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Analyzing Problems and Prospects of Buckwheat Cultivation in India

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ABSTRACT

Buckwheat is a multi-purpose crop grown widely at higher elevations in the Indian Himalayan region. Buckwheat contains high amounts of antioxidant compounds, mainly rutin (a flavonol glycoside) with several medicinal properties. The physiological and biological properties of rutin include anti-oxidation, anti-inflammation, anti-hypertension, vasoconstrictive, spasmolitic and positive inotropic effect. Out of 20 species reported world-wide only two, *Fagopyrum tataricum* and *F. esculentum* are cultivated in India and elsewhere in the world. The majority of the varieties grown are farmer's own selections, however, five varieties have been released through the All India Coordinated Project on underutilized crops. Besides, around 911 germplasm accessions have been conserved in medium term storage at Shimla; 837 out of these have also been maintained as base collection in the National Gene Bank. Although buckwheat has diverse uses as food, medicinal and industrial plant, the area under its cultivation is decreasing at an alarming rate mainly due to changing cropping patterns, migration, low productivity, changing food habits, and lack of alternative uses/ products. Screening of germplasm for biotic and abiotic stresses, restructuring of research and development activities towards value addition by exploiting its potential as fast food, medicinal and beverage plant and awareness of its food and medicinal value at grass root level are some of the new thrust areas for expanding buckwheat cultivation.

Keywords: conservation, genetic resources, potential, tartary, variety

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INTRODUCTION

The name buckwheat comes from the Anglo-Saxon words *boc* (seed resembles a small beech nut) and *whoet* (wheat) (Robinson 1980). Buckwheat is an ancient dicotyledonous crop belonging to the *Polygonaceae* family. Even though it is an underutilized crop in India, still plays an important role in the food and nutritional security of the people living in remote rural settlements of the Himalaya region (Rana *et al.* 2010b). Out of 20 species in the genus *Fagopyrum* (Li 1998; Ohnishi 1998; Liu *et al*. 2008; Tang *et al*. 2010; Shao *et al*. 2011), only two, *Fagopyrum tataricum* (tartary buckwheat) and *F. esculentum* (common buckwheat) are cultivated in India (Joshi and Rana 1995a; Chauhan *et al.* 2010). They are cultivated under low input conditions and adapted to highlands where climate extremes have generated tremendous genetic diversity of landraces/traditional varieties.

Buckwheat in India is known by various vernacular names such as *ogal, phaphar, bresha*, *kuttu*, *mittahe* (sweet), *titae* (bitter). The estimates for area and production under buckwheat in India are not available separately, since all underutilized crops have been dealt with under the term "coarse cereals". The area and production of coarse cereals is 20.94 million ha and 28.23 million tons in 2010-2011 as compared to 43.80 million ha and 30.41 million tons in 1975-76, respectively as per the first advance estimates of the Directorate of Economics and Statistics, Department of Agriculture and Cooperation, Government of India for 2010-2011. This shows that the area under these crops, including buckwheat, has decreased by 52% while production has only decreased marginally by around 7%, which may be attributed to the development of high yielding varieties in different crops in the recent past. We observed a similar trend for buckwheat while conducting more than 50 germ-

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plasm collection expeditions to throughout the Indian Himalayan region.

Although cultivation of buckwheat has shown declining trends in the recent past due to several factors discussed later, we found that farmers, and especially the old generation, love to grow and eat buckwheat in the tribal regions of Himalaya. It is not only for socio-climatic compulsion, but also due to its medicinal and nutritional properties of which local people are aware. Buckwheat is also emerging as a health food because of its richness in nutrients like protein, high content of lysine, fibrous materials, mineral compounds, vitamins, and bioflavonoid rutin (Keli 1992; Michalova *et al.* 1998; Fabjan *et al.* 2003; Ikeda *et al.* 2008). Rutin and other flavonoids derived from buckwheat are in increasing demand in the food, pharmaceutical and cosmetic industries due to their biological and physiological activities including antioxidant, anti-inflammation and anti-hypertension properties. Buckwheat can also be processed to various value added products such as cakes, instant powder, wine or vinegar to increase the economic returns to the buckwheat farmers. The recipes like *chillare* (unleavened bread) and *ghanti* (local wine) are popular among tribal communities. The flour also known as *kuttu ka atta* among the Indian folks outside the Himalayan region is eaten during *upbas* (fast), the religious days when food containing cereal and pulse is not permitted (Rana *et al.* 2011).

Despite having so much value, the decline in area and production of buckwheat across the region is a matter of concern. Farmers are now diverting more land under off-season vegetable, fruits and medicinal plants which give them better return. To make buckwheat an attractive farm crop, there is a need to put more research and funds in the cultivar development, crop management practices for improving yield and on more industrial and pharmaceutical uses. Therefore, buckwheat in the present context requires more management expertise than other crops.

DISTRIBUTION AND AREAS

Buckwheat exhibits rich diversity including those of wild species and distributed throughout the Indian Himalayan region with more preponderance in the western Himalayan region than the north-eastern region (Farooq and Thair 1987; Arora and Engels 1992; Baniya 1994; Ohnishi 1995; Rana 2004). This may be due to the common border between the Western Himalayan region and Tibet and also to migration that could have taken place along several trade routes such as the very famous silk route through this area from southern China and Tibet. The occurrence of buckwheat ranged from Jammu and Kashmir in the north to Arunachal Pradesh in the east and Tamil Nadu in the South (**Fig. 1**). The important areas where cultivation of buckwheat is more predominant are Kargil and Drass sectors, Gurez valley of Jammu and Kashmir; Bharmaur, Pangi, outer Saraj, Chopal, Dodra kuar, Neshang, Pooh subdivision, Lahaul valley, Pin valley in Himachal Pradesh; Pindari valley, Darma valley, Jolwan, Jaunpur, Kapkote in Uttranchal; Cooch Behar, Darjeeling in West Bengal; Lachan, Lachoong in Sikkim; Tawang, Bomdilla and Dirang in Arunachal Pradesh, other higher elevations of Meghalaya and Manipur and also sporadically in the Nilgiris and Palani hills in the southern part of India (**Fig. 2**).

Of the two cultivated species, the cultivation of tartary buckwheat is more common in the high lands above 2500 m, while common buckwheat is grown at lower elevations extending to 1000 m, where it is grown as an intercrop in apple orchards as a be pasturage plant. Ohnishi (1989) also found that the cultivation of common buckwheat in Tibet Himalayas was limited to approximately 500-2500 m in altitude and above 2500 m tartary buckwheat replaces it in cropping patterns. The majority of the varieties grown have been traditionally selected by the farmers upon the needs. However, in the recent past, a buckwheat improvement programme has been taken up and some high yielding varieties have been released.

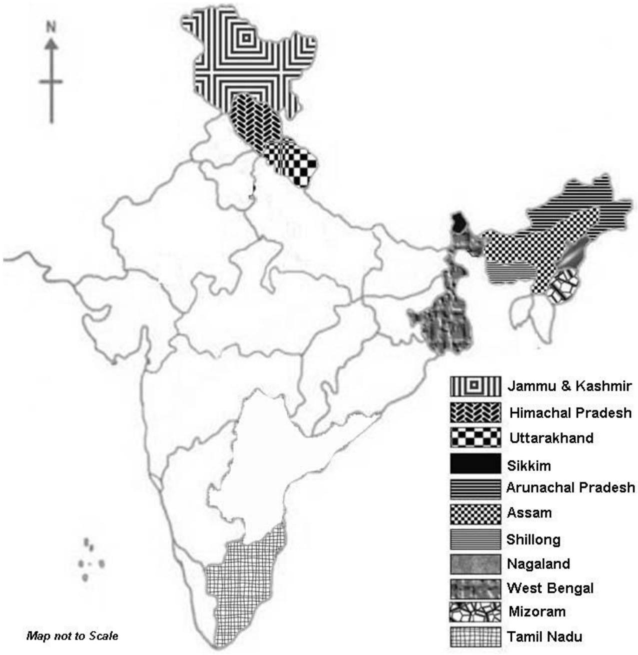

Fig. 1 Buckwheat-growing states in India.

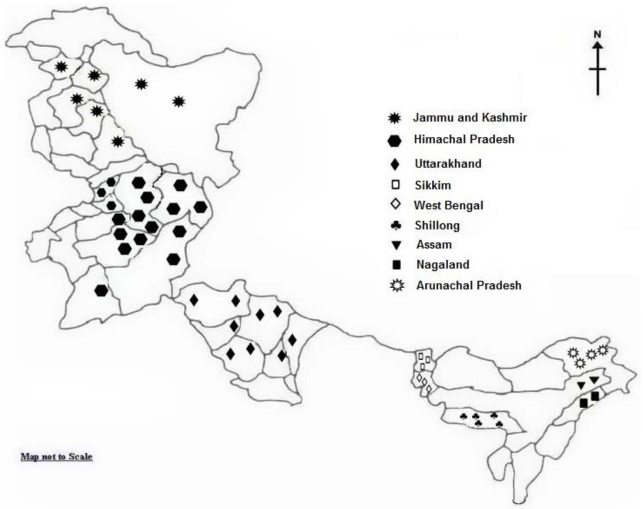

Fig. 2 Areas where buckwheat cultivation is predominant in different Indian Himalayan States.

ON-GOING RESEARCH WORK IN INDIA

Varietal improvement

After realizing the need to carry out a systematic multi-disciplinary research work on under-utilized crops by using a wide array of promising germplasm was started in 1982 under the All India Coordinated Project. Presently, 27 crops are being dealt with under the project and buckwheat, included in 1984, is one of them. Till date, more than 150 promising germplasm accessions/breeding lines have been tested for yield and adaptability at various locations viz. Shimla, Bhowali, Shillong, Almora, Srinagar, Bajaura, Palmpur and Sangla, and five high yielding varieties have been released by different institutions (**Table 1**).

Genetic resources management

Although crop improvement work has been initiated, the management of Plant Genetic Resources (PGR) in the underutilized crops has been viewed as one of the important areas. The National Bureau of Plant Genetic Resources is a nodal organization in India for the management of PGR for

Table 1 Buckwheat varieties developed and released by different research institutes in India.

Name of the varieties	Species	Name of the institute
Himpriya and Himgiri	*Fagopyrum tataricum*	National Bureau of Plant Genetic Resources Regional Station, Shimla, Himachal Pradesh
VL7	*Fagopyrum esculentum*	Vivekananda Parvatiya Krishi Anusandhan Sansthan, Almora, Uttarakhand
PRB1	*Fagopyrum esculentum*	G.B. Pant University of Agriculture and Technology, Hill Campus, Ranichauri, Uttarakhand
Sangla B1'	*Fagopyrum tataricum*	Himachal Pradesh Agriculture University, Palampur, Himachal Pradesh

Table 2 Promising germplasm identified for various agronomic and quality characters.

Characters	Botanical name	Accessions	Value
Leaf length	*Fagopyrum tataricum*	IC274444 ,IC109438, IC202264, IC202279, IC341081, IC274444, IC310104, IC278957	>10 cm
	Fagopyrum esculentum	EC58322, EC125939, EC216621, IC202288, IC313301, IC313300, IC106836, IC326998	>10 cm
Leaf width	*Fagopyrum tataricum*	IC202264, IC109714, IC329196, IC329200 ,IC310047, IC109458, IC202262, EC323730, EC216635	>10 cm
	Fagopyrum esculentum	EC58322, IC109716, IC274430, IC329471, IC341681, IC311004, IC310046, IC318859, EC323726	>10.5 cm
No. of internodes	*Fagopyrum tataricum*	IC415483, IC339688, IC13412, IC13143, IC13191, IC341680, IC313468, IC381077	>20
	Fagopyrum esculentum	IC423460, IC423476, IC423459, IC423435, IC258230, , IC109726, IC109757, EC125397	>21
No. of primary branches	*Fagopyrum tataricum*	IC42411, IC49664, IC49680, IC274423, IC318859, IC329194, IC318859	>8
	Fagopyrum esculentum	IC16971, IC42401, IC107310, EC216635, EC323723, EC018864, EC188664	>7.5 cm
Cyme length	*Fagopyrum tataricum*	IC107964, IC107961, IC107627, IC360826, IC547549, IC547346, IC547396, IC361635	>6.5 cm
	Fagopyrum esculentum	IC265491, IC27260, IC42401, IC341631, IC318859, EC125357, EC58322	>8
Days of maturity	*Fagopyrum tataricum*	IC24299, IC24301, IC28756, IC26755, IC329568 IC381130, IC13412, IC16558, IC42411	<75
	Fagopyrum esculentum	EC323731, EC323729, VL7, IC329568, IC381130, IC13412, IC16558, IC42411, IC24301, EC323731, EC323729	<80
Seed yield/plant	*Fagopyrum tataricum*	IC18869, IC18889, IC107964, IC107965, IC18869, IC18889, IC318859, IC329401	>15.5
	Fagopyrum esculentum	IC188701, IC16550, IC204085, IC329404 IC467923, IC447689, IC540858, EC218740	>22
1000-seed weight	*Fagopyrum tataricum*	IC201481, IC243184, IC318859, IC381077, IC381098, IC381049, IC58322, EC323724	>21 g
	Fagopyrum esculentum	EC58322, EC18864, EC125397, EC125940, IC360829, IC360846, IC361359, EC216685, EC213682	>24 g
Protein content	*Fagopyrum tataricum*	IC108499, IC108500, IC128519, IC107989, IC382287, IC310104, IC341671	>14%
	Fagopyrum esculentum	EC323724, EC323729, VL7, PRB1, EC125938, IC261963, IC341674, IC109729	>12.2%
Total phenols	*Fagopyrum tataricum*	IC310045, IC274439, IC341674, IC274439, IC323729	>1.6%
	Fagopyrum esculentum	EC323724, EC125938, IC329456, IC341593, IC423476	>0.95%
Lysine	*Fagopyrum tataricum*	IC310045, IC274439, IC341674, IC274438, IC108499	>4.5
	Fagopyrum esculentum	IC272442, PRB1, EC125938, EC323729, IC272442	>4.6
Rutin content	*Fagopyrum tataricum*	IC42421, IC14889, IC14253, IC107962, IC310045	>17 µg/mg

all the crops important for food and agriculture. The germplasm of buckwheat has been augmented both through collections made within the country and introduced from abroad. The present collection comprises 911 germplasm accessions consisting of *F. esculentum* (333), *F. tataricum* (540) and other wild species (38), and is stored in medium-term storage at 7°C and 35% RH (relative humidity) at Shimla. In addition, 837 accessions have been conserved for long term storage at -20°C as base collection in the National Gene Bank at New Delhi. Apart from the NBPGR, about 300 working collections are also maintained at ambient temperature by other institutes such as the G. B. Pant Agricultural University, Hill Campus, Ranichauri, Vivekananda Parvatiya Krishi Anusandhan Shala, Almora, and the Regional Stations of Agricultural University, Palampur at Sangla and Kukumseri.

These *ex situ* collections have always been viewed as backup to the *in situ* on farm conservation, which conserves and enhances utilization of PGR as species are continuously passing through evolutionally processes and generating more variability. Having so much importance, there are limited efforts across the globe for conserving the PGR on farm in general and under-utilized crops in particular. We understand that in the eventualities of changing agricultural scenario globally, the conservation of buckwheat is a big challenge to meet. Nevertheless efforts have been initiated to promote on-farm conservation, and to generate awareness on its food and medicinal value in areas like Bharmour, Pangi, Sangla and Nesang of Himachal Pradesh where buckwheat is grown as one of the major crops. On-farm conservation projects evaluating and conserving buckwheat landrace diversity *in situ* have been undertaken in Sichuan province (Zhao *et al*. 2010), because landraces occurring here are genetically more diverse than varieties found in other areas of China (Hou *et al.* 2009).

The entire collection has been characterized for various descriptors (IPGRI 1994 and NBPGR 2000). A wide range of variability has been noticed for traits such as plant type, maturity period, seed shape, seed colour and seed size, leaf shape and leaf size, flower colour, stem colour, resistance to diseases like leaf spot (*Cercospora fagopyri*) and powdery mildew (*Erysiphe polygoni*), tolerance to lodging. Promising accessions have been identified (Joshi and Paroda 1991; Rana 2004; Rana *et al.* 2010a) and a few of them are listed in **Table 2**. The genetic diversity analysis of 96 germplasm accessions of tartary buckwheat grouped them into 13 different clusters, indicating the range of diversity (Rana 1998). Another set of 40 ecologically diverse lines of common buckwheat was evaluated and 'IC13141', 'IC13374', 'IC42430', 'IC18869', 'IC136804', 'IC36914', 'IC42403' and 'NC64039' were found to be the most diverse and promising lines (Joshi and Rana 1995a). Multi-location testing of 13 elite varieties showed that 'IC13374', 'IC13411', 'Kulu gangri', and 'VL7' were the high yielding and most consistent varieties (Joshi and Rana 1995b). Germplasm for special traits like easy de-hulling/ loose hull and ultra early maturity have also been identified and registered as unique genetic stock. Two lines of tartary buckwheat, namely 'IC329457'and 'IC341679' have a loose hull which can be removed just by rubbing with hands and are popularly known as rice buckwheat (Campbell 1997). Other three lines, 'IC341671' (tartary), 'EC323729' and 'EC323731' (common) have been selected for ultra early maturity of 60-65 days, as compared to 90-150 days observed in other lines. Early varieties are now in great demand in the buckwheat growing areas because of the introduction of cash crops. In high lands, there is a gap of about 2-3 months between green pea harvesting and the onset of snowfall, so farmers prefer to use this period for growing early maturing buckwheat varieties.

Beside agronomic traits, the germplasm collection has also been evaluated for quality characters such as protein content, total phenol, free phenol and lysine content. We evaluated 60 promising accessions and found that protein content varied from 8.20 to 15.10%, total phenols from 1.4 to 1.70%, free phenols from 0.27 to 0.94% and available lysine from 3.89 to 5.60%. Similar trends were reported in germplasm of buckwheat in other parts of the world (Keli and Dabiao 1992; Suzuki *et al*. 2005; Lin *et al*. 2009). We also evaluated rutin content in the mature seeds of 200 *F. tataricum* accessions, which showed relatively large variation, ranging from 0.6 to 2.0% (dry weight) compared to only 0.07% (d.w.) in the selected accessions of *F. esculentum* (Chauhan *et al.* 2010). These results agree with previous reports on variation in rutin content in cultivated buckwheat (Eggum *et al.* 1981; Bonafaccia *et al*. 2003). Park *et al.* (2004) compared rutin content in different parts of some *Fagopyrum* species (*F. tataricum*, *F. cymosum* and *F. esculentum*), and revealed the highest level in the flowers and lowest in the roots. There are reports on rutin content variation in different *Fagopyrum* sp. coupled with changes in antioxidant activity, which decreased in the order: *F. tataricum* > *F. homotropicum* > *F. esculentum* (Jiang *et al.* 2006). Morishita *et al.* (2007) reported 3-4 times higher antioxidant activity in tartary than in common buckwheat grains. Studies have also been made and are being carried out on phytochemical screening and evaluation of nutritional and antioxidant potential, amino acid profiling, starch properties, protease inhibitors and antifungal protein, isolation and mapping of genes and also on the flavonoid biosynthesis genes (Senthilkumaran *et al.* 2007; Chrungoo *et al.* 2010; Gupta *et al.* 2011).

PROBLEMS AND CAUSES OF DECLINE IN CULTIVATION

It is now an established fact that buckwheat farming is on the decline in a wide variety of settings in the Indian Himalayan region. Farmers are reducing buckwheat plantings at every elevation, in every ethnic group, and in every region, for a wide variety of reasons (Rana *et al.* 2010b; Saunders 2010). In areas that still grow buckwheat, farmers grow less now than in the past 25 years. The reasons are numerous, of which we have synthesized a few important ones that have direct implication in the decline in buckwheat cultivation.

Changing cropping patterns

In earlier days, planting of buckwheat was an integral part of the cropping systems that hill farmers had adopted. Now, the agricultural policy of the Government is more focused in the introduction and promotion of crops like apple, green pea, cabbage, hops, kidney bean and potato (generally referred to as cash crops), which are more remunerative than buckwheat. Consequently, the area under buckwheat has declined substantially and it ranged from 60-92% in the past two decades in the Western Himalayan region of India (Rana *et al.* 2000; Rao and Pant 2001; Rana *et al.* 2010a). The area under buckwheat in Japan has reduced from over 200,000 ha in 1800 AD to 25,000 ha by 1970 (Ujihara 1983). The reports of other countries depict similar trends in buckwheat (Baniya *et al.* 1995; Fan and Chan-Kang 2005; Zotikov *et al.* 2010).

Improved economic conditions

The growing of cash crops has definitely improved the economic conditions of farmers in the traditional buckwheat growing regions. Apart from this, increased adventure tourism, home stay tourism scheme, hydro projects have opened up new job and business opportunities, thus contributing to the improvement of economic conditions of farmers. The job guarantee scheme for at least one member of the family has also resulted in shortage of labor. Changing economic conditions and their effects on farm labor supply have not only impacted the cultivation of buckwheat but also the cultivation of many other traditional crops like grain amaranth, small millets, barley and labor oriented crops like maize and potato (Zimmerer 1991; Rana *et al.* 2010a). Further, unlike for cash crops, there is no organized market for buckwheat. It is only common buckwheat that is purchased by middlemen at low price (about 0.5 US$/kg) and sold at high price (3-4 US$) in the down town market in the form of flour. Some farmers trade buckwheat for rice, wheat and other grocery commodities.

Migration

The demographics in the villages are also changing. Younger populations are leaving the villages to urban areas for education, job and business opportunities, and the leftover rural workforce is aging. Those who still inhabit the villages are engaged in business and jobs created locally by the Government rather than spend time in agriculture. Similar trends have been observed in other buckwheat growing countries (Cai and Chan 2009). Every 3rd family has only 2-3 members living in the village, thus neither there are sufficient hands to work in the field nor they need too much buckwheat since other crops like wheat, rice and maize are easily available at subsidized rate in the Government shops opened under the Public Distribution System. Saunders (2010) in her research reported that the exodus of the workforce from rural areas results in a drop in twin household demand in China. Farmers need to grow less food, because they cannot eat it all and buckwheat is a crop that is almost exclusively grown for household consumption.

Changing food habits

The food base has become narrow and restricted to wheat, rice and maize, particularly among the younger generation. A survey was conducted in the major buckwheat growing area (Kinnaur) and the partially buckwheat growing area (Kangra) to know people's preference for eating buckwheat. The data were generated in terms of number of days in a year on which people were eating buckwheat in 1997-98 and in 1977-78. It was observed that there is a reduction of 76% in Kangra and 37% in Kinnaur over the 20 years studied (Rana and Sharma 2000) and now the situation might be worse. There is a cultural component to the shift away from buckwheat as well. Some farmers, particularly young men, reacted strongly to our questions about buckwheat, insisting that times have changed, and they would not go back to growing buckwheat. Young generation often say, things are different now than they used to be. Even though people acknowledged buckwheat's nutritional superiority, they often painted it as a food from a more difficult past, associated with manual labor, subsistence farming, and mountain poverty; not a foodstuff of modern economic dynamism and prosperity (Saunders 2010).

Less alternative uses/ products

The crop in the Indian mountains is mainly used for grain and occasionally as leafy vegetable and brewing. Also, there are few value added products in the market unlike in Japan, China and Russia who have developed several products of buckwheat. In Japan 90% of the flour is used only for making popular noodles called 'SOBA', while Russia and other European countries use buckwheat in the form of several value added products such as groats, sprouts, malt, tea and bakeries (Kreft *et al.* 2010; Lin *et al.* 2010). It is only tartary buckwheat which is consumed locally in the Himalayan region as people in the traditional buckwheat growing areas believe that tartary buckwheat is easy to digest and products have good shelf life, while common buckwheat causes constipation and other stomach problems when eaten continuously for a week or so (Rana *et al.* 2000). Nevertheless, buckwheat is quite complementary to cereal flours, and can be used to improve their nutritional quality, since it is high in essential amino acids. Studies have shown that up to 60% buckwheat flour mixed with wheat flour

Table 3 Economic value of buckwheat.

Type of value	Features	References
Nutraceutical Value	Source of high biological value protein with high lysine content	Bonafaccia *et al*. 2003[a]
	Source of essential fatty acids (oleic, linoleic and linolenic acids)	Tsuzuki *et al.* 1991
	Rich in vitamins, particularly vitamin P, E and the B complex	Bonafaccia *et al*. 2003[a]
	Buckwheat proteins are gluten free and are a widely recommended diet for celiac patients as an alternative to wheat products	Campbell 1997
	High amount of soluble protein and very low amount of prolamin in the buckwheat kernel	Campbell 1997
	74% protein absorption rate makes it an excellent meat substitute	Campbell 1997
	Source of essential minerals (zinc, copper, iron, manganese, magnesium, potassium, and phosphorus)	Ikeda 1999
	Contains healing benefits components: flavonoids and flavones, phytosterols, fagopyrins and thiamin-binding proteins	Fabjan *et al*. 2003
	Buckwheat bran has high concentration of natural fagopyritols	Steadman *et al.* 2000
	Buckwheat contains choline, which facilitates the working of the liver	Udesky 1992
	Good source of avenanthramide	Campbell 1997
Medicinal Value	Reduces blood sugar, blood fat and urine sugar	Steadman *et al.* 2000
	Very good medicinal food for people who have been exposed to radiation	Campbell 1997
	Protection against gastric lesions	la Casa *et al*. 2000
	Ameliorates spatial memory impairment	Pu *et al*. 2004
	Toxic to plant pathogenic fungi, gram-positive and negative bacteria	Fujimura *et al*. 2003
	Chemopreventive activity	Ren et al. 2001
	Suppresses gallstone formation and cholesterol level	Tomotake *et al*. 2000
	Reduces mammary tumor development	Kayashita *et al*. 1999
	Treats peridontitis and gum bleeding	Campbell 1997
	Causes muscle hypertrophy, elevates carcass protein and reduces body fat	Kayashita *et al*. 1999
	Antioxidant properties	Christa and Soral-Mietana 2008
	Great promise in the treatment of Polycystic Ovary Syndrome and insulin disorder including type II diabetes	Campbell 1997
	Ameliorates renal injury	Yokozawa *et al*. 2001
	Antifungal peptide from buckwheat seeds with antiproliferative activity toward cancer cells	Fujimura *et al*. 2003
	Reports on HIV-1 reverse transcriptase inhibition	Heeney *et al* 2000
	Provides UV-B protection at high altitudes	Campbell 1997
Industrial Value	Buckwheat Hulls used as fillers in pillows and comforters	Campbell 1997
	Used as feed for hogs and as mulch for vegetable gardens to suppress weeds and conserve moisture	Chauhan *et al*. 2010
	Buckwheat produces a dark, strong-flavored honey, which is usually sold for a premium	Saeger and Dyck 2001
	Buckwheat hulls are used in aromatherapy products as well as in meditation cushions	Janes and Kreft 2008
	Buckwheat is used in baby food and in energy drinks	Fabjan *et al*. 2003
	Buckwheat flour is used in desserts, ice cream cones, dietetic foods, pancake mixes, canned meat products, canned vegetable products, and dried breakfast cereals	Bonafaccia *et al* 2003[a]
	Buckwheat is used to produce extruded cereal and snack products	Campbell 1997
	The Japanese mill buckwheat groats into flour for the production of soba noodles	Belton *et al*. 2002
	Raw materials of tartary buckwheat are used to prepare bitter buckwheat tea	Campbell 1997
	Bread, cakes, and dumplings are made with the addition of wheat flour	Fujimura *et al*. 2003

produced acceptable bread (Pomeranz 1983).

PROSPECTS AND POTENTIAL

Information presented indicates that, by any calculus, the future of buckwheat farming in its center of origin is cause for some concern. The yields are low and the price is low, as is consumer demand. Nevertheless, there is an economic bright side for buckwheat, since it is a commodity, which holds excellent opportunity for expanded utilization by virtue of its medicinal, nutritional and industrial value (**Table 3**). Current knowledge, coupled with an integrated research effort, will provide the framework necessary for increasing the utilization of this crop. Some areas that are required to be addressed to improve the production of buckwheat and make it an important hill crop are given below.

- Buckwheat, although it is an underutilized crop, has many advantages for both the grower and the consumer. It has a very short growing season and is thus often grown in areas with a short crop growing period, or as a second crop. Owing to the wide range of maturity dates among the varieties, it is now possible to select cultivars with 60-70 days to maturity. It has the potential of diversifying cropping systems, enhancing human nutrition, and contributing to regional (rural) economies. It can also be grown after the first crop fails for environmental or other reasons and will still produce satisfactory yields. In addition, buckwheat fields in bloom can serve as a valuable source of nectar for bees. Honey produced from buckwheat is typically dark and has a stronger flavour than honey produced from clover, and is preferred by consumers.
- Buckwheat is often called a lazy crop even by the farmers who grow it. It establishes quickly and competes well with weeds, requires minimal soil fertility compared to other grains, and can often be left alone between planting and harvest. However, it tends to yield much lower than other grain crops. For this reason, it is often planted in a village's poorest, most difficult to access farmland. Importantly, a great deal of detailed farmer knowledge is lost when a crop is removed from its human context (Nabhan *et al.* 2002). Farmers have done the painstaking work of characterizing and selecting their own germplasm, and also preserve knowledge of processing and cultivation techniques.
- The cold, arid region of Indian Himalaya is highly suitable for buckwheat cultivation, thus production can be increased substantially. Buckwheat has also been recognized as one of the most important nutraceutical foods - a food or part of a food that provides medical or health benefits, including the prevention and treatment of a disease (DeFelice 1995). In a study conducted in cooperation with the Johns Hopkins Medical Institute, Jiang *et al*. (1995) reported that subjects who consumed 30g of buckwheat regularly during the year preceding

the interview had the lowest blood pressure regardless of other factors such as age and weight.

- Tartary buckwheat has a tightly adhering hull which is difficult to dehull and also contains a bitter component that makes it less attractive for consumption. Rice tartary buckwheat, which has an easily removable hull and is equally rich in rutin and other nutritional constituents (Chauhan *et al.* 2010; Gupta *et al.* 2011) offers an opportunity to obtain white flour without bitterness. The available germplasm needs to be evaluated for agronomic performance, and traits also need to be introgressed in high yielding backgrounds of tartary buckwheat. Mukasa *et al.* (2007) have reported that loose hull genotypes are crossable with the other types of tartary buckwheat; however, Campbell (1997) found that crosses between the two types are extremely difficult.
- Although a lot of information on the origin and distribution of the various species of buckwheat has appeared over the past 10 years, a great deal of effort is still required to search for more genetic variability including traits of economic significance. Self fertile germplasm in common buckwheat, like the wild species *F. homotropicum*, is required to be collected or introduced. Such types may be available in the cold, arid region of the Indian Himalaya. Buckwheat populations of the Himalayan region are geographically unique, so significant genetic losses may occur when farmers discontinue cultivation. Preservation of the crop on this landscape should not be taken for granted, and more must be learned about the diversity of buckwheat landraces and farming systems in the traditional mountain farming systems. Doubtless, on-farm conservation of buckwheat landraces is an important strategic component of crop improvement, human health, and biodiversity conservation.
- The evaluation of germplasm for biotic and abiotic stresses such as frost, lodging, diseases, and for other desirable traits viz. short duration, synchronous maturity, resistance to shattering, loose hulled, bold seeded, more leafy types needs to be taken up. Suitable genetic stocks for alternate uses such as more rutin content, increased groat percentage, soil binding properties, medicinal and industrial uses should be identified. Buckwheat also has tremendous export potential e.g. the Japanese mill buckwheat into flour for use in soba noodles, which are a staple part of their diet (Udesky 1992). They consume over 100,000 tons of buckwheat every year, but only produce 20 to 30% of their needs domestically (Ujihara 1983) and rest is met through import mainly from China.

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