Buckwheat Genetic Resources: Status and Prospects in Nepal

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Food security and healthy life for the people of any country depends in part on the availability of plant genetic resources. This study was done to assess the richness in buckwheat genetics resources and its potential for food security and healthy life in Nepal. The study employed combination of field experiments and desk review with qualitative field survey such as key informant survey and focus group discussion. Field experiment included evaluations of buckwheat collections from Jumla along with accessions from ex situ and Hill Crops Research Program (HCRP), Kabre; Agriculture Research Station (ARS), Jumla in summer 2006 and in Khumaltar, Lalitpur in autumn 2007. Nepal is one of the centers of diversity for buckwheat where five species and four subspecies of *Fagopyrum* are found. Among them two species, *F. esculentum* (2n=2x=16, mithe) and *F. tataricum* (2n=2x=16, tite) are under cultivation. Wild, wild relatives and weedy form of tartary buckwheat species are reported from the Northern part of Nepal. *F. cymosum* (2n=2x, 4x=16, 32) is widely distributed wild species. Buckwheat is growing from 60 to 4200 m altitude in all four season i.e. summer, autumn, winter and spring. Different buckwheat genotypes have been introduced from Japan, Canada, USSR, Poland, China, South Africa, Brazil, Mongolia, Yugoslavia, India, USA, Sweden and Czechoslovakia. Similarly many genotypes of Nepalese buckwheat both cultivated and wild species have been taken away in Europe, North America, Japan, India and China. A total of 280 accessions consisting of 153 accessions of common and 127 accessions of tartary buckwheat are stored as ex situ collections in Agriculture Botany Division-NARC, Khumaltar. Diversity is found in seed color, in seed shape, in seed surface, in pigmentation, in flower color etc. Local *tite phapar* from Kabre has the yield potential of 3.73 t/ha which is the highest ever reported in the world. This diversity should be conserved properly and utilized for food security in the country.

Key words: Buckwheat, breeding, distribution, utilization

1. Introduction

Biological diversity in Nepal is closely linked to the livelihoods of many people and their economic development and touches upon agricultural productivity and sustainability, human health and nutrition, indigenous knowledge, gender equality, building materials, climate, water resources, and the aesthetic and cultural well being of the society. The Biodiversity Profiles Project (1995) ranked Nepal as having the tenth richest flowering plant diversity in Asia. Although it covers only 0.1% of the earth's land area Nepal is home to more than 2% of all the flowering plants, 8% of all birds and 4% of all mammals. Nepal's unique geographical position, and altitudinal and climatic variations create a great biological diversity.

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Agricultural lands are diverse in terms of climatic conditions. Both biotic and abiotic stresses have been limiting the crop production. Farmers prefer those crop varieties that can produce high yield in low input, that can tolerate stresses, that need less care of, that can grow in diverse conditions and that posses balanced nutrients. Buckwheat (*Fagopyrum* spp) is an important crop in terms of its adaptation to diverse climatic conditions, moisture stress regime, nutrient limitation and cool temperature and it fits well to different cropping patterns due to its short growing period (Baniya, 2001; 1999). Economically grain yield of buckwheat is very high as compared to other cereals crops. This crop is also very suitable for bee keeping due to its longer blooming period (around one month) and having numerous flowers per plant with higher amount of nectar. The iron content in buckwheat is the highest among all cereals and legumes (Rajbhandari, 2004). It is very unusual and unique crop and is very easy for cultivation and cooking (Campbell, 1997).

Buckwheat is one of the minor food crops in the temperate and hilly countries of Europe, East Asia and the Himalayan regions. China is the biggest buckwheat producer and exporter followed by USSR and Japan is the biggest importer (Sherchand, 2001). It belongs to Polygonacea family and it is treated as pseudo cereal, poor's people crop, neglected and underutilized crop. Research work on this crop was started as early as 1973 by Dr. S.N. Lohani in Nepal (Baniya, 2001). Buckwheat is grown in 43000 ha producing 23100 t with a productivity of 540 kg ha^{-1} (Sherchand et al., 1986). Farmers cultivate with low inputs and poor management and grow traditionally only when some lands remain fallow after main crops. It can grow well within a temperature range of 11-26^{o}C (Rajbhandari, 2004).

The increase of UV radiation at the Earth's surface due to the gradual depletion of ozone in the atmosphere has caused great concern about the consequent effects on ecosystems (Rozema et al., 1997). The plants, which are able to produce rutin and other UV absorbing compounds, are very important for protecting the environment and human health. Buckwheat is the only field crop that contain considerable amounts of rutin (Kreft et al 2003). Antioxidants in dietary plants have attracted attention because they protect the human body from oxidative damage caused by free radicals. Buckwheat is known to contain various antioxidative compounds such as vitamins B_1, B_2 and E and phenolic compounds such as rutin, quercetin and proanthocyanidines (Watanabe et al., 1995). Buckwheat grain has a higher antioxidative activity than other cereal grains (Zielinski and Kozlowska, 2000).

Despite its multiple values at local, national and international levels, research achievements are very limited in developing high grain yielding varieties in Nepal. The productivity of buckwheat especially common type is highly variable. It is 0.55 t/ha in Nepal, 3.0 t/ha in USSR and 0.89 t/ha in the world. High yielding site-specific variety is necessary to develop for securing the food especially in remote areas of Nepal. Therefore, this study was carried out with the objective of exploring the potential of buckwheat genetic resources in Nepal.

2. Approach and Methodology

2.1 Review and field visit

Literatures related to Nepalese buckwheat were reviewed. Fagopyrum journal, buckwheat proceedings and field reports were the major documents. Karnali zone; Hill Crops Research Program (HCRP), Kabre and Genetic Seed House (Gene Bank), Khumaltar were visited. Ex situ collections were analyzed.

2.2 Key informant survey

Basic information on Nepalese and introduced buckwheat genetic resources were collected from the key informant survey. Questionnaire was also sent to DADO of Jumla, Humla, Kalikot, Dolpa and Mugu for collecting information.

2.3 Focus group discussion and seed collection

One-day focus group discussion on buckwheat genetic resources management and utilization was organized in Jumla. Main focus areas of discussion were listing of *tite* (tartary) and *mithe* (common) landraces along with importance traits, problems, importance of buckwheat, etc. Discussions were also done with key staff of DADO, Jumla and ARS-NARC, Jumla. Available local diversity of buckwheat in Jumla was collected for characterization, evaluation and *ex situ* conservation. Seeds of 73 buckwheat populations were collected.

2.4 Field experiments

A total of 120 genotypes including both tartary and common buckwheat collected from Jumla district; Hill Crops Research Program, Kabre and Agriculture Botany Division, Khumaltar were characterized and evaluated in non-replicated design in summer 2006 in Agriculture Research Station, Jumla. Similarly in spring 2007, a total of 215 genotypes of tartary buckwheat collected from Jumla, Dolpa and Mustang districts; Hill Crops Research Program, Kabre and Agriculture Botany Division, Khumaltar were characterized and evaluated in non-replicated design in Khumaltar.

3. Findings

3.1 Species and varietals richness and distribution

A total of five species and four sub species are reported from Nepal (Table 1). Wild and weedy forms of tartary buckwheat are also found. Potential of existing other species are expected, therefore, exploration work is necessary particularly in Dolpa, Mustang and Solukhumbu districts. These wild and weedy buckwheat and wild relatives of buckwheat may be the potential sources of genes for developing high yielding possessing abiotic and biotic stresses tolerance.

Two species of buckwheat i.e. *F. esculentum* and *F. tataricum* are under cultivation. Among these two species, tartary has different local names but

common buckwheat is commonly called Mithe phapar in most of the locations (Upadhyay and Joshi, 2003) (Table 2). Average diversity is higher in common buckwheat than in tartary (Joshi and Baniya, 2006). In Jumla where species diversity is higher, food culture is also rich as compared to Mustang and Manang (Rijal et al., 2001).

Table 1. Cultivated and wild species of buckwheat found in Nepal

SN	Species /subspecies	Genome	Mode of pollination	Distribution	Local name	Growth habit
Cymosum spp group						
1.	Fagopyrum esculentum Moench (Syn. F. emarginatum Moench, F. sagittatum Gilib)	2n=2x=16	SI	Mid and high hills	Mithe	Annual
2.	F. tataricum Gaertn (Syn. F. suffruticosum Fr. Schmidt)	2n=2x=16	SC	Himalayan region	Tite, Dhup, Dop	Annual
3.	F. cymosum (Trev.) Meisn (Syn. F. dibotrys (D.Don) Hara, F. kashmirianum Munshi)	2n=2x, 4x=16, 32	SI + SC	Mid and high hills	Banbhade, Dhukupa, Bhande, Bommande	Perennial
Urophyllum spp group						
4.	F. gracilipes Dammer	2n=4x=32	SC	Eastern Nepal		Annual
5.	F. megacarpum Hong†			Dolpa		
Subspecies						
6.	F. esculentum ssp esculentum	2n=2x=16	SI	Mid and high hills		Annual
7.	F. tataricum ssp tataricum Gaertn	2n=2x=16	SC	Himalayan region		Annual
8.	F. tataricum ssp annum			Western-North Nepal		Annual
9.	F. tataricum ssp potanini Batalin	2n=2x=16	SI	Western-North Nepal		Annual
Wild and weedy type						
10.	Weedy tartary		SC	Western-	Jhura	Annual

SN	Species /subspecies	Genome	Mode of pollination	Distribution	Local name	Growth habit
	buckwheat			North		
11.	Wild tartary buckwheat		SC	Western-North		Annual
12.	Weedy common buckwheat		SI	Western-North Nepal		Annual
Closely related spp						
13.	Rumex acetosella L			Western-North Nepal		
14.	Fallopia convolvulas (L.) Holub (Npl. Khora Hyoppa)			Western-North Nepal		
15.	Persicoria hydropiper (L) Delarbre					
16.	Persicoria senticosum (Meisn.) H. Gross ex Nakai					

† Ohsako et al. (2001) suggested not to include this species into Fagopyrum. SC, Self-compatibility; SI, Self-incompatibility. The existence of *F. gracilipes* needs to be reconfirmed. Sources: Baniya et al., (2000); Baniya, (1999).

Nepalese farmers recognized the different types of buckwheat based on their agromorphology, taste and habitat. The details of classification of buckwheat are given in Table 3A and 3B. For example, there are two types, namely Sathiya and Gyabre in some areas based on days to maturity. Many types of buckwheat based on the growing season and growth habitat are found in Nepal however; Ujihara (1983) reported that most of the Nepalese common buckwheat lines are of autumn type, indeterminant growth and sensitive to day length. Two landraces (Adhikary et al., 1995; NHCRP, 1993) Madane and Barhamase, reported in Taplejung are high yielding with large seed size, and wrinkled with black seeded respectively. Barhamase can be grown in all season. Within Nepalese populations, geographical variation was also observed dividing the populations into mid-western, western and central regions (Bimb et al 2001). Ujihara and Matano (1982) reported high level of genetic variation in Nepalese wild buckwheat based on geographical distribution and grain shape.



Figure 1. Distribution of buckwheat genetic resources in Nepal. Dot indicates the availability of buckwheat in that district. District with more dots means more diversity at species, varietals and genetics levels. Sources: Gupta et al., (2000); Baniya, (1999); Baniya, (1990); Sherchand et al., (1986).

Table 2. Local name of some of landraces of common and tartary buckwheat in Nepal

Common buckwheat	Tatary buckwheat
Bahramashe, Batule, Bisam phapar, Chhendrung, Ghode, Ghyabre phapar, Guliyo phapar, Jhusile, Kalo, Madane, Mithe phapar, Mithi phapar, Ogale (Ogule), Phapar, Sathiya, Seto, Sheychan (red flower), Sheykar, Sheykan , Thulo, Tote	Aulo, Barkhe phapar, Barulo, Bhadaure, Bhadre, Bhalue tite, Bharule (Barule or Bhadule), Chhendrung, Jhoumbre, Chinia tite phapar, Chuchche, Dalle, Dhahasur, Dhau, Dhesu (Dhesoi), Dhop (Dhup), Ghambhre, Ghambre, Gharelu phapar, Gjorya, Gore, Goriya (Gore), Goray, Jagdulo, Jhoumbre, Kalo Kise (Bhate), Kambre, Khumbeli, Lekhari phapar, Pranah, Rani tite, Seto Kise (Bhate), Syangre, Tabre, Takule, Tan phapar, Tar, Tashung, Techhung, Tenshya phapar, Teta phapar, Thou, Tile, Tilkhude (Tilkude), Tite phapar, Tuchhi

Sources: Joshi et al., (2007); Dongol et al., (2004); Gupta et al., (2000); Baniya, (1999); Adhikary et al., (1995); NHCRP, (1993).

Nepal possesses very unique buckwheat genotypes for examples Bhate phapar (Seto and Kalo), *F. megacarpum*, different mutant types, the highest grain yielder in the world, high rutin content landraces, thorny red plant and red flower tite phapar etc. Within tartary species, different landraces having different degrees of bitterness are found. For example, Bhadule tite phapar is less bitter compare to

other tartary buckwheat. Tartary buckwheat from high altitude area are less bitter in taste. Bitterness increases as altitude decreases and vice-versa (Subedi et al 2001). Tite buckwheat from Marang, Mustang area is less bitter or bitter less and tastier than others. Grain size and quality of Marang tite are also better. Farmers use *Dhiki* to dehusk the tartary buckwheat and claimed that this process reduces bitterness. Another approach to reduce bitterness is that flour is soaked in water over night. On the following day, flour releases yellowish water, which is removed before preparing any recipe. Bitterness is thus removed along with such yellowish water (Rijal et al., 2001; Vaidya et al., 1999). Adhikary et al. (1995) reported that bread prepared on stove reduce bitterness. Bitterness is increased if the seeds are exposed to sun. If *Roti* is made on stone, it will be less bitter (NHCRP, 1993).

Bhate (Kishe, also called rice tartary buckwheat) phapar is tartary landrace, only reported in Nepal, Bhutan and China in the world. More than 5 different Bhate types are reported from Dolpa district and Kalo Kishe and Seto Kishe are important rice tartary buckwheat. Farmers claimed that Bhate landraces are free of bitterness. Bhate phapar, which has a non-adhering hull, allows the use of it as a rice replacement in the staple diet (Campbell, 2003).

Buckwheat is growing from 60 m in Jhapa to 4200 m altitude in Mustang all over the country and all year round in Nepal (Upadhyay and Joshi, 2003; Baniya et al., 1999). It is being cultivated in 61 districts out of 75 districts of Nepal (Figure 1). The value of this crop increases as altitude increases. The highest diversity was found in Dolpa followed in Mustang, Manang, Jumla and Solukhumbu districts. Every family grows tartary buckwheat in Dolpa and Upper Mustang (Vaidya et al., 1999). Diversity in Mustang, Manang and Dolpa is higher than any other district. It is very important crop in five districts, Dolpa, Mustang, Manag, Jumla and Solukhumbu. Both common and tartary buckwheat are commonly cultivated in Mustang and Dolpa. Smooth and notched wing seed shapes were recognized among cultivated tatary buckwheat in Mustang and Dolpa (Bimb et al., 2001). *F. cymosum* is distributed in Dolpa, Kaski, Dolakha, Solukhumbu, Jumla, Dhanusa and Kathmandu valley while it was absent in Mustang district. Wild and weedy forms of tartary buckwheat are reported from Mustang and Dolpa (Nakayama et al., 2001). *F. megacarpum* is found only in Dolpa (Bimb et al., 2001; Baniya, 1999). Mustang district revealed extensive distribution of the wild form of tartary buckwheat for example Khora Hyoppa, Kibre type, Khora Chhang, Khora Dhup and Khora Ghyabre (Vaidya et al., 1999). The northern Nepal seems to be potential place for housing frost and cold tolerance buckwheat landraces. Due to the huge diversity of buckwheat in Nepal, potential of finding lodging resistance, cold and frost tolerance lines and determinant type are very high.

Smooth and notched wing seed shapes were referred to as Nepali type and Tibetan type, respectively (Nakayama et al., 2001). Sichuan type is characterized by short and tiny growth habit and the others as Tibetan type with tall and vigorous growth habit. Both of these types were found in Mustang district, whereas only Tibetan type was observed in Dolpa district (Nakayama et al., 2001). So far, overlapping of geographical distribution of wild tartary buckwheat and *F. cymosum* was not observed in southern China but only in two sites in eastern Tibet. Although these

two species usually did not grow at the same site, they were found to coexist in the field of common buckwheat and common millet in Ruma village of Dolpa district (Nakayama et al., 2001).

Table 3A. Classification of buckwheat genetic resources based on agronomic, adaptation and use values

SN	Basis	Classes	Remarks
1	Habitat	Cultivated	Mithe, Tite
		Wild	Ban, Bhande, Banbhande
		Weedy	Jhura
2	Adopted area	Lekali (Sheychan)	Cultivated in high altitude
		Pahadi (Sheykar)	Cultivated in mid altitude
		Beshi (common type)	Cultivated in low altitude
3	Growing season	Barkhe	Rainy season
		Bahramase	Any season
		Autumn	
		Winter	
		Spring	
		Summer	
4	Growth habit A.	Determinant	Early
		Indeterminant	General type
		Indeterminant vigorous	Late, found in swampy and fertile land of Mustang and Dolpa areas
	B.	Busy	
		Erect	
		Dwarf	
5	Maturity	Sathiya	Mature in 60 days
		Gyabre	Mature in 100 days
6	Taste	Mithe	Sweet
		Intermediate	
		Tite (Dop)	Bitter
7	Uses	Bhate (Kishe) type	As rice
		Tarkary type	As vegetables
		Dindo/ roti type	As thick porridge or bread
		Fodder type	
		Medicinal use	

Table 3B. Classification of buckwheat genetic resources based on morphology

SN	Basis	Classes	Remarks
1	Flower color	Red	
		Pink	
		White	
		Greenish	
2	Seed shape	Chuchche	Pointed and slender
		Bhadre	Oblong
		Bharule	Ovate

SN	Basis	Classes	Remarks
		Dalle (Syangre, Tuchhi, Batule)	Round
		Jhusile (Kande)	Thorny (Rough surface)
		Tilkhude	
3	Seed size	Thulo	Large
		Sano	Small
4	Grain color	Grey (Khairo)	
		Dark grey	
		Brown	
		Black (Kalo)	
		White (Seto, Gore)	
		Mottled	
5	Groove number	Dhui Mukhe	Two groove
		Tin Mukhe	Three groove
		Char Mukhe	Four groove
		Panch Mukhe	Five groove
		Chha Mukhe	Six groove

Sources: Dongol et al., 2004; Baniya, 1999; Adhikary et al., 1995; NHCRP, 1993 (updated).

3.2 Exploration, conservation and introduction

Exploration and collection of different types of buckwheat were started from 1971 and are continued (Table 4). Most of the collections were made with the support of international organization. Main national collection institutes were Agriculture Botany Division-NARC, Khumaltar; Hill Crops Research Program-NARC, Kabre; IAAS, Rampur; RECAST-TU, Kirtipur and National Herbarium Center, Godawari. More than 534 buckwheat landraces are stored in Kabre, 280 accessions in Khumaltar, 288 common buckwheat cultivars in Kirtipur, some in Rampur and Godawari (Baniya, 2001).

Table 4. Buckwheat exploration missions undertaken by different organizations in Nepal

SN	Team/name of collector	Sponsor	Collection year	Sample collected, n
1.	SN Lohani	USAID/Nepal	1971	NA
2.	IBPGR, Multi-crop Collection Team	Japan	1984	115
3.	IBPGR, Multi-crop Collection Team	Japan	1985	151
4.	IBPGR, Multi-crop Collection Team	Japan	1986	NA
5.	S Yanagihara	USAID/Japan	1987	90
6.	NHCRP, Kabre	Nepal	1987-1992	85
7.	NHCRP, Kabre	Nepal	1993	27
8.	M Yoshida	JICA/Japan	1989-1992	50

SN	Team/name of collector	Sponsor	Collection year	Sample collected, n
9.	RECAST, TU	USAID/Nepal	1990-1993	288
10.	NHCRP	NARC	Different	507
11.	NARC/NIAR	NIAR	1999	50
12.	NARC/NIAR	NIAR	2000	108
13.	BK Joshi	NARC	2006	73

NA, Not available. Sources: Upadhyay and Joshi, 2003; Gupta et al., 2000; Baniya, 1999.

Due to the great variation in altitude of growing these species, diverse genotypes have been developed and maintained on farm. 153 accessions of common buckwheat and 127 accessions of tartary buckwheat were collected from 41 districts and conserved *ex situ* in Agriculture Botany Division, Khumaltar (data not shown). The highest numbers of collections of common and tartary buckwheat were from Mustang. The highest number of collections was made from 2520-2800 m altitude. The collections in 1986 were the highest in number.

Nepalese buckwheat genotypes are also stored and studied in Canada, China, Europe, India, Japan, USA and USSR (Baniya, 2001). About 250 exotic landraces of common buckwheat were introduced from 14 countries (Table 5). Only the common buckwheat varieties were introduced and evaluated in Nepal (BK Baniya, personal communication 2008). Nepalese landraces produced more grain than exotic however; exotic lines were dwarf and earlier in maturity than Nepalese landraces (Baniya, 1990). Some of the introduced common buckwheat genotypes are of self compatible, determinant and tetraploid type.

Loss of landraces in Jumla is reported by Joshi et al. (2005). Genetic erosion may also be in other districts. Based on the morphological data and value in term of area and number of growers, diversity status of buckwheat landraces of Jumla is determined and they are kept in red listing categories (Joshi et al., 2004), which could be useful for giving priority to conserve *ex situ*. Similar approach should be followed in other districts to categorize the landraces that helps to take conservation action.

3.3 Use and medicinal values

In Nepal, about 34 different kinds of food items are made from buckwheat. These food items are Dhindo (thick porridge), Roti (bread), Momo (Chinese pancake), Lagar (very thick bread), Dheshu (thicker than lagar), Fresh vegetables, Dried vegetables, Kancho pitho (raw flour), Chhyang or Jaand (local beer), Raksi (alcohol), Salad (leaves), Pickle (fresh and dry leaves), Soup, Ryale roti, Noodle, Sel roti, Bhat (rice), Sausage, Dorpa dal, Tea, Vinegar, Jam, Macaroni, Biscuit, Cakes, Mithai (sweet), Haluwa, Puri, Puwa, Buteko phapar (roasted grain), Satu, Phuraula, Porridge, Pakauda, etc. (Sharma, 2001; Vaidya et al., 1999; Baniya, 1999; Adhikary et al., 1995; NHCRP, 1993). Mountain people of Nepal prefer to eat as a dhindo because of tastier than any other cereals to eat in this form.

Common buckwheat is used during fasting period on special religious occasions when cereal consumption is prohibited (Baniya, 2001). It is used as fuel, fodder, feed and bedding materials for livestock. Its pillow is considered very important for keeping biological balance and improving eye health.

Locally it has been using for different kinds of human health problems. It is used in the following health problems: Cold, fire burn and general wounds, cough and tonsil, fever, gastric, indigestion, eye pain, dandruff, hair dropping, epilepsy, dysentery, stomach disorder, headache, jaundice, poisoning, pimples and scratch skin, sudden stop of stool and urine, dental gum bleeding and swelling, cholera, allergy (skin drying itching), pneumonia, blockage of throat due to bone and hair, diabetes or sugar, intestinal disorder, haemorrage, diarrhea, cancer, high blood pressure, poor immunity, bone fractures etc. (Vaidya et al., 1999; Baniya, 1999). Farmers also treat sick goat and small animal by buckwheat.

Buckwheat is a natural functional food and regarded highly not only for its balanced amino acid makeup, high value of proteins and favorable fat composition but primary for its high rutin content (Paulickova et al., 2004). Rutin is important therapeutic substances that favorably influence the increase of blood vessels elasticity, the treatment of circulating disorders and atherosclerosis, the reduction of blood pressure and stimulates the organism to utilize the vitamin C (Yildzogle-Ari et al., 1991). The production of rutin and other UV absorbing compounds in buckwheat was a response to the higher flux of UV in the high elevation ecosystems where it is originated (Kreft et al., 2003).

Table 5. Exotic genetic resources of buckwheat introduced in Nepal and their origin

SN	Origin	Exotic buckwheat
1.	Brazil	GF-5011
2.	Canada	GF-5004, GF-5007, GF-5010, GF-5013, GF-5016, Mancan, CBBP-1, CBBP-2, CBBP-3, CBBP-4, CBBP-5, CBBP-6
3.	China	GF-5005, GF-5018, GF-5020
4.	Czechoslovakia	*
5.	India	*
6.	Japan	GF-5009, IR-13, Tokyo, To-Matusoba, Shinshu-O-Soba (4x), Shinano-Ichigo, Shinano Soba, Botan Soba, Shinano-Natsu Soba, Miyazakizairai,
7.	Mongolia	GF-5019
8.	Poland	GF-5002, GF-5239, Emka (4x),
9.	Slovenia	Siva
10.	South Africa	GF-5006
11.	Sweden	*
12.	USA	GF-5015
13.	USSR	GF-5001, GF-5003, GF-5008, GF-5012, Scorospelaya, Soumchanka (determinant)
14.	Yugoslavia	Darja

*, Name not available. Sources: Adhikary et al., (1995); Baniya, (1990); HCIP, (1988).

3.4 Characterization and evaluation

Collections made within country and introductions are commonly characterized and evaluated on station particularly, in Jumla, Kabre and Khumaltar. About 822 buckwheat genotypes have been characterized and evaluated in Nepal (Dongol et al., 2004). Among them 288 genotypes were characterized and evaluated in Kirtipur, Tribuvan University and some in Rampur, Institute of Agriculture and Animal Sciences. The genotypes recently evaluated in ARS-NARC, Jumla and Biotechnology Unit-NARC, Khumaltar are given in Table 6 and 7 respectively. Three tartary genotypes namely GF-212, Sample-6-1 and Sample-7 were found stable (Joshi, 2004). Grain yield of some tartary landrace is 2.5 t/ha at farmers field (Vaidya et al., 1999). Tartary produce 66% higher grain yield than common during autumn and 380% higher during spring season (Baniya et al., 1992). This indicates that most of the common genotypes were poorly adapted to spring season.

Buckwheat cannot survive frost thus needs frost free period. Early buckwheat types can escape frost and also allow enough time to grow succeeding crops. Farmers perceive that tite types are better adapted even under more stressed environments and often produce more yield than mithe types. However, Dolpa bhate is poorly adapted when introduced to new environments, no matter whether it is warmer or cooler (Subedi et al., 2001).

The quality of buckwheat from the western mountain to eat is considered superior because rainfall during its growth cycles deteriorates its quality. The quality of buckwheat remains much better in the high mountains for taste and flavor even to eat as a local dish such as *Dhindo*. But as the buckwheat area moves down, the quality deteriorates. The level of bitterness in local landraces as reported by farmers is Chuchche> Bhadre> Kalo Kise> Seto Kishe > Syangre > Mithe (Adhikary et al, 1995). Rain during flowering and maturity time has a detrimental effect. Black type of tartary buckwheat is reported less bitter as compare to white type (Adhikary et al., 1995).

Table 6. Performance of some selected Jumla buckwheat collections in ARS-NARC, Jumla, 2006

SN	Landrace	Maturity day	Plant height, cm	Yield, kg/ha
Common buckwheat				
1	Mithe phapar UKH	66	78	700
2	Mithe phapar AB	73	67	300
3	Mithe phapar HBR	71	72	601
4	Mithe phapar DKU	66	54	863
5	Mithe phapar PSR	66	56	495
Tartary buckwheat				
1	Barule JR	74	56	696
2	Chuchche BC	76	45	600
3	Chuchche DB	78	46	537
4	Barule KU	106	49	616
5	Barule LBA	106	50	700

SN	Landrace	Maturity day	Plant height, cm	Yield, kg/ha
6	Chuchche NDA	66	51	550
7	Barule GBB	96	69	500
8	Tite phapar PU	96	42	593
9	Chuchche SD	76	45	844
10	Barule KB	78	63	1430

* Capital letter after landrace name is farmer name in short who provided the seeds.

Table 7. Performance of some selected tartary buckwheat evaluated in Khumaltar, 2007

SN	Accession	Maturity day	Plant height, cm	Yield, kg/ha
1	Khumla-7	83	74	2188
2	NPGR-2194	84	86	2146
3	Kabre tite	84	96	1986
4	NPGR-6058	85	78	2440
5	5-1	86	86	3584
6	Barule SLB	80	83	2220
7	Acc# 6485	86	91	2214
8	Acc# 5671	86	98	2316
9	Dolpa tite	85	26	2294

3.5 Genetics and breeding

Flower of common, tartary and cymosum buckwheat is bisexual but incomplete with 5 sepals. The pistil consists of a one-celled superior ovary and a three-part style with a knoblike stigma and is surrounded by 8 stamens (Campbell, 1997). Common buckwheat is self-incompatibility with dimorphic heterostyly i.e. pin and thrum type of flowers therefore; breeding principles of cross pollinated crop can be used to improve the common buckwheat. Tartary is self-compatibility with very small homostyly flower and thus breeding principles of self-pollinated crop can be used. Both heterostyly and homostyly flowers are reported in cymosum buckwheat. Both common and tartary buckwheat are diploid with 16 chromosomes number (2x =2n) (Table 1) and tetraploid and diploid forms of cymosum buckwheat are found in Nepal.

Study on genetics and breeding in Nepalese buckwheat is negligible. Research was started from 1973 and systematic research took place after the establishment of HCRP in 1986 (Baniya et al., 2001). So far major research works were concentrated only on introduction, collections, characterization and phenotypic selection. Promising common buckwheat accessions are IR-13, GF-5099, GF-5063, GF-5122, No-85603, GF-527 and promising tartary buckwheat accessions are AccNo-2227, GFF-212, GF-216 and AccNo-2223. Landraces from Nepal had the highest rutin content (Kitabayashi et al., 1995) in the world. The superior traits of Nepalese landraces have been reported in the world as a good source for improving buckwheat quality (Morishita et al., 2002).

3.6 Prospects

With the modernization of agriculture, crops growing environment is deteriorating over the year resulted in the decreasing trend in getting benefit from agribusiness. In such situation, buckwheat will get top place in the agribusiness because, it is easy for cultivation, needs less care of; it is short duration crop and suitable to different cropping patterns; it grows well without or with low inputs, in moisture stress and cold temperature (both in abiotic and biotic stresses); it is adapted to diverse and very adverse climatic conditions; it is the only alternative crop for marginal land of high hills where other cereals cannot be grown; it is used to make high quality pillow; it needs less time and energy for cooking; it can be used as vegetables, food, medicines, tea, fodder, etc. Farmers and breeders can use it as catch crop, emergency crop, hardy crop, cash crop, bonus crop, honey crop, vegetable crop, smother crop, feed and green manure crop, etc.

Modern agriculture has also been negative impact on human health and environment. Buckwheat is one of the functional food crops with very unique medicinal properties. Consumers will prefer this crop because, it is very useful for heart, kidney and stomach problems; useful for high blood pressure and diabetes; it protects DNA molecules from damage; it is taken as radical scavenger in human body; it has antibacterial, antioxidative and antimutant effects, etc. Buckwheat is only the field crop that produces UV absorbing compounds; therefore, its scope will be valued by environmentalists.

Due to variation in geography and varieties of buckwheat in Nepal, quality buckwheat can be produced and traded internationally. The highest rutin content in Nepalese landraces, production of grains organically and production of low bitter tartary buckwheat will take the market at international level.

4. Conclusions and recommendations

Buckwheat is an indigenous crop that plays a major role in food security of mountainous farming community. In addition, buckwheat has significant commercial, social, cultural and medicinal values in different niches of Nepal. Buckwheat cultivation is very easy and can be grown in marginalized soil and adverse environments. Field and storage pests are negligible in buckwheat crops and seeds. Available diversity in buckwheat indicates the potential of developing site specific as well as wide adaptability varieties suitable for diverse growing conditions and farmers' needs. Some of the major breeding objectives should be the development of low bitter taste and easy dehusking tartary buckwheat varieties, and high grain yielding common buckwheat varieties. Conservation and breeding works should be intensively carried out with the use of biotechnological tools. Research on its medicinal values should get priority because of its very importance for ageing people and for protection of DNA molecules from damage. Government should facilitate for providing buckwheat growers access to national and international markets. Its food, medicinal and environmental protection values

should be understood and considered by each farmers, consumers and policy makers to get benefit from the buckwheat.

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