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Strategies for *in situ* conservation and cultivation of buckwheat (*Fagopyrum* spp.) -A potential pseudocereal of North Western Himalayas

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Abstract

Buckwheat is very unusual and unique multipurpose crop of mountain regions above 1800 m elevation both for grains and greens. It is very hardy crop and yields greater on stony, unproductive soil under cool climatic conditions than most of other staple crops. Buckwheat owes its importance due to presence of excellent nutrition profile with a high protein content. Buckwheat does not contain gluten, so for the people with celiac disease or gluten intolerances, buckwheat serves as an excellent dietary alternative. Although it has a great relevance in agriculture still the resources available with this crop are very limited therefore it is also known as underutilized crop. It is used as a cereal though does not resemble the cereals in growth habit, seed quality or seed composition hence it is classified as a pseudocereal. It also has many desirable health components which make it a valuable part of the human diet. Buckwheat has a unique growth habit as compared to the cereals and thus fits into a much different area of crop production due to its rapid growth and flowering habit. Buckwheat as underutilized crop is very useful as it has short growing period, hence can be used for diversifying cropping systems and enhancing human nutrition value besides contributing to the rural economy. Buckwheat population in the Himalayan region is unique, so if the farmers discontinue cultivation, there may be huge loss of the peculiar genetic resources. Thus, on-farm conservation of buckwheat germplasm is an important strategic component of crop improvement and biodiversity conservation.

Key words: Underutilized crop, on-farm conservation, biodiversity.

Among the under-utilized crops grown in various parts of world, buckwheat has gained attention as an important supplementary pseudo-cereal crop. It possesses immense potential due to its nutritional quality, higher grain yield, nutra-ceutical attributes and multipurpose usages (Dutta, 2004). It is an important multipurpose crop of the mountainous regions used both for grains and greens, it occupies large area ranging from solid stands and expanding between 1800 m to more than 4500 m in the Himalayan regions. Being hardy crop yields better on stony unproductive soil under cool climatic conditions than most of the other staple crops. Based on its usage it has been classified as a pseudo-cereal. The word buckwheat is derived from the Anglo-Saxon boc (beech) and whoet (wheat) because the word beech was used since the fruit of the plant was similar to that of the beechnut (Edwardson, 1995).

Buckwheat is one of the best crops in higher altitude in terms of adaptation to climatic variables, water stress regimes, infertile soil, and freezing temperature and is easily fitted to different cropping pattern due to short life-cycle (Rana, 2004). In Europe, particularly in Russia, it constitutes one of the main food crops. Common buckwheat (*Fagopyrum esculentum* Moench) is a self-incompatible species. The main producers of common buckwheat are China, Russia, Ukraine and Kazakhstan (Campbell, 1995). Major exporters are China, Brazil, France, USA and Canada. Japan accounts for almost whole of the world's buckwheat imports.

View of buckwheat field in Sangla Valley of Himachal Pradesh

In India, it is mainly cultivated in the high hilly regions of Himachal Pradesh, Jammu and Kashmir, Sikkim, Manipur, Arunachal Pradesh, Assam, Nilgiris and Palni hills. In Himachal Pradesh main buckwheat growing areas are in the districts of Chamba, Lahaul&Spiti, Mandi, Kullu, Shimla and Kinnaur. It is common crop in Uttarakhand also owing to frost tolerance and requirement for less care in crop raising. Among other cultivated species, *F. tataricum* (L.) Gaertn.or Tartary buckwheat is also produced in many areas of the world (Clayton and Campbell, 1997). In many areas the trend is for replacement of common buckwheat, which has lower yielding ability and lacks frost tolerance, with other crops. At these altitudes tartary buckwheat frequently out-yields common buckwheat. Therefore, in some areas of India, Nepal and China common buckwheat production is declining but Tartary buckwheat is remaining stable or increasing. The farming of buckwheat is on the decline since previous years in the Indian Himalayan regions due to numerous reasons. The major factor is cropping pattern as government is more focused on the introduction and promotion of cash crops, which are more remunerative than buckwheat. Besides this growing of cash crops has impacted directly on the cultivation of buckwheat as there is no organized market for it (Rana *et al.,* 2010).

Evolutionary trends and genetic resources of buckwheat

The genus, *Fagopyrum* in the flowering plant family Polygonaceae contains 15 to 16 species of plants. Out of these, two cultivated species, *viz*., *Fagopyrum esculentum* Moench (common or Japanese buckwheat), *Fagopyrum tataricum* Gaertn. (Tartary buckwheat) and perennial wild species *Fagopyrum cymosum* Meisnn are important in this genus. The *Fagopyrum cymosum* is native to India and China and is considered to be the progenitor of both the cultivated species (*Fagopyrum esculentum* and *F. tataricum*). All the three species have 2n=16 chromosome number.

The domesticated buckwheat species, common buckwheat and tartary buckwheat are mainly cultivated in the temperate zones of the Northern hemisphere. De Candolle (1883) considered that common buckwheat originated in Siberia or in the area of the Amur River. His conjecture was mainly based on philological considerations and on the reported existence of wild common buckwheat by Russian taxonomists (Ledebour, 1841; Maximiwicz,1859). No proper name of buckwheat has been found in ancient Chinese or in Sanskrit which thus implies that buckwheat did not originate in China nor India.In the second half of the 19th century, botanical expeditions to China by European scientists revealed that wild buckwheat species were found growing only in Southern China. Steward (1930) described only eight wild species of *Fagopyrum* in his taxonomic studies on east Asiatic *polygonceae* species. These wild species did not contain any strong candidate for being the wild ancestor of cultivated common buckwheat. Hence, *F. cymosum,* which had been a well-known wild species, was thought to be the wild ancestor of common buckwheat (Nakao,1957).Ohnishi (1991) added two new species, *F. rubifolium* and *F. macrocarpum* from Sichuan province. Later, Ohnishi (1998) added four new species, *F. pleioramosum*, *F. callianthum*, *F.capillatum*, *F. homotropicum* and one subspecies *F. esculentum* ssp. *ancestral* which were found in the Sichuan and Yunnan provinces of China. Finally Ohsako *et al*.(2002) added two more new species, *F. jinshaense* and *F. gracilipedoides* from Yunnan province. Among these new species and new subspecies, *F. esculentum* ssp. *ancestrale* was proposed to be the wild ancestor of common buckwheat judging from its morphological similarity, except for several cultivated plant specific characters such as seed shattering habit and small achenes (Ohnishi, 1991).

Common buckwheat varies a great deal in many characteristics such as seed size and shape, pericarp colour, flower colour, plant height, leaf size and shape and many others. Flower colour is usually white in Europe, North America and Japan but is usually pink in South East Asia and Southern China. Commercialization of this crop has resulted in the exchange of many varieties between many of the areas producing the crop for export and therefore the range of diversity of most characteristics has been blurred or obliterated. This has indeed been hastened in many areas through the introduction and use of varieties from other countries in plant breeding or evaluation programmes (Chauhan *et al*., 2010). Many cultivars of buckwheat have been developed by many countries during the past several decades. Many of these have not been documented to date except in a few instances, such as by Joshi and Paroda (1991). Baniya *et al. (*1995) evaluated 507 buckwheat landraces, out of which 309 were common buckwheat, 196 were tartary buckwheat and 2 were wild types, at Kabre for a total of 27 different agro-ecological traits using the IBPGR buckwheat descriptors. Yang (1995) collected, multiplied, characterized, documented and compiled the buckwheat germplasm into The Catalogue of China's Buckwheat Germplasm. Dutta *et al.* (2008)

undertook study to assess the genetic variation, heritability, correlation, and direct and indirect effects of quantitative characters on seed yield in a set of diverse buckwheat genotypes. Chauhan *et al*. (2010) studied 15 known species of genus *Fagopyrum*, out of these only *Fagopyrum esculentum* and *F. tataricum* are cultivated while others occurs as wild or escapes around cultivated fields in Euro Asia. Germplasm comprising of 10,000 accessions has been preserved in gene banks across the world. Wide range of variations occurs in buckwheat germplasm accessions for agronomic and quality characters including rutin content. Hiremath *et al.* (2017) evaluated fifty-four diverse buckwheat genotypes and revealed highly significant differences between the genotypes for all characters studied suggesting the presence of adequate variability for selection. These authors review some of the known new cultivars that have been developed over the past three decades. These new cultivars contain many economically important traits that have been combined during the breeding process and are therefore very important from a conservation viewpoint. Although there are many collections of common buckwheat there appears to have been little agreement on important traits to be documented until recently. The preparation of a complete list of Buckwheat Descriptors (IPGRI,1994) was a major step forward in the coordination of passport data and descriptors on this crop. To date, in most evaluations, seed size and density, as well as plant height and lodging ability have been reported. Days to flowering and to maturity also have been recorded on many of the collections.

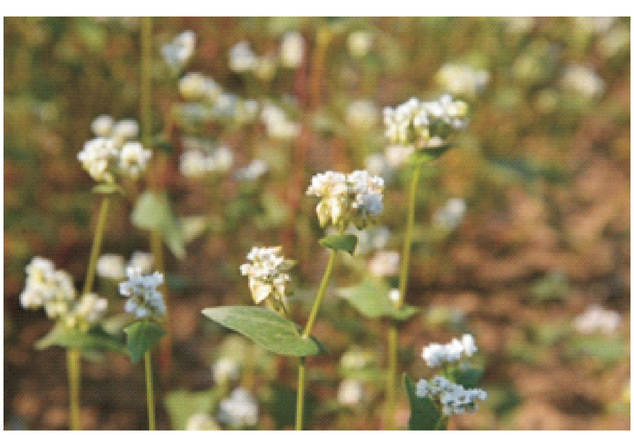
There appears to be little agreement between the breeding programmes worldwide on the most important traits for emphasis in crop improvement, other than yielding ability. Perhaps this has in part been due to the outcrossing nature of common buckwheat. Breeding programmes have had to select traits and attempt to stabilize them as in many cases they do not exist or are hard to find in collections. Increasing seed size and therefore increasing groat or flour content has been undertaken in Russia, Ukraine, Canada and Inner Mongolia. This has resulted in a steady increase in seed size of the cultivars being released and utilized in commercial production from these areas. This trend, however, is not evident in collections made in traditional buckwheat-growing areas such as Nepal, India and southern China. It would appear that the lack of frost resistance by common buckwheat or the frost resistance found in Tartary buckwheat is having an effect on grower preferences in many marginal areas of production. Common buckwheat production is declining while Tartary buckwheat production is staying almost stationary. Unfortunately to date there has been no reported finding of frost resistance, a very favourable trait, in common buckwheat. As a result, breeding programmes have been looking at means of introducing this trait from other species. Perhaps a more extensive evaluation of germplasm from very mountainous regions may find variability in this trait. As evaluations of these kinds of traits are expensive and appear to have limited success, most breeding programmes have concentrated on yield parameters and other agronomic traits such a determinate growth habit for inclusion into new varieties. Although frost tolerance is a very favourable characteristic of Tartary buckwheat there has been little evaluation of this trait and therefore the distribution or variability of this trait is not known. The development of lower-shattering types of buckwheat has taken place in Russia and Canada. However, there appears to be little evaluation for this trait in present collections. Lodging resistance also has been emphasized in some crop improvement programmes, most notably in Japan; however, it was more readily obtained through the development of tetraploid varieties than from variation in germplasm. The parental material for the production of the tetraploid varieties was usually taken from the highest-yielding and most adapted local landraces available. The finding of 'rice' buckwheat, a Tartary buckwheat that has a non-adhering hull and therefore dehulls very readily, has been reported in Nepal, Bhutan and southern China. This allows the use of it as a rice replacement in the staple diet in these areas. This trait, however, although reported as desirable, has not resulted in increased production of this type of Tartary buckwheat. Perhaps this has been due to lack of crop improvement efforts that must address yield as well as the ease of dehulling capabilities. The rutin content of Tartary buckwheat has been found to be higher in lines from Nepal than from lines collected elsewhere (Kitabayashi *et al*., 1995) which should allow selection and improvement of this characteristic. The inheritance of the rutin content in the seeds was found to be much higher than for the content found in the leaf and therefore much faster progress should be possible to increase seed content (Campbell, 1997).

Recent breeding approaches for buckwheat improvement

Buckwheat is often regarded as medicinal, exportable, and industrial commodity. Despite of its economic and nutritive value, it remains as a minor and neglected crop and have never attained the status of major cereal crop from the production and yield point of view (Adachi, 2004). The improvement of buckwheat by breeding has not been attempted as extensively as has the improvement of other commonly cultivated field crops, probably because buckwheat is of minor economic importance in the world's agriculture. However, it is of considerable importance in certain regions, owing to the fact that it yields greater returns on stony, unproductive soil and under cool climatic conditions than most of other staple crops. Most of the varieties developed so far are the result of introduction, pureline selection or mass selection methods. The Breeding objectives in Buckwheat are increased seed size, increased seed-shattering resistance, early maturity, easier dehulling ability, determinant flowering, seed coat colour, flower colour, leaf size, both small and large, lodging resistance etc. Research reports from several studies indicated that the dimorphic self-incompatibility system, limited variation in its reproductive system and susceptibility to different pest and diseases are the major yield limiting factors in common buckwheat (Campbell, 2003). Due to the complex nature of this crop and factors imposed by environment, genetic improvement in buckwheat through conventional method of breeding is not successful (Campbell, 1995). Now breeders around the world are initiating several strategic researches to overcome the complexities associated with this crop. One of the strategies includes wide hybridization of cultivated buckwheat with its closely related wild relatives. For breeding point of view we need to identify some cross compatible species of buckwheat, male sterile line, mutagenic agents, simplified breeding techniques and character of interest for introgression from indigenous as well as exotic lines. Germplasm characterization and storage is also needful for further use in breeding programs. The two cultivated species of buckwheat are known i.e. *Fagopyrum esculentum* and *F. tataricum* but some investigators name a third species, *F. emarginatum* but others prefer to consider this form a variety of *F. esculentum only. F. esculentum* and *F. tataricum* are apparently alike with regard to the number of chromosomes which is 2n=16.

The development of new buckwheat varieties has been successful in the production of larger seeded varieties which give better groat yields. There has also been development of lines with other desirable characteristics such as earliness or with shorter plant habits which are more resistant to lodging. These include the determinate flowering habit types as well as semi-dwarf plant habits.

This successful inter-specific hybridization of *F.esculentum* and *F.homotropicum* at the diploid level has opened a new methodology for the improvement of common buckwheat. Traits such as self-pollination, seed and plant characteristics can now be transferred to common buckwheat. *F. homotropicum,* being a self-pollinating species, sets all of its seeds before flower opening, in a similar manner as Tartary buckwheat. Common buckwheat has a seed abortion problem so that approximately 10 to12 % of the flowers it produces develops into seeds. Therefore, the transfer of the self-pollinating mechanism into common buckwheat allows for increased yield. However, the high number of flowers produced by *F.esculentum* must be drastically reduced to allow for the nutrients now being utilized for their growth to be diverted into filling the increased number of seeds being formed. The development of haploids for utilization in crop improvement programs is now receiving attention in several countries. These can be utilized for the production of double haploid homozygous lines. They also can be used for producing homozygous lines for use in the development of buckwheat hybrids. In recent years some progresses have made in inter-specific hybridization among some major species in



Flowers of *F. esculentum*

Flowers of *F. tataricum*

Fagopyrum with some help of *in vitro* techniques (Hirose *et al*., 1994; Lee, 1994; Campbell, 1995; Samimy, 1996). In spite of successes in such inter-specific hybridizations, it remains still for further investigation to break through breeding barriers for practical use. For this reason, ultra-structural characteristics of the fertilized ovule and another reproductive organ should be analyzed in detail. Ultra-structural aspects on degeneration of embryo, endosperm and suspensor cells were observed in some combination of the inter-specific hybridization (Shaikh *et al*., 2001). To determine the nature of the post-fertilization barriers in buckwheat the comparison of TEM configurations were very effective where the abnormalities in cytoplasmic components were detected in different time course among different cross combinations. The deficiency and degeneration of endosperm that were observed at 2 to 3 DAP may lead to the degeneration of hybrid embryo in the case of *F.esculentum* x *F. tataricum*. Therefore, rescue of hybrid embryos at this critical stage may overcome one of the main post-fertilization barriers by ovule culture. Otherwise, *in-vitro* fertilization technique should be operated as a non-conventional method for inter-specific hybridization.

a) Flowering behaviour and pollination techniques:

The appearance of the flowers in the different species of buckwheat is decidedly dissimilar. *F. esculentum* and *F. emarginatum* have somewhat showy flowers, which are distinctly dimorphic, whereas *F. tataricum* has rather insignificant flowers, which are not dimorphic. The flowers of the two species first named are visited much more frequently by insects, particularly honeybees, than the flowers of *F. tataricum.*

Common buckwheat is dimorphic, having plants bearing one of two types of flowers. The pin flowers have long pistils and short stamens while the thrum flowers have short pistils and long stamens. Similar length of pistil and stamen of a flower (Esser, 1953; Marshall, 1969) and lines with only one floral type (Marshall,1969; Fesenko and Antonov, 1973) have been reported. The pistil consists of a one-celled superior ovary and a three part style with a knoblike stigma and is surrounded by eight stamens. Three of the stamens closely surround the pistil and open outwards, while the other five are closer to the outside and open inward. Nectar-secreting glands are at the base of the ovary. New flower forms well adapted to self-pollination such as the one found by Marshall (1969) have short stamens and pistils. The tartary buckwheat is self-pollinating type.

b) Selfing and crossing techniques in buckwheat

The flowers of buckwheat are very small causing difficulties in selfing and crossing work. Studies on this aspect of the crop are meagre. For the selfing of common buckwheat which is cross-pollinated in nature, different procedures include bagging of plants by covering the entire plant with muslin cages spaced at large intervals or covering of flower clusters with glassine bags just large enough so that each bag covered include several flower clusters from the same plant under one bag. Alternatively entire plants can also be covered with muslin cages. Pollination can be done by rubbing between the thumb and forefinger without removing the glassine bags or self-pollination by rubbing the ripened anthers of a certain flower on the stigmatic surface of the same flower.

In tartary buckwheat which is self-pollinating type, for emasculation besides hand emasculation which is very difficult due to small flower, hot water treatment can be a good alternative. The procedure include soaking of apical clusters of flower buds in a constant temperature water bath ranging from 40-50℃ in the afternoon, and the flowers that had opened the next morning are used for artificial pollination. Mukasa (2011) completely inhibited self-fertilization by hot water treatment at 42^{0}C for 5 minutes, and a relatively high rate of pollinated flower set seeds was obtained by subsequent hand pollination in buckwheat**.**

c) Establishment of autogamous buckwheat and prospect for breeding strategy

Common buckwheat is an outcrossing species with distylic incompatibility as mentioned above. Due to allogamy, the individuals in a population are highly heterogeneous even in their seed storage proteins. As a strategy to overcome breeding barrier among *Fagopyrum* species, development of self-pollinating (autogamous) type buckwheat will be reliable by interspecific hybridization between common buckwheat and a wild homomorphic relative, *F. homotoropicum* (Campbell, 1995; Woo and Adachi, 1997). The hybrids were successfully produced through embryo rescue and forwarded to successive nine generations by recurrent backcrossing and selection to homostylar morphs. The maximum IgE binding activity was detected with protein bands of 22, 36, 39-40 and 70-72kDa (Nair and Adachi,1999a).The respective cDNA was isolated, coding for a 22kDa protein, from a recent developed autogamous strain of common buckwheat and confirmed its IgE-binding activity using recombinant *Fag e1* and sera of allergic patients. The determination of the *Fag e 1* epitope was performed by amino acid sequencing from *Fage 1* cDNA and then by overlapping peptide library.

Cultivation practices

Buckwheat thrives best on well drained sandy loam soils under cool and moist conditions. The optimum sowing time in hills depends on the height of the hilly terrains. In higher hill region (1500-2400 m asl), sowing should be done during second fortnight of May and in medium and lower hills, first fortnight of June is optimum period of sowing. Optimum seed rate for line sowing is 25 kg/ha. If broadcasted, the seed rate is increased to 30 kg/ha. Seed is treated with Azotobacter @ 10 g/kg seed, 10 to 15 minutes before sowing. The row to row spacing of 30 cm and plant to plant spacing of 10 cm. The sowing should be done at 4-6 cm depth. Thinning should be done at 15-20 days after sowing to maintain plant to plant distance. Fertilizer should be applied at the rate of 40:20:20 (N: P: K) kg/ha at the time of sowing to get maximum yield. Half dose of nitrogen with full dose of phosphorus and potassium should be applied as basal and remaining half dose of nitrogen to be applied after 40-50 days of sowing after weeding of the crop. This crop can also be successfully grown on the less fertile soils. Two hand weedings, first at 20 days after sowing and second at 40 days after sowing are important to keep the crop weed free. Alternatively application of alachlor@1.5 kg a.i./ha can also be used. To increase the seed set in common buckwheat, apiary should be encouraged in hills. It gives an additional income of 60-70 kg honey/ha. Generally, irrigations are not needed as this crop is grown in rainy season but in the absence of rains, irrigation is required during germination and at flowering stage. There should be proper drainage of water to avoid diseases and pests. This is a short duration crop and is ready for harvest in 3-4 months. Harvesting should be done when 75-80% crop is mature. This crop gives 10-12 q/ha yield.

Varieties

The first crop improvement programs on common buckwheat resulted in the development of some famous and well known varieties. The variety Bogatyr was developed in Russia from 1901 to 1909. The Japanese variety Hashigamiwase was bred in 1919 and Botan Soba was released in 1930. It is very interesting to observe that some of these original varieties are still being grown to a limited extent. This clearly demonstrates that progress on crop improvement in common buckwheat has been slow due to its' out-crossing nature and may also be due to limited variation that is present in this species. Following varieties have been released under the umbrella of All India Coordinated Research Network on Potential crops, a national programme on the improvement of underutilized species:

1. **Himpriya:** This is the first *tataricum* variety released in 1991 as a pure line selection. It gives an average grain yield of 12 q/ha and matures in 119 days. Growth habit is trailing and indeterminate with average plant height of 90 cm. This is free from leaf spot diseases and insect pests. The seed weight is around 7.0 g. The variety is suitable for early as well as normal planting.
2. **VL UGAL 7:** The variety was developed and released in 1991 by VPKAS, Almora through mass selection. This is high yielding variety of common buckwheat and most suitable for cultivation in mid-hills and valley areas. Flower colour is white and seeds are black. It is very early in maturity taking 70-80 days in spring planting and 55-60 days in normal or late planting. It gives 8-10q/ha seed yield.
3. **PRB-1:** The variety was developed and released by G.B. Pant University of Agriculture& Technology, Hill Campus, Ranichauri, Tehri Garhwal in 1997 for hilly regions of UP, HP and North Eastern states. It belongs to *esculentum* group and matures in about 100-108 days. It requires low input under timely and late sown conditions. The variety suits well to double cropping system in mid and high hill regions. It requires low inputs under timely and late sown conditions. The variety has slightly bolder seeds than Himpriya and is high yielding giving an average grain yield of 18-20 q/ha. Its growth habit is tall, erect and highly branched. Average plant height is 131 cm and has dark green foliage.
4. **Shimla B-1:** This is a *tataricum* variety released in 2005 through pure line selection for mid and high hills of Himachal Pradesh and Uttrakhand. This variety can fit well in double cropping system where buckwheat is grown after potato, cabbage, peas and hops during mid-August to mid-October. It gives 12.11 q/ha seed yield and matures in about 80 days.
5. **Sangla B-1:** The variety was released in 2005 for mid and high hills of Himachal Pradesh and Uttrakhand as pure line selection. It belongs to *tataricum* group and matures in about 106 days. It is resistant to powdery mildew and gives 13 q/ha seed yield.

Diseases and Pests

a) Diseases

- **Damping-off:** It is caused by fungus (*Rhizoctonia* spp). Symptoms include failure of seedlings to emerge, light brown, seedlings with light brown to red water-soaked roots and stems, collapse of plants, plants dry up and die. It occurs more often in cold temperatures when growth of seedlings is slow and in moist soil. Management of the damping-off is through treatment of seeds with fungicide (Bavistin @ 2 g/kg of seed) prior to sowing.
- **Powdery Mildew:** It is caused by fungus (*Erysiphe polygoni).* Light blotches on leaves; small necrotic areas on foliage near seed fill stage. Management of the disease is through crop rotation, use of healthy seed and/or treat the seeds with fungicide (Bavistin @ 2 g/kg of seed) prior to sowing.

b) Insect-Pests

- **Aphids:** Small soft bodied insects on underside of leaves and/or stems of plant; usually green or yellow in colour. If aphid infestation is heavy, it may cause leaves to yellow and/or distorted, necrotic spots appear on leaves and/or stunted shoots; aphids secrete a sticky, sugary substance called honeydew which encourages the growth of sooty mold on the plants. Distinguishing features include the presence of cornicles (tubular structures) which project backwards from the body of the aphid; generally not move very quickly when disturbed. It is managed by spray on crop with cypermethrin (0.01%) at fortnightly interval.
- **Cutworms:** Stems of seedlings may be severed at soil line; larvae causing the damage are usually active at night and hide during the day in the soil at the base of the plants or in plant debris of toppled plant. The management is by the removing all plant residues from soil after harvest or at least two weeks before planting and hand-picking larvae after dark; diatomaceous earth around the base of the plants.

Uses of buckwheat

Buckwheat has multifarious uses, tender shoots of the crop are used as leafy vegetables while the flower and green leaves are used for extraction of rutin (glucoside) used in medicines. The flower produces honey of very good quality. The seed is used in a number of culinary preparations as well as alcoholic drinks. The grain is also fed to livestock and poultry. The crop helps in soil binding and checks soil erosion during rainy seasons and is a good green manuring crop. The multipurpose use of buckwheat coupled with early maturity, low nutrient demand and ability to adapt well to marginal and degraded lands makes it an ideal candidate for future sustainable agriculture (Dutta *et al*., 2008).The crop helps in soil binding and checks soil erosion (Joshi and Paroda,1991). It is used to suppress weeds. It is also a good green manure crop and improves soil texture. Buckwheat can also increase phosphorus and micronutrient availability in the root zone.

Dried buckwheat leaves for tea were manufactured in Europe under the brand name "Fagorutin. Buckwheat is also used to make alcoholic drinks, the liquor prepared from tartary buckwheat being ascribed medicinal qualities. The flowers are rich source of quality and flavoured honey. In China, it is used in the production of vinegar. The flour blended with wheat flour is used in the preparation of pancakes, biscuits, noodles, breakfast cereals etc. (Robinson,1980).In North America, it is used primarily for making buckwheat pancakes, and is commonly marketed in the form of prepared mixes. These mixes generally contain buckwheat flour mixed with wheat, corn, rice, oat or soybean flours, and a leavening agent. Buckwheat is also used with vegetables and spices in kasha and soup mixes, and with wheat, corn, or rice in ready-to-eat breakfast products, porridge, bread, and pasta products. In Japan, buckwheat flour is used primarily for making *soba* or *sobakiri* (buckwheat noodles) and *Teuchi Soba* (hand-made buckwheat noodles).

Conclusions

Cultivation of buckwheat is in declining phase since a decade. Many factors are responsible for this decline. Change in cropping pattern is one of these as government is more focused on the introduction and promotion of cash crops, which are more remunerative than buckwheat. Growing of cash crops has improved the status of living by improving the economic condition of the farmers, which has impacted directly on the cultivation of buckwheat as there is no organized market for it (Rana *et al.,* 2010). The second major factor is low productivity of buckwheat compared to other cash crops making it less attractive for the farmers where the main cause of low productivity in buckwheat is presence of self-incompatibility caused by dimorphic heterostyly, incomplete reproductive organs mainly in the female, failure of fertilization and seed collapse in the early developmental stage of embryo (Rana *et al*.,2012). Despite its consumption and use in many parts of the world systematic research is lacking in this crop.

Keeping in view the present scenario, new strategies are required to be adopted to boost its production as well as conservation. There is need to undertake areas and character specific explorations to collect more landraces and wild species from the leftover areas. The highlands of Himachal Pradesh and Jammu & Kashmir are suggested for wild species. Breeding stretegies to improve its productivity include evaluation of germplasm for biotic and abiotic stresses such as tolerance to frost, lodging, shattering resistance, disease resistance and other desirable traits viz. short duration, synchronous maturity, easy de-hulled, bold seeded, more leafy types etc. and selection of germplasm lines having potential for their alternate uses such as more rutin content, increased groat percentage, longer flowering, soil binding properties, duration and various other medicinal and industrial uses. Diverse germplasm can be used for genetic enhancement for selected characters such as short duration, easy de-hulling, bold seeded and for tolerance to lodging and frost. Restructuring of research and development activities towards value addition by exploiting its potential as fast food, medicinal and beverage plant will help in the popularization and revived cultivation of buckwheat. Buckwheat as a kind of health food have good prevention and control to diseases such as diabetes and hypertension. Therefore, requirement of buckwheat food in society is increasing greatly. The researchers should utilize this opportunity, closely cooperate with food processing enterprises, and develop more kinds of buckwheat health foods. Incorporating present knowledge of medicinal and health benefits with targeted market research will provide the framework necessary to advance the utilization of buckwheat (Rana *et al*., 2012).

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