. The extension advisors felt exposure visit and in-service training as appropriate method of competency development. The findings of the study could internalize for human resource development.

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