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Buck Wheat (*Fagopyrum esculentum*) -A Neglected Crop of High Altitude Cold Arid Regions of Ladakh: Biology and Nutritive Value

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ABSTRACT

Buckwheat (Fagopyrum esculentum) is one of the important unattended crops cultivated in the pockets of the high altitude temperate zones of Ladakh, jammu and Kashmir. Buckwheat was one of the staple foods of Ladakhi people a few years ago. A most popular food item made from buckwheat flour in Kargil is known as kiseer or giziri, which is similar to plain dosa? But now the situation of such nutritious crop is at the verge of extinction though it is of high medicinal and nutritive value. Reason behind this is unattended importance of research scientist, lack of high yielding variety that is the big reason farmers give preference to cultivate fodder crops and other food crops which gives high returns as compared to buck wheat. Nowadays, its cultivation and consumption have reduced drastically. The area under buckwheat in Ladakh has also reduced considerably. Keeping in view the nutritional quality of its grain and early maturity and suitability of the crop for marginal and degraded lands, there is a need to revive its cultivation in cold arid conditions of Ladakh (Jammu and Kashmir).

Key words: *Buck Wheat, Cold Arid, Biology, Nutritive value*

INTRODUCTION

Buckwheat (*Fagopyrum esculentum*), also known as common buckwheat, Japanese buckwheat and silverhull buckwheat[1] .is a plant cultivated for its grain-like seeds and as a cover crop. A related but bitter species, *Fagopyrum tataricum*, domesticated food plant common in Asia, but not as common in Europe or North America is also referred to as buckwheat. The total production of buck wheat around the world is shown in Table 1. Despite the name, buckwheat is not related to wheat, as it is not a grass. Instead, buckwheat is related to sorrel, knotweed and rhubarb. Because its seeds are eaten and rich in complex carbohydrates, it is referred to as a pseudocereal. The cultivation of buckwheat grain declined sharply in the 20th century with the adoption of nitrogen fertilizer that increased the productivity of other staple food crops that responded better to nitrogen application

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There are a lot of advantages and scope to grow this crop in the cold desert region at high altitudes of Jammu and Kashmir, where cereal crops like rice cannot be grown due to extreme low temperature. The prevailing agro-ecological conditions of the region are suitable for growing such an under-utilized crop. Cultural practices to grow this crop are simple and economical. To maintain the large and dense population, a higher seeding rate is necessary. Sowing time is very important to grow this crop effectively. As the availability of high yielding varieties is a serious concern, scientific improvement of the traditional lines is of utmost importance. We have started the work on scientific improvement of buckwheat for increasing its production and on farm conservation to benefit the poor and marginal farmers of the cold desert regions of Ladakh, Jammu And Kashmir at Mountain Agriculture Research and Extension Station Kargil. We are evaluating various genotypes at our research station in which we identified one genotype namely Himachal Local as best fit and high yielding with respect to other genotypes, but further evaluation is required for validation (Fig. 1)

I II III

Fig. 1: I &II Research Trial at MAR&ES Kargil, SKUAST-Kashmir, III- Variability at flowering stage

The crop is economically important primarily due to its edible protein and carbohydrate rich grains, hardiness of plants, short growth span and foliage being used as a green vegetable. Buckwheat is also used for livestock and poultry feed, buckwheat honey and as cover for wild life. Buckwheat noodles are particularly used in Japan. Buckwheat protein quality is high due to high concentration of most essential aminoacids especially lysine, tryptophan and threonine; besides buckwheat contains a high content of albumins+globulins and a low content of prolamins. However, due to a high content of crude fibre and tannin, the true digestibility is below 80%. Buckwheat foliage is one of the chief sources of rutin (quercetin 3-rutinoside). Rutin is used as a medicine in the treatment of increased capillary fragility with associated hypertension; protects against the harmful effects of X-rays; counteracts the effects of drugs such as salicylates, thiocynates and sulphadiazines which cause weakening of capillaries. Rutin can act as antioxidant of ascorbic acid that can trigger diabetes, cardiovascular diseases besides hypertension. The use of pure rutin from buckwheat is considered safe [2].

Table 1: FAO world production estimates 2017

Country	Area harvested (ha)	Production (tonnes)
Russia	712,047	700,000
People's Republic of China	136,700	167,440
Ukraine	136,700	167,440
United States	78,000	83,000

Kazakhstan	64,600	46,500
Poland	62,710	83,499
Japan	59,900	31,100
Brazil	49,000	64,000
Lithuania	37,400	35,600
France	30,100	111,300
Tanzania	21,910	22,150
Belgium	18,504	18,382
Nepal	10,510	10,335
Latvia	9,300	8,500
Bhutan	2,133	4,294
South Korea	2,095	1,934
Slovenia	1,551	1,279
Czech Republic	1,000	2,500
Estonia	800	600
Bosnia and Herzegovina	705	926
South Africa	570	240
Hungary	500	530
Croatia	310	495
Slovakia	176	67
Georgia	100	100
Moldova	50	50
Kyrgyzstan	23	22

History

The wild ancestor of common buckwheat is *Fagopyrum esculentum* ssp. *ancestrale*. *F. homotropicum* is interfertile with *F. esculentum* and the wild forms have a common distribution in Yunnan, a southwestern province of China. The wild ancestor of tartary buckwheat is *F. tataricum* ssp. *Potanini* [3]. Common buckwheat was domesticated and first cultivated in inland Southeast Asia, possibly around 6000 BC, and from there spread to Central Asia and Tibet, and then to the Middle East and Europe. Domestication most likely took place in the western Yunnan region of China[4]. Buckwheat was documented in Europe in Finland by at least 5300 BC[2] as a first sign of agriculture, and in the Balkans by *circa* 4000 BC in the Middle Neolithic. Russian-speakers call buckwheat гречка (*grechka*) meaning "of Greece", due to its introduction in the seventh century by the Byzantine Greeks; the same is the case in Ukrainian and Lithuanian.

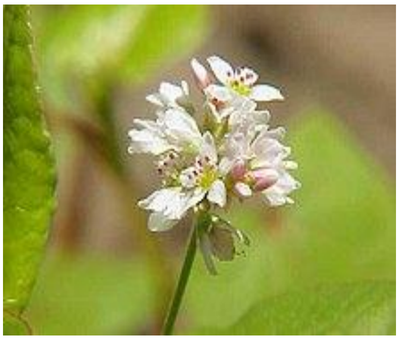
The oldest remains found in China so far date to *circa* 2600 BC, while buckwheat pollen found in Japan dates from as early as 4000 BC. It is the world's highest-elevation domesticate, being cultivated in Yunnan on the edge of the Tibetan Plateau or on the plateau itself. Buckwheat was one of the earliest crops introduced by Europeans to North America. Dispersal around the globe was complete by 2006, when a variety developed in Canada was widely planted in China. In India, buckwheat flour is known as *kuttu ka atta* and is culturally associated with Navratri festival [4].

DESCRIPTION OF THE CROP

General description

The Polygonaceae family have leaves that vary in size, arrangement and shape, but the leaf stalk is always surrounded by a membranous or chaffy sheath at the base. The flowers are often grouped in clusters that are showy owing to the colour of the sepals or bracts, for there are no petals (Fig. 2). The fruit is a triangular nut, sometimes prominently winged. The common buckwheat plant is a broadleaved, erect annual with a single main stem and a branching habit. The main stem is grooved, succulent and smooth except at the nodes. The plants generally grow to 0.6-1.3 m tall. The stem is hollow and therefore subject to breakage by high winds and hail. The plant can recover from hail damage by branching from lower leaf axils if the hail occurs at immature stage of the crop. The plants have a short taproot and fine lateral roots producing a root system that is about 3-4% of the weight of the total plant. Prior to maturity, the stems and branches vary from green to red. They become reddish brown at maturity.

Common buckwheat is an indeterminate species. The flowers of *F. esculentum* are perfect but incomplete. They have no petals, but the calyx is composed of five petal-like sepals that are usually white, pink or dark pink. The flowers are showy and densely clustered in racemes at the ends of the branches or on short pedicels that arise from the axils of the leaves. This species is dimorphic, having plants bearing one of two flower types. The pin flowers have long pistils and short stamens while the thrum flowers have short pistils and long stamens. Flowers with pistils and stamens of similar length[5,6] .and lines with only one floral type[6,7], have been reported. The pistil consists of a one-celled superior ovary and a three part style with a knob like 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 such as the one found by[6] , have short stamens and pistils and are well adapted to self-pollination[8,9]. and reported the inheritance of the flower type in common buckwheat as monogenic. A ratio of 1:1 of the flower types occurs owing to the incompatibility system. Although genetic control of the flower type, either pin or thrum, appears monogenic, the locus probably is a complex one resembling the model proposed by[10,6,6].found eight distinct classes of style length in F_2 populations derived from crosses between inbred lines of pin flowers with differing style length. He also developed self-fertile lines that bred true for reduced style length. Two sizes of pollen are associated with the heteromorphic system. Large pollen grains approximately 0.16 mm in diameter are produced by thrum flowers while pin flowers produce smaller pollen grains that are approximately 0.10 mm in diameter.


F. Esculentum **Common buck wheat flower** **Seeds**

Fig. 2: Pictorial representation of common buck wheat plant and seeds

Reproductive biology

Flowers of cross-pollinating species of buckwheat are attractive to insects because of the nectar secreted by the glands at the base of the ovary. Bees and other insects contribute to the distribution of pollen. The glands secrete nectar only in the morning and early afternoon and therefore if honey bees are introduced to increase seed set, they must be forced to work the buckwheat[11]. found that the alfalfa leafcutter bee is a satisfactory pollinator of buckwheat. In studies at the University of Pennsylvania, however, seed set was not reduced when bees and other relatively large insects were excluded by caging plots of buckwheat[12]. Microscopic examination of pistils collected in the field revealed that essentially all flowers were pollinated, even on days unfavourable for insect activity, and pollen tubes had reached the vicinity of the micropyle[13]. In a growth chamber experiment, Marshall reported that buckwheat pollen is transported by wind. Plants that were 30 cm from a wind source set 53 seeds per plant compared with 12 seeds per plant at a distance of 330 cm[6]. After cross-pollination between pin and thrum flowers, pollen tubes reach the base of the short styles in 5-15 minutes and the base of the long styles in 15-20 minutes[14]. Information on the time to fertilization is inconsistent[15]. reported that a three-celled proembryo was present 18 hours after compatible pollination. However[16], reported that fertilization required 48-60 hours after such pollination[17] .reported that under summer conditions zygotes of diploid buckwheat at 1 day after pollination had divided 1-4 times, and free endosperm nuclei were dividing around the proembryo at the micropylar pole. At 3 days after pollination, the embryo was in the globular or heart-shaped stage and the suspensor could be observed clearly at the micropylar pole. At this stage the width of the embryo was 41-142 mm. On the other hand, they reported that development of embryos in autumn was slower than in summer. The zygotes at 1 day after pollination had divided only twice. After 3 days, they developed into early globular or globular stage embryos. At this stage the width of the embryos was 25-80 mm. They also reported that no differences could be found between diploid or tetraploid embryos in the autumn, although almost all ovules of the tetraploid varieties examined were more or less abnormal in summer.

Fertility of buckwheat has been reported to be quite low[17]. reported that the rate of abnormal embryo sacs in diploid buckwheat at 1 day after pollination was 56-58% for a summer type and 73% for an autumn type buckwheat. This compared with 91-100% in the tetraploid varieties. In autumn the rate of abnormal embryo sacs at 3 days after pollination was 9-25%. The ultrastructure of the mature embryo sacs before fertilization was studied with transmission electron microscopy by[18]. Mature embryo sacs consisted of a central cell and egg apparatus that included an egg cell and two synergies. Polar distribution of the egg apparatus cytoplasm and the fusion nucleus of the central cell was observed. Enervative sterility in mature embryo sacs was observed, especially under high summer temperatures. The egg cell apparatus showed various features of degeneration, i.e. the accumulation of osmiophilic deposits in the egg cells and the synergies. These degeneration phenomena created functional alterations that did not allow normal fertilization to proceed favourably. The developmental processes of the fertilized embryo sac were compared with that of the abortive embryo sac at normal and high temperatures. Beginning with early globular embryos, the border cell walls of the suspensor began to develop some small projections. This ultrastructure image of the suspensor supports the conclusion that the function of the suspensor is to absorb symplastic and apoplastic nutrients from the surrounding tissue. In the globular embryos, border cell walls developed toward a thin layer of endosperm and formed strong outside walls with projections. The formation of these structures might mean that the embryo border expands in absorptive areas and begins to absorb nutrients at the globular stage. In contrast to the normal embryos, they found that these features were not found in the abortive embryo sacs that developed under high temperatures. These embryos developed slowly and produced large vacuoles. Around the vacuolated embryo the degenerated endosperm was present in two types: (1) the endosperm was displayed as a dark electron density and the membrane systems of the organelles were broken down and (2) as the number of ribosomes decreased drastically, the endosperm became less dense, the organelles were dispersed or gathered around the nuclei. The endosperm is an important source of nutrients for the developing embryo and has been classically assigned the function of nourishing the embryo. The degeneration of the endosperm resulted in a less inherent function of the nutrient source and possibly directly affected the developing embryo.

Nutritional attributes

Carbohydrates

Starch is the major component of the buckwheat seed. In whole grain of common buckwheat, the starch content varies from 59 to

70% of the dry matter, but the concentration can vary with the method of extraction and between cultivars. The chemical composition of the starch from buckwheat grains differs from the composition of cereal starches. The amylose content in buckwheat granules varies from 15 to 52% and its degree of polymerization varies from 12 to 45 glucose units[19]. Buckwheat starch granules are irregular in shape with noticeable flat areas due to compact packing in the endosperm. They vary from 4 to 11 nm in size. Buckwheat grains also contain 0.65-0.76% reducing sugars, 0.79-1.16% oligosaccharides and 0.1-0.2% non-starchy polysaccharides. Among the low molecular weight sugars the major component is sucrose. There is a small amount of arabinose, xylose, glucose and probably the disaccharide melibiose.

Proteins

The protein content in common buckwheat varies from 7 to 21%, depending on the cultivar and environmental factors during growth. Most commonly grown cultivars yield seeds with 11-15% protein on a whole seed basis. The major protein fractions are globulins which represent almost one-half of all the proteins and consist of 12 to 13 subunits with molecular weights between 17,000 and 57,000. Other known buckwheat protein fractions include albumins and prolamins. Older reports of gluten or glutelin being present in buckwheat seed have recently been discredited[19]. The albumin fraction, with a molecular weight of 7000-8000, consists of at least 12 proteins. Prolamin has been fractionated into at least two peaks by gel filtration and into three major and several minor components. Buckwheat proteins are particularly rich in lysine (Table 2). They contain less glutamic acid and proline and more arginine, aspartic acid and tryptophan than do the cereal proteins. Owing to the high lysine content, buckwheat proteins have a higher biological value than the cereal proteins, such as those of wheat, barley, rye and corn. About 56% of glutamic and aspartic acids were found in the form of amides[20]. Digestibility of buckwheat protein, however, is rather low and this is probably due to the high fibre content (17.8%) in buckwheat, which may be desirable in some parts of the world. Buckwheat fibre is free of phytic acid and is partially soluble. The mineral and vitamin contents of buckwheat are given in Table 2.

Lipids

Seeds of common buckwheat contain 1.5-3.7% total lipids. The highest concentration is in the embryo at 7-14% and the lowest is in the hull at 0.4-0.9%. Groats or dehulled seeds of Mancan, Tokyo and Manor buckwheat contain 2.1-2.6% total lipids, of which 81-85% are neutral lipids, 8-11% are phospholipids and 3-55% are glycolipids. The major fatty acids of common buckwheat are palmitic, oleic, linoleic, stearic, linolenic, arachide, behenic and lignoceric. Of these, the 16 and 18-carbon acids are commonly found in all cereals. The long-chain acids-arachidic, behenic and lignoceric which represent approximately 8% of the total acids in buckwheat, are only minor components or are not present in cereals (Table 3).

Phenolic compounds

The phenolic content of common buckwheat is 0.74% in the hulls and 0.79% in the groat. However, that of Tartary buckwheat is 1.87% in the hull and 1.525% in the groat. The three major classes of phenolics are flavonoids, phenolic acids and condensed tannins. Flavonoids are compounds that possess the same C-15 (C6-C3-C6) basic skeleton.

Table 2: Nutritional profile of buck wheat per 100 g

Parameter	Quantity	Parameter	Quantity
Energy	1,435 kJ (343 kcal)	Calcium	(2%) 18 mg
Carbohydrates	71.5 g	Iron	(17%) 2.2 mg
Dietary fiber	10 g	Magnesium	(65%) 231 mg

Fat	3.4 g	Manganese	(62%) 1.3 mg
Saturated	0.741 g	Phosphorus	(50%) 347 mg
Monounsaturated	1.04 g	Potassium	(10%) 460 mg
Polyunsaturated omega-3 omega-6	1.039 g 0.078 g 0.961 g	Sodium	(0%) 1 mg
Protein	13.25 g	Zinc	(25%) 2.4 mg
Thiamine (B1)	(9%) 0.101 mg	Other Constituents	
Riboflavin (B2)	(35%) 0.425 mg	Copper	1.1 mg
Niacin (B3)	(47%) 7.02 mg	Selenium	8.3 µg
Pantothenic acid (B5)	(25%) 1.233 mg		
Vitamin B6	(16%) 0.21 mg		
Folate (B9)	(8%) 30 µg		
Vitamin C	(0%) 0 mg		

Table 3: Essential amino acid composition of buck wheat in comparison to other cereals (as percentage of protein)

Food grain	Lysine	Methionine	Tryptophan	Leucine
Buck wheat	5.9	3.7	1.4	5.8
Amaranth	5.0	4.4	1.4	4.7
Wheat	2.6	3.5	1.2	6.3
Rice	3.8	3.0	1.0	8.2
Maize	1.9	3.2	0.6	13.0
Fao/Who Recommedation	5.5	3.5	1.0	7.0

Three of the numerous classes of flavonoids are found in buckwheat: flavonols, anthocyanins and C-glucosyl-flavones. Rutin (quercetin-3-rutinoside), a well-known flavonol diglucoside used as a drug for treatment of vascular disorders, occurs in the leaves, stems, flowers and fruit of buckwheat. Other reported flavonols are quercitin (quercetin 3-rhamnoside) and hyperin (quercetin 3-galactoside). At least three red pigments have been found in the hypocotyls of buckwheat seedlings. One of these is cyanidin, the other two are presumed to be glycosides of cyanidin.

The C-glycosylflavones present in buckwheat seedling cotyledons are vitexin, isovitexin, orientin and isoorientin. The phenolic acids of buckwheat seed are the hydro benzoic acids, synigic, *p*-hydroxy-benzoic, vanillic and *p*-coumaric acids. Soluble oligomeric condensed tannins are present in common buckwheat seeds, which, along with the phenolic acids, provide astrigency and affect colour and nutritive value of buckwheat products. The effects of phenolic compounds on the nutritive value of buckwheat products have been reported by[21].

Rutin

There is an increased need to identify and utilize value-added components of buckwheat. This will have the effect of increasing farmer's income and thus increased emphasis on the production of this crop. Rutin was discovered in 1842. Since that time it has been found in at least 34 plant families and 77 plant species. The use of rutin as a medicinal agent for the treatment of vascular disorders characterized by abnormally fragile or permeable capillaries has stimulated interest in this compound. Treatment by rutin results in a decreased incidence of vascular complications such as retinal haemorrhage, apoplexy and coronary occlusion[22]. Rutin has been identified in *Fagopyrum esculentum, F. tataricum* and *F. cymosum.* It occurs in concentrations of 3-6% of the dry weight, with *F. tataricum* having the highest concentrations. Although Tartary buckwheat was utilized in the 1940s for the extraction of rutin, it was supplanted by other sources. But now, there is a trend back to natural sources and a higher concentration of rutin would make the processing of buckwheat economically feasible. The occurrences and concentrations are not known for the other species of buckwheat that have now been identified. As some of these species are now being crossed with common buckwheat and the remainder may be utilized as sources of specific traits, this information could be of high practical value [23] evaluated the varietal differences and heritability of rutin content in the seed and leaf in common buckwheat. Twenty-seven cultivars or strains were evaluated and a wide variation in the rutin content was found. The seed rutin content of tetraploid cultivars from Japan at 20.0-22.1 mg/100g dry weight was higher than that of diploid ones at 14.5-18.9 mg/100g dry weight. Although, there was no significant difference between the ploidy levels for leaf rutin content, the varietal differences were significant for rutin content in the seed and the leaf. Highly significant differences in the rutin content of seed were recognized among geographical areas. Some lines from Nepal had a higher rutin content in both the seed and leaves, with the seed content being significant. The differences within areas for leaf rutin content were significant for Japanese diploid lines. The heritability of the rutin content in the seed and the leaf was estimated at 0.59 and 0.25, respectively. The results showed that the rutin content in the seed was one of the traits with a relatively high heritability among the main characters in common buckwheat, and that the rutin content in the leaf was a trait comparatively affected by environmental conditions. As[23], stated, although a few attempts have been made so far to analyze the varietal differences in rutin content in seeds of common buckwheat, no studies have ever dealt with materials from a wide range of areas in the world. [24, who determined the rutin content in seeds of strains collected from various areas of Japan did not observe any differences among the strains[25]. reported that the varietal differences in rutin content in seeds were significant in 12 strains and varieties mainly from Japan. In the study conducted by[23], it was shown that there was a wide variation in the rutin content among strains evaluated. Some of the Nepalese material was considered to be a useful breeding material for high rutin content owing to the considerable variation that was found. The estimated heritability for seed rutin content found was higher than that for 1000-seed weight. Although the rutin content in leaf tissue of common buckwheat has been studied for some time, little is known of varietal differences[27]. suggested that no significant differences in rutin percentage could be detected in 17 strains tested for a 3-year period. Differences between years, however, were highly significant. It is possible that leaf rutin content could fluctuate because of environmental conditions. A study conducted by[28], Suzuki *et al.* [27], indicated that the content of rutin fluctuates with light intensity. The grain, however, contains one or more dyes which, as a result of fluorescence are photodynamically active. They can produce an irritating skin disorder, on white or light-coloured areas of skin or hide, under conditions of heavy consumption of buckwheat and exposure to sunlight[29].

Uses of buck wheat

Buckwheat grain is grown mainly for human consumption and as animal feed, although it can also be used as a vegetable, a green manure crop, as a smother crop and as a source of buck wheat honey.

Human consumption

Common buckwheat is consumed in different preparations in different countries. In Japan, it is mainly consumed as a noodle *soba.* In Europe and North America, buckwheat flour is generally mixed with wheat flour to prepare pancakes, biscuits, noodles, cereals, and is used as a meat extender. In Russia and Poland, the groats and flour are used to make porridge and soup. In Sweden, it is used to stuff fish. In Southeast Asia, buckwheat is a staple food in many hilly areas. Here the flour is used to make unleavened bread *chapattis.* It is also mixed with water and fried to produce a crisp *pakora.* The flour also can be mixed with potatoes to make *parathas.* It is also used for fasts and for religious celebrations. Buckwheat is used to make alcoholic drinks; the liquor prepared from Tartary buckwheat has been ascribed with medicinal qualities. In China, it has been reported that buckwheat is used for the production of vinegar.

Vegetable crop

Buckwheat is often raised as a leafy vegetable crop in many areas of the Indian subcontinent. The leafy tender shoots of the plants are harvested and dishes prepared from them. This often augments the supply of fresh vegetables that are available at this time of year. The crop is generally dual purpose as the remainder of the crop is harvested for grain and straw.

Honey crop

Common buckwheat has been used as a source of nectar for honey production in many countries. Buckwheat fills a special need for the beekeepers because honey production comes late in the season when other nectar sources are scarce. Pure buckwheat honey is relatively dark-coloured and has a strong flavour that is relished by some people but is disliked by others. According to[30], Morse[29], buckwheat was once a major source of nectar for beekeepers in New York State of the USA and the supply did not meet the demand. However, in many areas buckwheat production has declined and buckwheat honey is so uncommon that it demands a premium price. The nectar flow in buckwheat is most favourable under adequate moisture conditions. Under these conditions, a hectare could support up to 2.5 hives and produce up to 175 kg of honey in a season. It is not uncommon for a strong colony to glean 5 kg/day while foraging for buckwheat[31,20]. Although buckwheat is a dependable and high-yielding honey plant, it normally yields nectar only during the morning and bees are unable to complete a full day of nectar collection. As honey bees prefer to work the same crop plant all day, they become agitated and hard to work with. They therefore prefer to work other plants and need to be forced to work the buckwheat plants for maximum honey production.

Green manure and soil conditioner

Buckwheat is useful as a green manure crop for renovation of low-productivity land because it grows well on such land and produces a green manure crop in a short time [20,20]. As many as 7 t/ha of dry matter have been obtained at an age of 6-8 weeks under conditions in Pennsylvania, USA. When ploughed under, the plant material decays rapidly making nitrogen and mineral constituents available for the succeeding crop. The resulting humus improves the physical condition and moisture-holding capacity of the soil. When a crop is harvested early in a year, a second crop of buckwheat often can be grown and ploughed down as green manure.

Smother crop

Buckwheat has been used as a smother crop, owing to the lack of good herbicides for broad-leaved weed control. Buckwheat is generally a very good competitor as it germinates rapidly and the dense canopy that it produces soon shades the soil. Often growers will increase the seeding rate in areas where they expect more weed competition so that the canopy is developed more quickly. This rapidly smothers out most weeds, especially broadleaved ones. If the weed growth gets above the buckwheat canopy, buckwheat becomes a poor competitor. Buckwheat has been cited as being a useful crop for the control of many weeds including quack grass, Canada thistle, sowthistle, creeping jenny, leafy spurge, Russian knapweed and perennial pepper grass[32,30].

Feed and cover for wildlife

Sportsmen have long known that buckwheat is useful as a food and cover crop for wildlife. Deer eat buckwheat and will begin foraging as soon as a few seeds have developed. The grain is also eaten by wild turkeys, pheasant, grouse, waterfowl and other birds. The crop is generally planted and not harvested so that the standing plants provide both food and cover for wildlife.

Ethnobotanical anecdotal information

Few ethnobotanical reports exist for common buckwheat. It is popular in Japan as a healthy food because of its rutin content. This is reported to aid in increasing the elasticity of the blood vessels and therefore prevent hardening of the arteries. Tartary buckwheat, on the other hand, is reported to be used as a medicinal plant. According to[33], Hu *et al.*[31], the leaf of Tartary buckwheat is a drug used in traditional Chinese medicine. They state that according to the *Chinese Materia Medicine Dictionary*, the therapeutic function of the leaf and stem includes treating choking, ulcer, haemostasis and for bathing wounds. They also reported that the book *Classified Materia Medica for Emergency* mentions that the leaf can be used as food and may improve the functions of sight and hearing, and keep adverse energy down. The plant is also used to treat hypertension, which is believed to be related to the fact that in rural areas, where the incidence is lower, the leaf of Tartary buckwheat is used as a food. In Nepal, the consumption of Tartary buckwheat is reported to aid in stomach disorders. In some areas *jang*, a local beer made from Tartary buckwheat, demands a higher price because of its medicinal effects. Clinical observations carried out on 75 diabetic patients treated with Tartary buckwheat biscuits showed a decrease in the blood sugar level[34,32]. Other reports from China indicate that Tartary buckwheat shows a hypoglycaemic effect. Tartary buckwheat noodles are used as a treatment for diabetes. Tartary buckwheat has been reported to treat peridontitis and gum bleeding. Patients who brushed their teeth and gargled every morning and evening with Tartary buckwheat flour showed a 62% recovery[35,33]. This effect was believed to be due to Tartary buckwheat containing many microelements, vitamins, and being especially rich in quercetin and rutin. They report that these special compositions have the effects of maintaining resistance of blood capillaries, decreasing its fragility and permeability, protecting and recovering its elasticity and diminishing inflammation.

Future Directions

- ✓ Preference must be given on collecting wild and weedy species. This will not only allow these to be utilized in the breeding programmes now and in the future but will allow a clearer understanding of the site of origin and the differentiation that has taken place between buckwheat species. This should also allow for a more systematic approach to be taken in collecting individual characteristics in species that are closely related to the two economically important species presently being cultivated.
- ✓ Cultivars that have been produced over the past several decades appear not to be stored according to any coordinated method. Although many of these are probably in working collections or in long-term storage, their status should be determined.
- ✓ An electronic database should be developed that will allow for faster updates and faster dissemination of the data that is available in the present germplasm storages.
- ✓ Germplasm storage sites should be developed or appointed that have the mandate for storing buckwheat and its closely related species. These must be developed a means of having, for the

collections now in place and those of the future, standardized evaluations on many of the characteristics that the breeders or those utilizing the germplasm deem to be the most important. As funds decrease for breeding programmes, this will become increasingly more important from a global viewpoint. It will also make the entire system more efficient as it will reduce duplication of effort between breeding programmes. This should also allow for faster dissemination of the data obtained.

- ✓ Collaboration must be encouraged and supported between the collection sites and the breeders utilizing these sites.
- ✓ A more coordinated effort should be made in the area of crop improvement through the utilization of stored germplasm.

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