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REVIEW ARTICLE

ORIGIN, DOMESTICATION, TAXONOMY, BOTANICAL DESCRIPTION, GENETICS AND CYTOGENETICS, GENETIC DIVERSITY AND BREEDING OF BUCKWHEAT (*Fagopyrum esculentum* Moench)

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ABSTRACT

Buckwheat belongs to the Family *Polygonaceae*, Genus *Fagopyrum* and Species *Fagopyrum esculentum* (Moench). Buckwheat is the common name for plants in two genera of the dicot family Polygonaceae: The Eurasian genus, *Fagopyrum*, and the North American genus, *Eriogonum*. In particular, the name is associated with the common buckwheat (*Fagopyrum esculentum* or *F. sagittatum*), which is an important crop plant. Tartary buckwheat *(F. tataricum)* or "bitter buckwheat" also is used as a crop, but it is much less common. Despite the common name and the grain-like use of the crop, buckwheats are not grasses (and are therefore considered pseudocereals) and are not related to wheat nor other monocots. Locally buckwheat is known by various names, *viz*., *dyat*, *dro*, *bro*, *fafar*, in different regions of Ladakh. In other languages *viz.*, English: Buckwheat, common buckwheat, Japanese buckwheat; Assamese: Doron, Phapar; Garo: phapar; Hindi: Kotu, Kuktu, Phaphra; Kannada: Kaadu godhi; Malayalam: Kadu godhi; Manipuri: Wakha Yendem; Nepali: Phapar. In NE region, buckwheat is locally called by different names such as Paphar (meetha Paphar: *F. esculentum* and teeta Paphar: *F. tataricum*) and Khuster in Sikkim; Jheem, Kyap, Brasma, Chikaw, Bherem, Jamu, Dunchung and Grunching in Arunachal Pradesh; Phapar and Demsi in Assam. Buckwheat (*Fagopyrum* spp.) is grown as a subsistencecrop in the mountainous areas of Asia. The tartary buckwheat (*F. tataricum*), because of its frost tolerance, is generally grown at the higher altitudes whereas common buckwheat (*F. esculentum*) is grown at the lower altitudes. The crop is a pseudocereal. The seeds (strictly achenes) are usually classified among the cerealgrains because of their similar uses. An important crop of marginal lands, buckwheat, is grown in nearly every country that cultivates grain crops and is usually consumed locally, but it is especially important in colder regions of high altitude or high latitude in Asia. The distribution of *Fagopyrum* spp. has been reported from the states of Sikkim, Meghalaya, Arunachal Pradesh, Assam, Manipur and Nagaland in the Northeastern Region. The crop seeds (strictly achenes) are usually classified as pseudo-cereal and are cultivated at different altitudes in Arunachal Pradesh. The Monpas and Sherdukpen tribes of the Tawang district of Arunachal Pradesh use the grain as a staple food since rice cannot be grown at this altitude due to physiological problems. The grain is generally used as human food, animal/poultry feed, cover crop, with the dehulled groats being cooked as porridge and the flour used in the preparation of pancakes, chapattis, biscuits, noodles. Buckwheat noodles are a typical delicacy in Japan and are even served on Japanese international airlines. Although buckwheat is a dependable and high-yielding honey plant, it normally produces nectar only during the morning and bees are unable to complete a full day of nectar collection. This crop is a good source of honey production because the buckwheat flower produces a good quality of honey. In some areas *jang*, a local beer made from Tartary buckwheat, demands a higher price because of its medicinal effects. This crop helps in soil binding and checks soil erosion during the rainy season. It is considered a sustainable crop for supporting the livelihoods of millions of hill populace under changing climatic conditions in future. Inthe higher Himalayan region of India (4500 amsl), this isthe only crop grown and occupies about 90% of cultivated land as a pure crop. It has the potential to produce reasonably good yield under rainfed condition of Himalayan eco-system when soil moisture is not able to support any kindof crop cultivation. Common buckwheat is gaining more popularity in the Himalayan region due to its palatable taste and shorter growing period as compared to tartary buckwheat. Buckwheat has the potential for fixing atmosphere nitrogen and solubilizing native soil phosphorus and potassium. It thrives well under poor soil fertility conditions. In this review article on Origin, Domestication, Taxonomy, Botanical Description, Genetics and Cytogenetics, Genetic Diversity, Breeding, Uses, Nutritional Value and Health Benefits of Buckwheat are discussed.

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INTRODUCTION

Scientific name of buckwheat comes from the Latin *fagus* (beech) and the Greek *pyrus* (wheat), resulting from the resemblance of the achene to a beech-nut and from the fact that it is used like wheat. The word *esculentum* is of Latin origin and means edible (Dictionary of Botanical Epithets). Similarly, the English word "buckwheat" refers to beech-nut and wheat, being of Dutch origin (Online Etymology Dictionary) (Gondola and Peter, 2010). The name "buckwheat" or "beech wheat" comes from its tetrahedral seeds, which resemble the much larger seeds of the beech nut from the beech tree, and the fact that it is used like wheat. The word may be a translation of Middle Dutch *boecweite*: *boec* "beech" and *weite* "wheat" or maybe a native formation on the same model as the Dutch word (Wikipedia, 2023). Its scientific name comes from the Latin and Greek, "fago" (meaning beech) and "pyrum" (meaning nut); "*esculentum*" means "edible." Indeed, its nutty seeds are edible (in small doses; care should be taken not to eat too many!). Clusters of pinkish-white, five-parted flowers bloom at the tips of the stems in June to September (Go Botany. 2023). Synonyms in various European languages are: French wheat; saracen corn; beechwheat (English); blé noir; sarrasin (French); buchweizen; heidekorn (German); poganka (Polish); pohán-ka; hajdina; tatárka (Hungarian); grano saraceno (Italian); ajda (Slovenian); boekweit (Dutch); viljatatar (Finnish); grechikha posevnaia (Russian); grano turco, trigo sarraceno (Spanish); navadna ajda (Croatian); bokhvete, bokkveite (Norwegian) (Gondola and Peter, 2010). Buckwheat belongs to the Family *Polygonaceae*, Genus *Fagopyrum* and Species *Fagopyrum esculentum* (Moench) (Gondola and Papp, 2010). Buckwheat is a temperate zone plant used for human nutrition since prehistoric times. It is a fast-growing annual plant with a variety of potential uses. The floury grain of buckwheat is used in a way similar to the grains of cereals, despite that botanically buckwheat is not a member of the family *Gramineae* or *Poaceae* ("Grass" family). Buckwheat is a dicotyledonous broadleaved plant, belonging to the family *Polygonaceae*, the "smartweed" family, also called "knotweed" family or "buckwheat" family. For this reason the seed of buckwheat is rather a fruit than a grain (the botanical term is "achene"). It is often referred to as a *pseudocereal* (Gondola and Peter, 2010). Although the genus *Fagopyrum* comprises several species, only two of them are of notable economic importance, these are the common (also named sweet) buckwheat (*F. esculentum* Moench) and tartary (also named bitter) buckwheat (*F. tataricum* Gaertn.), both with numerous varieties and landraces in commercial production. Globally, common buckwheat is far more important than tartary buckwheat, estimated on the smaller number of countries where this latter species is grown (mainly in the mountainous regions of China, Bhutan, Nepal and Northern India). Buckwheat has been extensively grown in the northern hemisphere, from Eastern Europe through Japan, as a low input subsistence or cash crop. It is also grown in the Americas. It performs best in temperate or subtropical climate if the rainfall is reliable during the growing season. It may be grown successfully at higher elevations in the tropics. Buckwheat is adapted to poor lands. It does well on soils where most of the important cereals fail. At present the crop is hardly affected by diseases and pests, which, together with the short growing period and the low requirements for management, offers a great potential for both organic and conventional buckwheat production (Gondola and Peter, 2010). Buckwheat refers to several genera of the family *Polygonaceae*: the genus *Eriogonum* is native to North America, and is not closely related to the Eurasian genus *Fagopyrum.* The agricultural weed "wild buckwheat" syn. "climbing buckwheat" (*Polygonum convolvulus* L. syn. *Fallopia convolvulus* L.) is also in the samefamily, but belongs to genus *Fallopia* (Gondola and Peter, 2010).

Today common buckwheat is called *ogal* in India, *mite phapar* in Nepal, *jare* in Bhutan, *grecicha kul'furnaja* in Russia and *tatarka gryka* or *poganka* in Poland. In French it is called *sarrasin, blé noir, renouée, bouquette;* in Italy *fagopiro, grano saraceno, sarasin, faggina* and in Germany *Buchweizen* or *Heidekorn.* It is referred to as *soba* in Japan where the same word also refers to buckwheat noodles. In Mandarin common buckwheat is called *tian qiao mai* while Tartary buckwheat is referred to as*ku qiao mai* (Campbell, 1997). Buckwheat (*Fagopyrum* spp.) is grown as a subsistencecrop in the mountainous areas of Asia. The tartary buckwheat (*F. tataricum*), because of its frost tolerance, is generally grown at the higher altitudes whereas common buckwheat (*F. esculentum*) is grown at the lower altitudes. The crop is a pseudocereal. The seeds (strictly achenes) are usually classified among the cerealgrains because of their similar uses (Campbell, 1997). Tartary buckwheat is called *phapar* in India, *tite phapar* in Nepal and *bjo* in BhutanIt is interesting to note that in both China and Nepal, common buckwheat is referredto as sweet buckwheat while Tartary buckwheat is called bitter buckwheat. This probably relates to the taste of the flour as Tartary buckwheat leaves a very bitter taste after being eaten (Campbell, 1997). Common buckwheat *(Fagopyrum esculentum* Moench) has been a crop of secondary importance in many countries and yet it has persisted through centuries of civilization and enters into the agriculture of nearly every country where cereals arecultivated. The main producers are China, Russian Federation, Ukraine and Kazakhstan. The species *F. tataricum* - or Tartary buckwheat - is also produced in many areas of the world but generally is consumed or traded locally. The crop is not a cereal, but the seeds (strictly achenes) are usually classified among the cereal grains because of their similar usage. The grain is generally used as human food and as animal or poultry feed, with the dehulled groats being cookedas porridge and the flour used in the preparation of pancakes, biscuits, noodles, cereals (Campbell, 1997). The protein of buckwheat is of excellent quality and is high in the essential amino acid lysine, unlike common cereals. This, coupled with the plant's ability to do well on poorer soils, probably accounts for its widespread usage. It is also a multipurpose crop. The small leaves and shoots are used as leafy vegetables, the flowers and green leaves are used for rutin extraction for use in medicine. The crop produces honey of a very good quality. Buckwheat is grown throughout a large area of Asia and Southeast Asia as a crop that fits the farming system on marginal and fairly unproductive land. It is used asa subsistence crop in many of the more mountainous areas where it is often grown with barley at the higher altitudes (Campbell, 1997). Genetic diversity of plant genetic resources (PGR) for food and agriculture is a unique and irreplaceableresource for further crop genetic improvement and for increasing crop diversity and cultivars in agriculture. They are a reservoir of genetic adaptability, which act as a buffer against potentiallyharmful environmental and economic changes. Erosion of these resources poses a severe threat to world foodsecurity in the long term. Although often undervalued, there is an urgent need to conserve and utilize PGR asa safeguard against an unpredictable future (Œpková *et al*., 2009). Although originally from China, at present buckwheat is widely cultivated as a minor crop in many countries aroundthe world. Common buckwheat grain has attracted increased attention because of its protein content and high nutritional value, which is the results of a favourable amino acid composition as well as starch with special properties that differ from other cereals. In addition, the seed also contains high levels of vitamins, fibre, minerals, and flavonoids, which have positive effects on some chronic diseases, such as diabetes, hypertension, hypercholesterolemia, and cardiovascular disorders (Œpková *et al*., 2009). In NE region, buckwheat is locally called by different names such as Paphar (meetha Paphar: *F. esculentum* and teeta Paphar: *F. tataricum*) and Khuster in Sikkim; Jheem, Kyap, Brasma, Chikaw, Bherem, Jamu, Dunchung and Grunching in ArunachalPradesh; Phapar and Demsi in Assam (Misra *et al*., 2019).

Buckwheat grains are primarily used for human consumption and also for livestock, poultry and piggery feeds. Rural population of hilly region of India use buckwheat sprouts and as pan cakes especially in breakfast, however, the recommended intake of buckwheat sprouts are less than 40 g/day. Further- more, buckwheat is also grown as a cover crop, green manure crop, fodder crop, fertility restoring crop, honey crop and medicinal plant. The crop is also a good source of rutin (quercetin-3-rutinosid) and fagopyrin that are known to be used in preventing various human disorders (Babu *et al*., 2018).

Among the pseudo and minor-cereals, buckwheat has the potential to meet the ever increasing food demand of rapidly expanding population in hill areas of the country inthe changing climatic scenario. Buckwheat is one of the best suited crops for higher altitudes, where crop growingseason is very short. It thrives well in different croppingpattern due to its short duration nature (3-4 months) and better adaptability in low temperature and moisture stress conditions (Luitel *et al.,* 2017). It is considered a sustainable crop for supporting the livelihoods of millions of hill populace under changing climatic conditions in future. Inthe higher Himalayan region of India (4500 amsl), this isthe only crop grown and occupies about 90% of cultivated land as a pure crop (Singh *et al.,* 2014). Similarly, it has the potential to produce reasonably good yield under rainfed condition of Himalayan eco-system when soil moisture is not able to support any kindof crop cultivation. Cultivated buckwheat *(Fagopyrum* spp. 2n=16) is a dicot pseudo-cereal belongs to the family,Polygonaceae, which is distinct from the monocot cereals(Family; Poaceae). The grain of buckwheat is botanically achene; structurally the endosperm resembles cereals as it has a non-starchy aleurone layer and a starchy endosperm. Out of the 20 species of genus *Fagopyrum,* only two *F. esculentum* (Common buckwheat) and *F. tataricum* (Tartary buck- wheat) are cultivated in India (Chauhan *et al.,* 2010). Tartary buckwheat is also called "India wheat" and "Duck wheat". However, among these two species, common buckwheat is grown at lower altitudes, whereas tartary buckwheat is grown at higher altitudes (Babu *et al.,* 2016).

Common buckwheat is gaining more popularity in the Himalayan region due to its palatable taste and shortergrowing period as compared to tartary buckwheat. Buckwheat has the potential for fixing atmosphere nitrogen (Alekseyeva, 2002) and solubilizing native soil phospho rus and potassium (Kontturi *et al.,* 2004). It thrives well under poor soil fertility conditions. It is a multiuse crop mainly cultivated to obtain grains for human consumption, livestock, piggery and poultry feeds, as green manures, soil binding crop and as a smother crop. Further-more, it attracts beneficial insects like pollinators and natural enemies for suppressing pests especially whitefliesand aphids, hence, can be grown in strips as an insectary crop (Babu *et al*., 2018). Its tender leaves are utilized as a leafy vegetable and for making chutneys. It is also a high-yielding honey plant; normally produces nectar only during the morning hours. In certain parts of India popped grains are eaten and the leaves consumed as vegetable (Gohil, 1984). Buck- wheat flowers, leaves and seeds are good source of rutin and quercetin, which have protective effect against diabetes, anti-inflammatory activity and alsoused as medical agents for treating the cardiovascular disorders. Tartary buckwheat isricher in rutin and quercetin content as compared to com-mon buckwheat. Seeds of tartary buckwheat are also less huskythan the common buckwheat. The seed is also used in a number of culinary preparations as well as alcoholic drinks (Babu *et al*., 2018). Buckwheat flour is known as a *Kuttu ka Atta* in northern part of India and mainly eaten during religious *Upvas* (fast) when cereals and pulses are not permitted toeat (Rana *et al*., 2011). The protein content (11-14%) in buckwheat seed is of high quality due to its balanced amino acid composition and rich in lysine (5.5-6%) and arginine (9.2 – 10%), which are generally deficit in cereals (Unala *et al.,* 2017).

Buckwheat is a temperate zone plant used for human nutrition since prehistoric times. It is a fast-growing annual plant with a variety of potential uses. The floury grain of buckwheat is used in a way similar to the grains of cereals, despite that botanically buckwheat is not a member of the family Gramineae or Poaceae ("Grass" family). Buckwheatis a dicotyledonous broadleaved plant, belonging to the family Polygonaceae, the "smartweed" family, also called "knotweed" family or "buckwheat" family. For this reason the seed of buckwheat is rather a fruit than a grain (the botanical term is "achene"). It is often referred to as a pseudocereal. Although the genus *Fagopyrum* comprises several species, only two of them are of notable economic importance, these are the common (also named sweet) buckwheat (*F. esculentum* Moench) and tartary (also named bitter) buckwheat (*F. tataricum* Gaertn.), both with numerous varieties and landraces in commercial production. Globally, commonbuckwheat is far more important than tartary buckwheat, estimated on the smaller number of countries where this latter species is grown (mainly in the mountainous regions of China, Bhutan, Nepal and Northern India) (Gondola and Papp, 2010). Buckwheat has been extensively grown in the northern hemisphere, from Eastern Europe through Japan, as a low input subsistence or cash crop. It is also grown in the Americas. It performs best in temperate or subtropical climate if the rainfall is reliable during the growing season. It may be grown successfully at higher elevations in the tropics. Buckwheat is adapted to poor lands. It does well on soils where most of the important cereals fail. At present the crop is hardly affected by diseases and pests, which, together with the short growing period and the low requirements for management, offers a great potential for both organic and conventional buckwheat production. *Fagopyrum* is a genus of about 15 species, most of them indigenous to eastern Asia. The species are of different ploidy levels, and represent two types of breeding system, self-compatibility and self-incompatibility, with the economically most important species, *F. esculentum* being self-incompatible. Domesticated species are mainly cultivated in temperate and subtropical areas (Gondola and Papp, 2010).

Buckwheat is believed to be cultivated first in the Himalayan region of Asia from where spread to other part of the world. Buckwheat provides food security to traditional, resource poor farmers during1900s. Buckwheat research started seriously from 1980 when International Buckwheat Research Association (IBRA) was formed. IBRA has been publishing a separate journal fagopyrumthe, chief buckwheat producing countries are Soviet Republic, Japan, Canada, USA, China, Poland, Brazil, Hungary, Korea, India, iran, Afghanistan, Nepal, Pakistan, Germany, Switzerland, Italy, France, UK Austria, and Australia. In india buckwheat production is confined to moist and temperate part of Himalayas Jammu & Kashmir, Himachal pardesh, Sikkim, Hilly region of UP, Assam and some part of Tamil Nadu and Kerala. Both common and tartary buckwheat are cultivated as a summer crops in Turtuk valley during last week of July to first week of October. Howeverin Turtuk valley Buckwheat has become endangered species due to lack of labours, urbanization and modernization. (Hayder, 2021). Crossing of diploid and tetraploid is one of the ways for achievement of polyploid individuals. Some sterile individuals of common buckwheat could be obtained through this alternative approach. There are published reports of hexaploid buckwheat (*F. tibeticum*, 2n=6x=48) from the interspecific cross between diploid *Fagopyrum* esculentum and tetraploid *Fagopyrum homotropicum*, but there are no reports on the availability of autotetraploids of *Fagopyrum esculentum*. Present work thusholds significance of polyploidization in cultivable specieof buckwheat. However, majority of species are diploids with 16 chromosomes which are natural and hybrid but spontaneous polyploidy is rare, at best. Thus, artificial induction of tetraploid line is a demanding method (Srivastava and Kumar, 2022). Buckwheat (*Fagopyrum esculentum*), or common buckwheat, is a flowering plant in the knotweed family Polygonaceae cultivated for its grain-like seeds and as a cover crop.

The name "buckwheat" is used for several other species, such as *Fagopyrum tataricum*, a domesticated food plant raised in Asia (Wikipedia, 2023). Despite its name, buckwheat is not closely related to wheat. It is not a cereal, nor is it even a member of the grass family. Buckwheat is related to sorrel, knotweed, and rhubarb, and is known as a pseudocereal because its seeds' culinary use is the same as cereals, owing to their high starch content (Wikipedia, 2023). *Fagopyrum esculentum* Moench (Buckwheat) locally known as 'Trumba' is a native of Central Asia and cultivated in China and other Eastern countries as a bread-corn. Generally it is a plant of hilly temperate regions and cultivated on marginal land under rain-fed conditions where very limited crops grow (Kamili,. 2023). In this review article on Origin, Domestication, Taxonomy, Botanical Description, Genetics and Cytogenetics, Genetic Diversity, Breeding, Uses, Nutritional Value and Health Benefits of Buckwheat are discussed.

ORIGIN AND DISTRIBUTION

Cultivation of buckwheat was step by step spreading from the place of origin to other parts of the world: to SouthEast Asia, India, Minor Asia in the 8th century, to Siberia and Russia in the 13th century, to Europe in the 15th century,to the Americas in the 17th century, and later to Africa. An important part of the spread might haveoccurred via transmission on the silk-road.

Despite that common buckwheat has been cultivated since ancient times in several Asian countries includingChina, Korea and Japan, the place of origin and the process of expansion of cultivation remained obscure for long. Buckwheat was thought for a long time to have its origin in northern China or the area of the river Amur. In the late 19th century and in the first half of the 20th century, the discovery of a large number of wild relatives of common buckwheat by several investigators in southern China suggested that the theory of De Candolle on buckwheat's origin in northern China or the area of the river Amur was false. All the written evidence we now have (geographical distribution of *Fagopyrum* species, allozyme variability between southern China and the Himalayan region) suggest that both common and tartary buckwheat were born in southern China, and diffused westward along the southern slopes of the Himalayas together with two wild species also born in southern China (Gondola1 and Peter, 2010). The centres of origin can also be defined as the region where domestication of the particular plant first took place and where the wild ancestor and the derived cultivated species co-exist. Archaeological data and written historical records indicate that buckwheat was extensively cultivated and used as a staple food by ancient Chinese as early as the 5th-3rd centuries BC and thereafter, thus ancient Chinese were the earliest nation to discover and utilize buckwheat. Not only was buckwheat cultivated, but it was highly appreciated as a crop that contributed to overcome famine and disaster. The health protecting abilities of foods made of buckwheat were first recognized and documented around 600 CE (Gondola1 and Peter, 2010). It is a diploid species with an indeterminate growth habit. Flowers are hermaphroditic, heteromorphic and self-incompatible. The floury grain is used as a cereal. Cultivation goes back to the distant past. According to archaeological data and written historical records, ancient civilizations in China and Japan used buckwheat as a staple food (Gondola and Peter, 2010).

Buckwheat was one of the domesticated crop in Asia and Was used as a food crop in China 5000 – 6000 years ago (Meyes and Meinke, 1994). Buckwheat grown as aminor crop in Turtuk valley, is cultivated as a summer crop in some part of Ladakhand Baltistan (now in Pakistan). There are different types of Buckwheat available in Turtuk *i.e.*, common buckwheat called (Geyass) in local language and Tartary buck wheat (brow) and wild buckwheat (Khebrow) or weed. First two varieties of buckwheat are mostly grown in the farmers field through theTurtuk valley (Hayder, 2021). Plant is native to the Chinese regeion of Manchuria**.** In ancient times it was widely cultivated throughout China and later itb was introduced in Russia and Europe by the Tartars and Turkish inclusions in the late Middle Ages. Buckwheat arrived in England the 17th century, although it was the Duch who exported this plant to the U.S. in the same century (Anon., 2023). Genetic resources distribution of buckwheat inthe world mainly concurs with central Asia especially in the south-western China . Therefore, China is considered as center of origin of buckwheat. Common buckwheat was domesticated and first cultivated in inland South-east Asia, possibly around 6000 BC, and later spreads to Central Asia, Tibet, Middle East and Europe. The common buckwheat (*Fagopyrum esculentum*) is passionately grown in all the continents of the globe; however the Tartary buckwheat (*Fagopyrum tataricum*) is mainly confined in the hilly and mountain region of China and the Himalayas. Globally buckwheat is cultivated in 2.4 M ha areas with average production and productivity of 2.4 million tonnes and 1000 kg/ha, respectively. Among the buckwheat growing countries in world,Russia stood first both in buckwheat area (1.12 M ha) andproduction (1.19 Million tonnes) followed by china and Ukraine. With regards to the productivity, France has thehighest buckwheat productivity (3735 kg/ha) in the world(FAO STAT, 2018). Fig. 1 is showing the top ten buckwheat producing countries in the world (Babu *et al*., 2018).

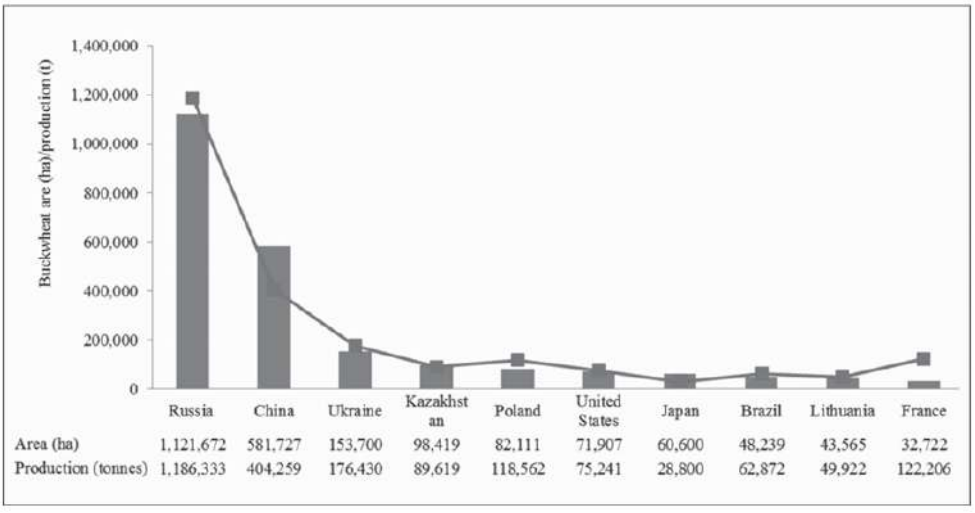


Fig. 1. Top ten buckwheat producing country in the world (2016)

Buckwheat is distributed throughout the Indian Himalayan region, but western Himalayan region has more diversity. The occurrence of buckwheat ranged from Jammu Kashmir in north to Arunachal Pradesh in east and Tamil Nadu in the south. However, Jammu Kashmir, Himachal Pradesh, Uttarakhand, West Bengal (Kalimpong, Coochbehar, NewJalpaiguri and Darjeeling region), Sikkim, Assam (Upper Assam), Arunachal Pradesh, Nagaland, Meghalaya (Higher elevation region), Manipur, Kerala Tamil Nadu (Nilgiris and Palani hills) and Chhattisgarh are the major buckwheat growing areas in India (Fig. 2). Among the twocommonly cultivated species of buckwheat, Tartary buck-wheat cultivation is more common at higher altitudes (>2500 m) however, common buckwheat cultivation con-fined at lower altitudes extended up to 1000 m. Generally,buckwheat is acclimatized to monoculture production. Inthe high altitude areas of Arunachal Pradesh, Jammu andKashmir, Himachal Pradesh and Sikkim, only one crop isproduced in a year, while two and three crops of buckwheat in a year is grown in the mid and foot hills, respectively(Babu *et al*., 2018). *Fagopyrum esculentum* is native to south-central China and Tibet, and has been introduced into suitable climates across Eurasia, Africa and the Americas. The wild ancestor of common buckwheat is *F. 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*. Common buckwheat was domesticated and first cultivated in inland Southeast Asia, possibly around 6000 BCE, and from there spread to Central Asia and Tibet, and then to the Middle East and Europe, which it reached by the 15th

century. Domestication most likely took place in the western Yunnan region of China. The oldest remains found in China so far date to *circa* 2600 BCE, while buckwheat pollen found in Japan dates from as early as 4000 BCE. 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 has long been culturally associated with many festivals ike Shivratri, Navaratri and Janmashtami. On the day of these festivals, food items made only from buckwheat are consumed (Wikipedia, 2023).

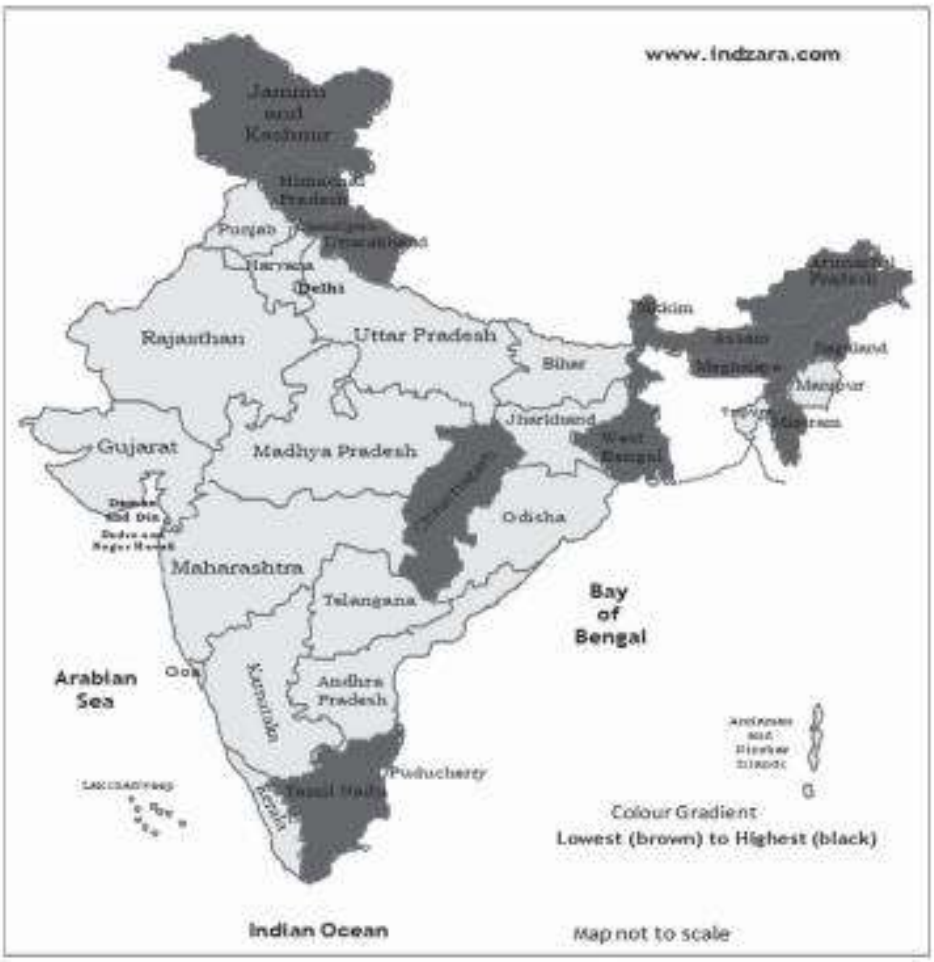


Fig. 2. Dark colour denotes major buckwheat producing states of India

TAXONOMY

Scientific name of buckwheat comes from the Latin *fagus* (beech) and the Greek *pyrus* (wheat), resulting from the resemblance of the achene to a beech-nut and from the fact that it is used like wheat. The word *esculentum* is of Latin origin and means edible (Dictionary of Botanical Epithets). Similarly, the English word “buckwheat” refers to beech-nut and wheat, being of Dutch origin (Online Etymology Dictionary) (Gondola and Peter, 2010). The name "buckwheat" or "beech wheat" comes from its tetrahedral seeds, which resemble the much larger seeds of the beech nut from the beech tree, and the fact that it is used like wheat. The word may be a translation of Middle Dutch *boecweite*: *boec* "beech" and *weite* "wheat" or maybe a native formation on the same model as the Dutch word (Wikipedia, 2023). Its scientific name comes from the Latin and Greek, "fago" (meaning beech) and "pyrum" (meaning nut); "*esculentum*" means "edible." Indeed, its nutty seeds are edible (in small doses; care should be taken not to eat too many!). Clusters of pinkish-white, five-parted flowers bloom at the tips of the stems in June to September (Go Botany. 2023). Synonyms in various European languages are: French wheat; saracen corn; beechwheat (English); blé noir; sarrasin (French); buchweizen; heidekorn (German); poganka (Polish); pohán-ka; hajdina; tatárka (Hungarian); grano saraceno (Italian); ajda (Slovenian); boekweit (Dutch); viljatatar (Finnish); grechikha posevnaia (Russian); grano turco, trigo sarraceno (Spanish); navadna ajda (Croatian); bokhvete, bokkveite (Norwegian) (Gondola and Peter, 2010). Buckwheat belongs to the Family *Polygonaceae*, Genus *Fagopyrum* and Species *Fagopyrum esculentum* (Moench) (Gondola and Papp, 2010).

Buckwheat is a temperate zone plant used for human nutrition since prehistoric times. It is a fast-growing annual plant with a variety of potential uses. The floury grain of buckwheat is used in a way similar to the grains of cereals, despite that botanically buckwheat is not a member of the family *Gramineae* or *Poaceae* (“Grass” family). Buckwheat is a dicotyledonous broadleaved plant, belonging to the family *Polygonaceae*, the “smartweed” family, also called “knotweed” family or “buckwheat” family. For this reason the seed of buckwheat is rather a fruit than a grain (the botanical term is “achene”). It is often referred to as a *pseudocereal* (Gondola and Peter, 2010). Although the genus *Fagopyrum* comprises several species, only two of them are of notable economic importance, these are the common (also named sweet) buckwheat (*F. esculentum* Moench) and tartary (also named bitter) buckwheat (*F. tataricum* Gaertn.), both with numerous varieties and landraces in commercial production. Globally, commonbuckwheat is far more important than tartary buckwheat, estimated on the smaller number of countries where this latter species is grown (mainly in the mountainous regions of China, Bhutan, Nepal and Northern India). Buckwheat has been extensively grown in the northern hemisphere, from Eastern Europe through Japan, as a low input subsistence or cash crop. It is also grown in the Americas. It performs best in temperate or subtropical climate if the rainfall is reliable during the growing season. It may be grown successfully at higher

elevations in the tropics. Buckwheat is adapted to poor lands. It does well on soils where most of the important cereals fail. At present the crop is hardly affected by diseases and pests, which, together with the short growing period and the low requirements for management, offers a great potential for both organic and conventional buckwheat production (Gondola and Peter, 2010). Buckwheat refers to several genera of the family *Polygonaceae*: the genus *Eriogonum* is native to North America, and is not closely related to the Eurasian genus *Fagopyrum.* The agricultural weed "wild buckwheat" syn. "climbing buckwheat" (*Polygonum convolvulus* L. syn. *Fallopia convolvulus* L.) is also in the same family, but belongs to genus *Fallopia* (Gondola and Peter, 2010).

Classification of the genus: A case study on Yunnan, South West China in 2001 listed nine wild species of *Fagopyrum* as endemic to this province, each species given a vernacular name: golden *Fagopyrum* (*F. cymosum*), rock *Fagopyrum* (*F. gilesii*), thin cauli wild *Fagopyrum* (*F. gracilipes*), toothalar wild *Fagopyrum* (*F. gracilipes* var. *odontopterum*), small wild *Fagopyrum* (*F. leptopodum*), sparse stachys small *Fagopyrum* (*F. leptopodum* var. *grossii*), linear leaf wild *Fagopyrum* (*F. lineare*), bolting *Fagopyrum*(*F. statice*) and hard twig ten thousand-year *Fagopyrum* (*F. urophyllum*) (Gondola1 and Peter, 2010). The family *Polygonaceae* comprises about 50 genera and more than 1100 species of herbs (commonly), shrubs and small trees. Numerically the most important genera are *Eriogonum* (250 species), *Polygonum* (200 species), *Rumex* (200 species), *Coccoloba* (120 species) and *Calligonum* (80 species). Some well- known members include *Rumex* (sorrel), *Rheum* (rhubarb), *Polygonum* (knotgrass) and *Fagopyrum* (buckwheat), with sorrel and buckwheat as crops of economical importance. Many common and noxious weeds are found within this family. The family is present worldwide, with a few speciesin the tropics and the greatest biodiversity in the northern temperate regions. "The family is named for the many swollen node joints that some species have; poly means many and goni means knee or joint" (Gondola and Peter, 2010). Buckwheat belongs to the family Polygonaceae. This plant group is generally referred to as the buckwheat, rhubarb or sorrel family. There has been a great deal of interest generated over the past 10 years regarding the classificationof *Fagopyrum* species. Much of this has occurred as a result of Ohnishi's work in the finding of six new species in China and his work on their classification. Ye and Guo (1992) suggested a key to the classification of 15 species that occur in the temperate areas of Euro-Asia, with approximately 10 species occurring in China. However, the key to classification of the genus *Fagopyrum* by Ohnishi (1995) is more complete and is given in Table 1 (Campbell, 1997).

Table 1. Key for the detemination of Fagopyrum species

1	thick plaited cotyledons lie in the centre of the achene	*(Fagopyrum)*	2
2	cotyledons horizontally long, large lusterless achene is partially covered with persistent perianths		3
2*	cotyledons laterally long or round, small lusterless grains are completely covered with persistent perianths		4
3	cotyledons in endosperm are colourless, blade veins are transparent		5
3*	cotyledons in endosperm are yellowish, blade veins are transparent		6
5	heterostylous and cross-pollinating species	*F. esculentum*	
5*	homostylous, self-fertilizing species	*F. homotropicum*	
6	surface of achene is smooth	*F. cymosum*	
6*	surface of achene is rough, with a canal in the centre	*F. tataricum*	
4	five perianths are equal in size, the lower two lack a green stripe		7
4*	perianths consist of two smaller and three larger: the lower small perianths have greenish stripes		8
7	perennial with well-developed roots	*F. statice*	
7*	annual with a poor root system		9
8	ochrea is green and not transparent	*F. urophyllum*	
8*	ochrea is transparent with greenish stripes		10
9	achene are relatively large and plants are vigorous	*F. u$_e$*	
9*	achene are very small and plants are small and slim		11
10	ochrea is not pubescent, main blade vein number is 5		12
10*	ochrea is pubescent, main blade vein number is 7		13
11	blades are ovate or cordate	*F. leptopodum*	
11*	blades are linear	*F. lineare*	
12	plants are erect	*F. callianthum*	
12*	many branches are creeping on the ground	*F. u$_l$*	
13	ochrea is not heavily pubescent, stem is not pubescent, it has many creeping branches	*F. pleioramosum*	
13*	ochrea are heavily pubescent, stems also pubescent		14
14	ochrea and stems heavily pubescent, blades are cordate or sagittate, inflorescences are drooping	*F. gracilipes*	
14*	pubescence in ochrea and stems is not as heavy as *(F. grac.)*, blade cordate or ovate, branches are erect	*F. capillatum*	

Fagopyrum is a genus of about 15 species, most of them indigenous to temperate eastern Asia. Common buckwheat (*Fagopyrum esculentum* Moench), the most important species in the genus, has been extensively grown in the northern hemisphere, from Eastern Europe through Japan and in the Americas, as a low-input subsistence or cash crop (Gondola and Peter, 2010).

Yunnan province possesses 11 species of the genus, nearly three- quarters of the total of 15 species known in the early 1990's. These are (Gondola1 and Peter, 2010):

- Sweet (common) buckwheat (*F. esculentum* Moench1794)
- Bitter buckwheat (*F. tataricum* Linn. ((Gaertner)) 1791)
- *F. cymosum* (Trev) Meisn. 1832

- *F. gilesii* (Hemsley) Hedberg 1946
- *F. gracilipes* (Hemsley) Dammer ex Diels (1918)
- *F. leptopodum* (Diels) Hedberg (1944)
- *F. grossii* (Levl) H. Gross 1913 (Variant)
- *F. odontopterum* Gross 1913 (Variant)
- *F. lineare* (Samuelss) Haraldson 1978
- *F. statice* (Levl) H. Gross 1913
- *F. urophyllum* (Bur. et Franch) H. Gross 1913.

Synonyms (Go Botany. 2023).

- *Fagopyrum fagopyrum* (L.) Karst.
- *Fagopyrum sagittatum* Gilib.
- *Fagopyrum vulgare* Hill
- *Polygonum fagopyrum* L.

Synonyms of *Fagopyrum esculentum* Moench, (Hammer, 1986)

Methodus (1794) 290. - *Polygonum fagopyrum* L., Sp. Pl. (1753) 522;
Fagopyrum vulgare Hill, Brit. Herb. (1756) 486, nom. illeg.;
Polygonum tataricum Lour., Fl. cochinch. (1790) 242, non L.;
F. sagittatum Gilib., Exerc. phyt. 2 (1792) 435, nom. illeg.;
Polygonum cereale Salisb., Prodr. (1796) 259;
Fagopyrum sarracenicum Dumort., Fl. Belg. Prodr. (1827) 18;
F. cereale (Salisb.) Raf., Fl. Tellur. 3 (1836) 10;
Kunokale carneum Raf., l.c., 12;
Phegopyrum esculentum (Moench) Peterm., Fl. Bienitz (1841) 92;
Fagopyrum fagopyrum Karst., Deutschl. Fl. (1883) 522;
Helxine fagopyrum Kuntze, Revis. 2 (1891) 553.

Fagopyrum sagittatum Gilib. also has been designated a distinct species based largely on a sagittate leaf shape (Govil and Rathar 1981). Buckwheat has been divided into subspecific taxa as *F. esculentum* var. *himalianum* and *F. esculentum* var. *emarginatum* (see Fig. 1). However, they are generally regarded/treated as being
conspecific with *F. esculentum.* (Hammer, 1986)

Fagopyrum tataricum (L.) Gaertn., Fruct. Sem. pl. 2 (1791) 182, t. 119, f.6. (Hammer, 1986)
Polygonum tataricum L., Sp. Pl. (1753) 364;
Fagopyrum subdentatum Gilib., Exerc. phyt. 2 (1792) *436;*
F. dentatum Moench, Methodus (1794) *290;*
F. triangulare Meissn. in Wall., Pl. As. Rar. 3 (1832) 63, p. p. (quoad descr. fruct.);
F. rotundatum Babingt. in Trans. Linn. Soc.18 (1841) 117;
F. tataricum var. *vulgare* Alef., Landw. Fl. (1866) 287;
F. tataricum var. *rotundatum* (Babingt.) Alef., 1. c., 287;
Phegopyrum tataricum (L.) Peterm., ET. Bienitz (1841) *92;*
Helxine tatarica (L.) Kuntze, Revis. 2 (1891) 553;
Fagopyrum tataricum var.edentulum Waisbecker in Mag. Bot. Lap. 7 (1908) 54;
F. tataricum subsp. *Tubercualtum* Krotov in Kul't. Flora SSSR 3 (1975) 32, subsp. *rotundatum* (Babingt.) Krotov, 1. c., 32, subsp. *himalaicum* Krotov, l.c., 33.

Description of Species: At present it is thought that there are about 15 species and numerous subspecies, ecotypes comprised in the genus *Fagopyrum*, which implies a great genetic diversity. According to the description in Flora of North America they are mostly annual, taprooted herbs with erect or ascending stems, glabrous or puberulous. The leaves are deciduous, cauline, alternate, petiolate (proximal leaves) or sessile (distal leaves). The ocrea is persistent or deciduous, chartaceous, with the petiole base articulated. The blade is cordate, triangular, hastate, or sagittate, with the margins entire to sinuate. Pedicels present. Inflorescences are axillary, or terminal and axillary, raceme- or panicle-like, pedunculate. Flowers are bisexual or, rarely, bisexual and staminate on the same plant, 2-6 per ocreate fascile, heterostylous or homostylous, base stipe-like. The perianth is nonaccrescent, white, pale pink, or green, broadly campanulate, glabrous; The tepals are 5, distinct, petaloid, dimorphic, with the outer ones smaller than the inner ones. Stamens are 8, with distinct, free and glabrous filaments. The anthers are white, pink, or red, oval to elliptic. The 3 styles are reflexed, dis- tinct, with the stigmas capitate. The achenes are strongly exserted, brown to dark brown or gray, sometimes mottled black, unwinged or essentially so, bluntly to sharply 3- gonous, glabrous. Seeds: embryo folded, $x = 8$ (Gondola and Peter, 2010).

BATONICAL DSECRIPTION

Description of *Fagopyrum esculentum* Moench: This is an annual herb, up to 1 m tall, branched, glabrous (Fig. 3). Leaves are petiolate, blades are ovate-triangular to triangular, 2-8 cm long, with acuminate tips, bases are cordate or approximately hastate; upper leaves are smaller, sessile. Inflorescences are terminal and auxiliary, branch in dense corymbose or paniculate cyme. Flowers are white or pink, 6 mm in diameter; pedicel is 2-3 mm long, articulate; perianths are 3 mm long; 8 nectaries are yellow, alternating with stamens; being heterostyly, capitate stigma. Achene is triquetrous, acute angle, longer than 5 mm, more than twice the length of the persistent perianths, brown or black-brown, lucid. This species is common buckwheat and is widely cultivated over the northern and to some extent the southern hemisphere. There are many cultivars or landraces in this species. Their achene forms can vary greatly, some of them being winged on the angles (Campbell, 1997).

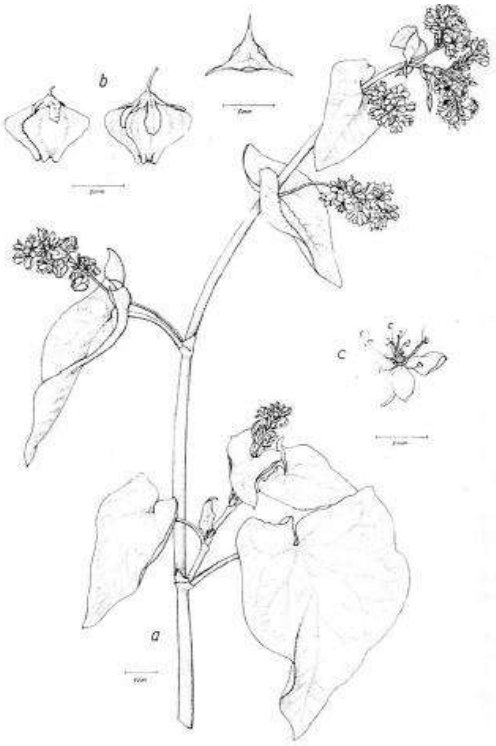


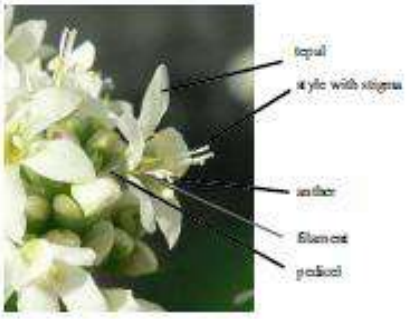
Fig. 3. *Fagopyrum esculentum* Moench var. *emarginatum* (Roth) Alef. Flowering branch, b) Fruits, c) Flower

Dscription of *Fagopyrum tataricum* (L.) Gaertn: This is an annual herb, up to 1 m tall, branched or unbranched with stem, which is striate, always having papillate on branchlet. Leaves are petiolate, most blades are triangular, width equals length, 2-8 cm, bases are cordate or hastate. Inflorescences are dense spicate or corymbose. Flowers are yellow-green, 2.5 mm in diameter, pedicels are nonparticulate; perianths are 2 mm long; 8 nectaries are yellow, alternating with stamens being homostyly, stigmas are capitate. Triquetrous achene is about 5 mm long, exserting more than twice the length of the persistent perianths, with three deep grooves and the angles are rounded, except at the tip. This species is now cultivated in the high-altitude mountainous areas of Asia and to a much lesser extent elsewhere. It has many cultivars or landraces. Its achene forms and sizes differ greatly, some of them are winged or spinous on the angles and some with hulls that split between the angles on maturity. The plants of *F. tataricum* are usually less husky in growth than those of *F. esculentum.* They are more branched and the leaves are more arrow-shaped. The flowers are smaller, have inconspicuous greenish-white sepals and do not appear to be attractive to insects. The flowers are homomorphic, self-fertile and are cleistogamous, with pollination occurring before the flower opens (Campbell, 1997).

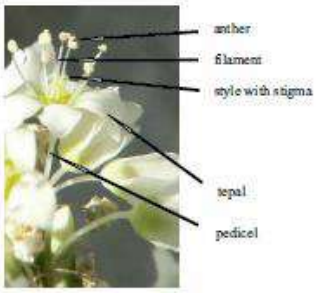
Common buckwheat (*Fagopyrum esculentum* Moench) is a heterostylous diploid species with an indeterminate growth habit (Fig. 4, 5, 6). It is an annual broadleaved plant, with a smooth, succulent stalk, a knotted single main stem that develops lateral branches (1). Generally, in a field population the plants only develop primary branches. The main stem is grooved, generally green, but sometimes tinged with red. Plant height varies from 30 to as much as 120 cm or more. The stems are more or less round and hollow, with a diameter of 3 to 15 mm. At the time of maturity the stems and branches turn red. The plants have a short taproot, penetrating to a depth of 30 to 50 cm in the soil, with fine lateral roots spreading to a width of 25 to 30 cm. Root architectural characteristics give buckwheat a relatively shallow rooting habit. The leaves are petiolate, positioned alternately on the opposite sides of the stem, heart shaped, ovate-triangular to triangular, 4 to 8 cm long. The blades are glabrous (hairless). The flowers grow terminal, densely clustered in racemes, light fresh in colour, and perfumed (2). The sepals are usually white, pink or dark pink. Flowers are hermaphroditic and heteromorphic, *i.e.* two types of flowers are produced on separate plants. In buckwheat, heteromorphism is manifested in stylar length and therefore the term heterostyly is preferred to heteromor- phism. Common buckwheat, a distylous species, is com- posed of two types of plants. The pin flower has long styles with short stamens, whereas the thrum flower is of the opposite arrangement. The floral structure for the pin type is shown in 3 and for the thrum type is shown in 4. Heteromorphic incompatibility renders both self-pollination and intramorph (illegitimate) cross-pollination infertile. Fertilization can only take place between pin and thrum types of flowers. This complex of floral mechanism is governed by a single locus which also regulates the incompatibility relation. The inability of selfing is explained with pollen incompatibility between the two types rather than with the heterostylic architexture of the flowers. Two sizes of pollen are associated with the heteromorphic system in common buckwheat. 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. Pollen tube in intramorphic pollination in heterostylous *Fagopyrum* species was inhibited at the stigma or style, and was shorter than that in intermorphic pollination within the same species. Heterostyly has sporadically evolved in various phylogenic taxa. It can be hypothesized that the genus *Fagopyrum* is entirely heterostylous. The non-heterostylous species (*F. tataricum* and *F. gracilipes*) might have arisen from the heterostylous species by the loss of heterostyly and simultaneous development of self-fertilizing mechanisms … Due to heterostyly and open pollination by insects, seedset is generally low in common buckwheat. Buckwheat flower is very attractive to bees that use the nectar to produce a specially flavoured, dark honey. The nut (so-called 'seed') has a dark brown, tough rind, enclosing the kernel or seed, and is three-sided in form, with sharp angles (5). The single gene complex that controls self-incompatibility and flower morphology segregates as a simple Mendelian factor, with two allelic states, *S* and *s*, which control the thrum (*Ss*) and the pin (*ss*) forms. The pattern of segregation is shown in Fig. 7. (Campbell, 1997; Gondola and Peter, 2010).

1 A stand of buckwheat

2 Flowers of common buckwheat



3 Structure of pin type flower of common buckwheat



4 Structure of thrum type flower of common buckwheat

5 Ripening fruits of common buckwheat

Fig.4. Description of Common Buckwheat

X		gametes of the thrum parent	
		S	*s*
gametes of the pin parent	*s*	*Ss*	*ss*
	s	*Ss*	*ss*

genotypes and relative frequencies of the progeny

Fig. 5. Mendelian segregation of the single gene complex that controls self-incompatibility and heterostylous flower morphology in common buckwheat (*Fagopyrum esculentum* Moench)

Young Plants

Plants in Flowering

Plants in Flowering

Plants in Flowering

Plants in Flowering

Plants in Flowering

		
Flower Bunch	**Honey Bees Pollinating**	**Plants with Flowers and Seeds**
		
Matured Seeds	**Matured Seeds**	**Harvsting the Crop**
		
Bundles of Crop	**Bundle being Carried**	**Mannual Harvesting**
		
Sun Drying	**Sun Drying**	**Threshing**

Fig. 6. Batonical Description of Buckwheat

Go Botany (2023) gives the following description:

Flower petal color- pink to red white

Leaf type- the leaves are simple (i.e., lobed or unlobed but not separated into leaflets)
Leaf arrangement-alternate: there is one leaf per node along the stem
Leaf blade edges- the edge of the leaf blade is entire (has no teeth or lobes)
Flower symmetry- there are two or more ways to evenly divide the flower (the flower is radially symmetrical)
Number of sepals, petals or tepals- there are five petals, sepals, or tepals in the flower
Fusion of sepals and petals- both the petals and sepals are separate and not fused
Stamen number -8

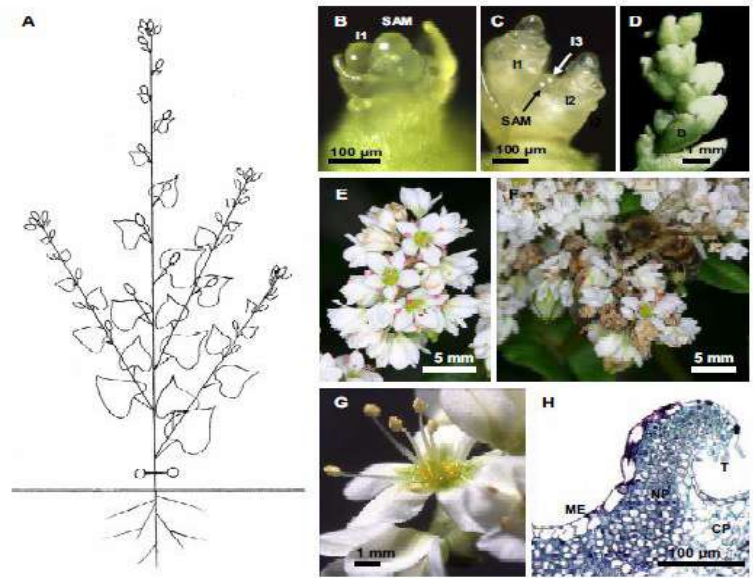
Fruit type (general)- the fruit is dry but does not split open when ripe
Fruit length- 4–6 mm

Buckwheat is a herbaceous annual flowering plant growing to about 60 cm, with red stems and pink and white flowers resembling those of knotweeds. The leaves are arrow-shaped and the fruits are achenes about 5–7 mm with 3 prominent sharp angles. The buckwheat plant has a branching root system with a primary taproot that reaches deeply into moist soil. It grows 75 to 125 centimetres tall. Buckwheat has tetrahedral seeds and produces a flower that is usually white, although can also be pink or yellow. Buckwheat branches freely, as opposed to tillering or producing suckers, enabling more complete adaption to its environment than other cereal crops. Buckwheat has a growing period of only 10–12 weeks and it can be grown in high latitude or northern areas. Buckwheat is sometimes used as a green manure, as a plant for erosion control or as wildlife cover and feed (Wikipedia, 2023).

Buckwheat is a summer annual with rather coarse, branched stems and large, broadly arrow-shaped leaves. Flower panicles and leaves rise from the nodes, both on the main stem and branches. The inflorescence consists of large racemes with more or less densely clustered flowers. The plant begins to bloom 4-6 weeks after seeding. The flowers are dimorphic and therefore naturally cross-pollinated. Fruit is dark-brown with a pale brown triangular testa. The endosperm is white opaque and starchy as compared to cereal grain endosperms. Seeds are pointed, broad at the

base, and triangular to nearly round in cross section. They vary in size in different kinds from about 4 mm at maximum width and 6 mm. long to 2 mm. wide and 4 mm. long. The seed consists of an outer layer or hull, an inner layer, the seed coat proper, and within this a starchy endosperm and the germ (Kamili,. 2023). Buckwheat is a grain plant belonging to the botanical family of grasses (Family Polygonaceae). It is considered a pseudocereal. It is a robust herbaceous plant, with annual growth that can measure 20- 70 cm. It roots from a taproot from which small secondary roots grow. The stem is erect, gnarled and green, but sometimes present in red colors. The leaves grow alternatively and are characteristically large and sagitate (heart shaped). The upper leaves are perfoliate (born in the stem and around it, clasping); lower ones have a petiole that joins the stem. Each stem terminates in an inflorescence in small clusters or clusters of flowers. Flowers are monoeceous and are pollinated by bees. These flowers are white or pink. They are pentameric flowers; each flower has a corolla and calyx formed around 5 petals and 5 sepals. The fruit is a dry fruit Achene with 3 edges that is used for human consumption. This grain is covered by a blackish brown cuticle that is not edible and that forces the grain to be peeled to be eaten or for marketing (Anon., 2023).

Pollination/Reproductive biology: Figure 7 gives the description of 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 seedset they must be forced to work the buckwheat (Campbell, 1997). Flowering starts 4 to 6 weeks after sowing and goes on during 4 to 15 weeks. Flowers are usually in anthesis only one day. The first anthesis occurs on the lowest inflorescence appearing on the 3rd to 5th node above the cotyledons of the main stem and the flowering progresses acropetally (from the base towards the top) along this axis (A). Under this inflorescence, the flowering of axillaries progresses basipetally (from the top towards the base) along the main stem whereas along the axillaries flowering progresses acropetally (A). At the inflorescence scale, flowering starts with the anthesis of the first flower formed in the first cyme. Flowering continues from the base towards the top of the inflorescence (E), and within the cymes few days after anthesis of the first flower, another flower enters in anthesis. A peak of flowering which corresponds to anthesis of the maximum number of flowers per day occurs about 2 to 3 weeks after the first anthesis, and at this time plant growth stops. After pollination, about 10 days are required before the embryo reaches its maximal size and two more weeks are needed for grain maturity. The zygote divides more actively in summer than in autumn, and three days after pollination its size is 1.7 times larger under autumn conditions. The fruit (the seed) is a triangular achene that measures about 5 mm long. Under the pericarp, the endosperm is covered by a fine testa and the embryo is situated at the centre of the endosperm. Pericarp which is green during seed filling becomes brown then grey when the seed is mature (F). Due to the profusion of flowers (tens in anthesis per plant and per day), the long flowering period and consequently the long ripening period (seeds at all stages of ripening coexist within plants and inflorescences; (F), choice of appropriate harvesting time is difficult. Moreover, there is no abscission layer but the pedicels are delicate and wind may cause scattering of grains on the soil. During flowering, temperature influences yields through impacts on development and fertility of the reproductive structures. Due to its frost sensitivity, buckwheat culture is restricted to low altitudes in temperate areas and harvest must be done before early frosts. The optimal temperature for its growing is between 18 and 23°C. The flowering is inhibited below 15°C (delayed initiation and reduction of flower number) and flowers wither early at 10°C. High temperatures (_ 25°C) and dry winds cause flower withering, abortion of reproductive structures in development, malformations of embryo sac and fruit desiccation. During flowering and seed maturation, limiting water supply and flooding are damaging to endosperm development. They may cause embryo abortion and lighter mature seeds. In order to stay viable, pollen needs humidity. Viability is lost in 1h when pollen is placed at 23°C in dry atmosphere (Cawoy *et al.*, 2009).



A. Drawing of plant
B. Front microscopic view of shoot (aged 12 days)
C. Front microscopic view of shoot (aged 17 days)
D. Compound raceme before flowering
E. Inflorescence when the flowering has reached last cyme
F. Honey bees drinking the nector
G. Thrum flowers in anthesis
H. Longitudinal section of a nectory.

Fig. 7. Morphology of buckwheat reproductive structures

Pollination efficiency depends on the insect abundance and on the insect ability to collect, transport and deposit pollen on a compatible stigma. Honeybee foraging activity (time spent per inflorescence and plant) is not affected by day period, although fewer flowers are visited per trip after mid-day, whereas syrphid foraging activity decreases in the course of the day. Honeybees are more active during warm and sunny days as well as during the flowering peak. A single honeybee visits an average of 14-20 flowers min-1, and works on buckwheat for 4-5 h d-1. This insect appears to be the most effective pollinator of buckwheat because it collects both types of pollen (pin and thrum) on a same trip and its foraging and prospecting behaviour, collecting nectar and pollen, promotes frequent contacts with stigmas (**F).** Nevertheless, when more attractive flowers are available (as *Phacelia tanacetifolia*, *Raphanus sativus* and *Sinapis alba*) honeybees neglect Buckwheat. Some syrphids (*Eristalis* spp.) and

perhaps other *Diptera* species could act as co-pollinators due to their high relative frequency and activity during the entire flowering period. Under experimental cages, the efficiency of honeybee pollination (introduced colony) is good since this insect deposits compatible pollen on most flowers (>90%) without discrimination between floral morphs. On the other hand, honeybee spends more time on thrum (higher producer of nectar) than on pin flowers, particularly in the morning, visiting more thrum inflorescences and more thrum flowers per inflorescence. Despite its better pollinator attraction, thrum flower stigmas capture fewer pollen grains than those of pin flowers. Nevertheless, thrum flowers receive three times more compatible pollen grains than pin flowers. Along the day, pollen deposition on stigmas and pollen tube growth increase. The saturating pollen load for fruit initiation occurs at about 10 pollen grains per flower allowing a high fruit set (80-90%). Seed weight and progeny vigor increase if pollen number is higher than 10 grains due to gametophytic competition. A single insect visit delivers only an average of 5 pollen grains. Two or more honeybee visits are therefore required for an optimal fruit set, similar to hand cross pollination. However, the most flowers mainly pollinated by honeybees in the Belgian fields present less than 10 pollen grains at the end of their life (one single day). Moreover, more than one hour usually separated two successive insect visits. This delay limits gametophytic competition as pollen tube growth is very fast: only 5-10 min are necessary to reach the ovules in thrum styles and 15-20 min in pin styles. These facts could be seemed as a pollen limitation transfer, but although seed set is low (about 15%) under field conditions in Belgium, it does not increase after hand cross-pollination, suggesting an absence of pollen limitation. These results show that factors other than pollination events are leading fertility in buckwheat. Nevertheless, in order to avoid insufficient pollination, the availability of pollinators, such as honeybees which are the main pollinators of buckwheat in Western Europe, should be considered before choosing field location or to add hives **(**Cawoy *et al*., 2009**).** Within the genus *Fagopyrum*, there are self-pollinating and cross-pollinating species with three types of flowers: short three-parted styles and long anthers (thrum type, *Ss*), long-styled and short anthers (pin type, *ss*) within the species (*F. esculentum, F. cymosum*, etc.) **(Fig. 8).** Thrum and pin flowers within a species represent one hetero-styled group with a self-incompatible pollination mechanism (Luthar *et al*., 2021).

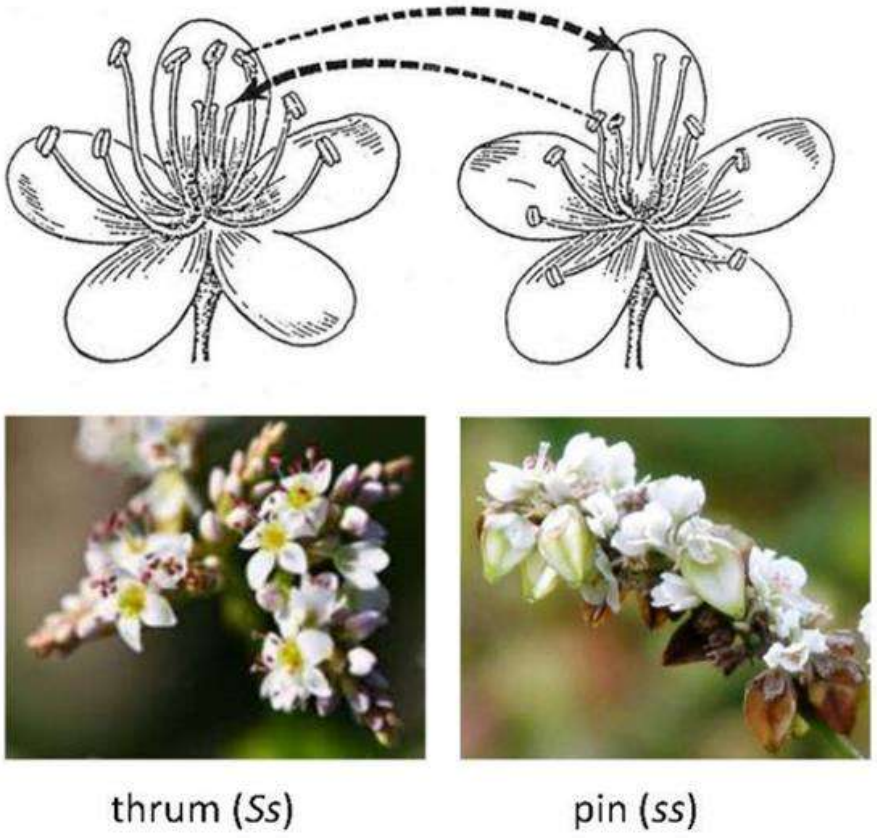
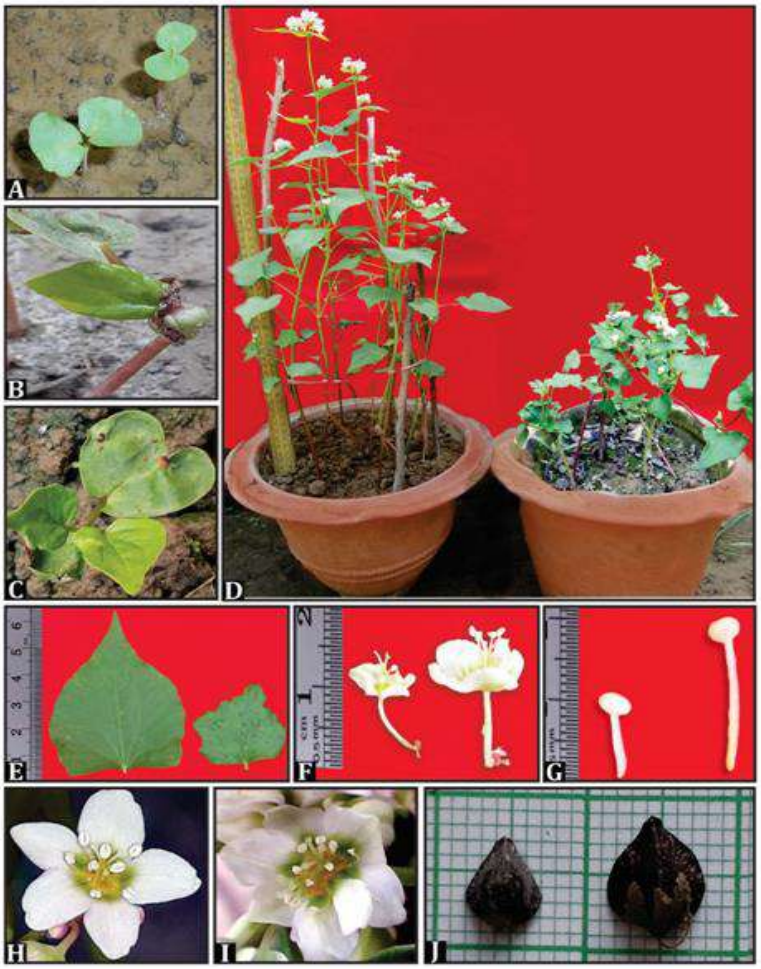


Fig. 8: Morphology of flowers and cross-pollination between pin and thrum plants of Fagopyrum esculentum;

Left—thrum (Ss), short-styled and long anther and right—pin (ss), long-styled and short anther. The arrows show compatible cross-pollination.

GENETICS AND CYTOGENETICS

The significance of polyploidy in the evolutionary process of plants history is well documented. In this concern, seed priming with colchicine as well as the cotton-swab method for polyploidy induction in plants becomes much acquainted in cytogenetic study. The aim of present study was to achieve chromosomal doubling by the application of colchicine to apical meristem of young seedlings. The young seedlings were treated with three different concentrations of colchicine (0.2, 0.4 and 0.6%) for durations of 12, 24 and 36 h each. The colchiploidy with highest proportion approximately 50% with 2n=4x=32 was found at 0.2% concentration for 24 and 36 h. Autotetraploid enduring plants were identified with morphological and cytological variations such as thickness of leaf, larger stomata with low density, larger pollen, large flower etc. Buds were selected from these plants for the cytological study. Cytological analysis including chromosome counting demonstrated that the chromosome number was doubled. The confirmation of autotetraploid plants was achieved by this technique. Tetraploid plants were grown up to maturity and the harvested seeds were sown to establish the second generation which may be used in future breeding programme (Fig.9) (Srivastava and Kumar, 2022).



A = Seedling (Control), B = Swollen node at seedling stage, C = Two basal leaves at one node where one is smaller than other one, D = Diploid plant (left side), Autotetraploid plant (right side), E = Diploid leaf (left side), Autotetraploid leaf (right side), F = Diploid flower (left side), Autotetraploid flower (right side), G = Diploid anther (left side), Autotetraploid anther (right side), H = Diploid flower with five tepals, I = Autotetraploid flower with seven tepals and J = Diploid seed (left side), Autotetraploid seed (right side)

Fig. 9. Induced Autotetraploid in Fagopyrum esculentum Moench:

GENETIC DIVERSITY

Genetic diversity for shape, size and color of buckwheat seeds;Genetic diversity for shape, size and color of buckwheat seeds; Genetic diversity for shape, size and color of buckwheat hulled grains are presented in Fig. 10, 11 and 12. Ujihara (1983) reports on the evaluation of 217 local buckwheat varieties collected from throughout Japan. Although buckwheat production was over 200 000 ha around 1800 AD it had declined to 25 000 ha by 1970.

Fig. 10.: Genetic diversity for shape, size and color of buckwheat seeds

Fig. 13. Genetic diversity for shape, size and color of buckwheat hulls

Fig. 12: Genetic diversity for shape, size and color of buckwheat hulled grains

This decline puts added emphasis on the need to collect these local varieties before further erosion of this important resource takes place. Ujihara (1983) and others in Japan have shown that many Japanese cultivars have a photoperiodic response. This has been classified into three types: summer, autumn and intermediate. The summer type appears to be insensitive to short days while the autumn type is sensitive and can only be grown in the autumn season. Collections from South East Asia exhibit a short day response when grown in North America with common buckwheat exhibiting a stronger response (unpublished data). Ujihara (1983) selected 26 landraces from different locations in Japan that were different in latitude. These were evaluated for days to flowering, plant height, number of leaves, number of branches, number of flower clusters, number of mature grains, weight of dry matter and weight of grains. He found that the number of days to flowering became less as the latitude advanced, with a correlation coefficient of -0.69. As latitude increased, plant height, number of leaves and number of branches tended to decrease. Generally, he reports that the later the flowering occurred, the better developed were the vegetative parts. Similar tendencies were found for dry matter. The correlation of latitude to number of flower clusters was highly negative and thought to be closely related to seed yield. Seed yield per plant showed no clear dependency on latitude. Joshi and Paroda (1991) reported on 408 collections of buckwheat grown in single row observation plots during the years 1985 and 1986 at the Regional Station of the National Bureau of Plant Genetic Resources, Phagli Shimla. Data were recorded on three representative randomly selected plants each year and the average of the six plants produced in the catalogue produced. A wide range of variation was found in the germplasm which is given in Table 6. Plant height varied from 60 to 181 cm, number of branches from 1 to 6 and number of internodes from 6 to 28. The number of leaves varied from 10 to 45. Leaf length ranged from 2.8 to 8.0 cm while leaf length ranged from 2.1 to 8.9 cm. A wide range of variation was reported for days to flower (24-78) and days to maturity (75-150), indicating a great deal of variability that could be utilized in the development of lines for different growing periods or for use in double-cropping systems. The 100-seed weight varied from 1.2 to 5.0 g while yield per plant ranged from 2.3 to 20.0 g. The seed size variation of more than a 4-

fold range from smallest to largest could again be utilized in crop improvement programmes. The seed size for many collections has shown that 100-seed weights of over 35 g occur only rarely in most areas that have been collected. Keli and Dabiao (1992) studied 1505 accessions for amino acid, vitamin E and P contents. They found that out of 18 amino acids present, glutamic acid was the highest at over 2%, aspartic acid and arginine were intermediate at 1-2% and tryptophan was lowest at 0.12-0.13%. They found little difference between common and Tartary buckwheat on the average. They did find that the Vitamin E content in common buckwheat was 0.4-0.5 mg/100 g higher than in Tartary buckwheat, while the Vitamin P content as 0.31 mg/100 g higher in Tartary buckwheat.

Few studies have evaluated or reported on the geographical distribution of traits in common buckwheat. Yan *et al.* (1992) compared the geographical distribution and evaluation of red-flowered buckwheat with white-flowered types. They reported that China's common buckwheat resources of 1221 accessions were composed of 434 with red flowers and 787 with white flowers. They found that the red-flowered types were mainly distributed over regions that were over 1000 m above sea level in western China, namely the Loess Plateau, Yunnan, the Guizhou Plateau, Qinghai, the Tibet Plateau in the Tacheng area of Xinjiang and the Shennongjia area of Hubei. The white-flowered types were mainly found in regions below 1000 m in east and south China. These areas are the Northeast Plain, North China Plain, the middle and lower reaches of the Yangtze River, the hilly areas of south China and Northeastern Inner Mongolia. They also state that in the Loess Plateau the redflowered types are earlier than the white-flowered types with less height and higher 1000 seed weight (2.2-5.4 g). This compares with the Guizhou Plateau and the Tibetan Plain where the red-flowered types are shorter than white-flowered types; however, their 1000-seed weight is 1.3-2.2 g lower than white-flowered types. They feel that the white-flowered types were cultivated at an earlier period and possibly the red flowered types were introduced from other areas.

When common buckwheat landraces were rated for maturity, Keli (1992) found that 21.2% (204 lines) were less than 70 days, 64.6% (623 lines) were from 70 to 90 days and 14.2% (137 lines) were longer than 90 days. Tartary buckwheat landraces were mainly midseason at 70-90 days (59.6%) while late-maturing types made up 33.7%. Only 6.7% were early maturing types of less than 70 days. When he rated 1000-seed weight he found a large difference between common and Tartary buckwheat. He classified common buckwheat into four sizes: small (<25 g), mid (25.1-30 g), large (30.1-35 g) and super large (<35 g). He reports that small-seeded types made up 36.8%, midseeded 40.1%, large-seeded 21.7% with only a few being super large or over 35 g/1000 seeds. In artary buckwheat the rating system used was small-seeded (<15 g), mid (15.1-20 g), large (20.1-25 g) and super large-seeded (>25 g). They comprised 12.4% small, 59.7% mid, 59.7% large and 0.4% super large-seeded. He also reports that plant height in common buckwheat varied from less than 80 cm to more than 140 cm. The range he found in plant height in Tartary buckwheat was wide, with more than 95% of the short and midrange landraces being found in Guizhou and Sichuan and more than 85% of the super high types (>140 cm) being found in Yunnan and Tibet. He also reports on variation found in branch number, nodes on the main stem, grain weight per plant and flower colour of the collection.

Zhuanhua *et al.* (1995) found that when 100 samples, composed of 48 Tartary and 52 common buckwheat populations were compared by polyacylamide gelelectrophoresis there was little within-species variation found for superoxide dismutase (SAD), but a large difference for between-species variation. Esterase bands were similar in common buckwheat except that some lines from Sichuan and Quighai showed a strong E4 band, while other populations from different regions did not. They speculate that the loss of these alleles probably occurred before and during the spread of buckwheat cultivation.

In the Repulic of Korea, the Crop Experiment Station at Suwon collected and evaluated 100 local landraces and 180 introductions from 15 countries (Choi *et al*. 1995). These were evaluated for flowering, seedset, agronomic traits and grain yield from 1988 through 1993. They state that most landraces of southern Korea are photoperiod-sensitive and belong to fall buckwheat and therefore flower but do not set seeds when planted in the spring. They found that summer-type buckwheat generally produced higher yields when planted in the early spring than fall types planted in the summer. In 95 landraces evaluated in 1989, plant height ranged from 63 to 149 cm, branch number ranged from 5 to 9, the number of flower clusters per plant varied from 5 to 97, and grain yield per plant varied from 0.1 to 4.5 g. When 43 summer types were evaluated in 1990 the stem diameter was found to range from 2.4 to 7.0 mm, stem length varied from 27 to 85 cm, and nodes on the main stem ranged from 3 to 10 with 2 to 9 branches per main stem.

A total of 507 buckwheat landraces, out of which 309 were common and 196 were Tartary and 2 were wild types. (Baniya *et al.* 1995) for a total of 27 different agro-ecological traits using the IBPGR Buckwheat Descriptors. In common buckwheat, days to 50% flowering varied from 26 to 45 while days to 95% maturity varied from 67 to 98. This gave a grain-filling period that varied from 33 to 69 days. Plant height ranged from 25 to 116.4 cm, the number of primary branches ranged from 1.4 to 14, number of leaves from 2 to 18.4, number of flower clusters from 1 to 6 and number of seeds per cluster from 7 to 50.2. There was a large variation noted in 1000-grain weight: from 10.2 to 31.8 g. The ratings for disease were from no disease to 100% infection for powdery mildew and from no disease to 60% infection for downy mildew showing a wide variation that could be utilized in crop improvement programmes.

When the plants were considered for 12 morphological traits they again showed a large range of variation: 68% had erect growth habit, 80% had red stem colour, 83% had leaves remaining green at maturity, 57% had red petioles and 99% had green flower stalks. Baniya *et al.* (1995) also reported a wide variation in flower and seed colour. Approximately 42% of common buckwheat landraces had pink flowers, 36% had greenish white and 18% had red flowers. More than half of the common landraces had greyish black seed, 36% had brown seed and the rest had either grey or black seed. Over 92% of the landraces were reported to have a smooth seed coat surface, with 8% having winged seed and one entry having a rough surface similar to Tartary buckwheat.

A report on some of the many characteristics of Nepalese buckwheat also was made by Shershand and Ujihara (1995). They reported less variation in days to flowering (27-38) and in the number of branches per plant (2.2-7.0), and a much higher number of flower clusters per plant (10 to 91). Possibly this recorded variation results from different rating systems or to the large variation that is available in the Nepalese landraces, which is caused by the large variation in altitude and agroecological conditions under which they have developed. The most obvious example of a coordinated approach within a country has taken place in China, where in 1988 a National Coordinated Research Group for Buckwheat Breeding, Cultivation and Utilization was formed. The buckwheat germplasm was collected, multiplied, characterized and documented and compiled into The Catalogue of China's Buckwheat Germplasm (Yang 1995). During 1986-90 over 20 agricultural institutes in China cooperated to evaluate the collections. In addition they attempted to preserve all the germplasm compiled in the catalogue in the National Gene Bank. In China some 2000 accessions had been collected before 1958 but all were lost for some reason. They have again collected 2147 accessions from 694 counties. Of these, 1508 have been registered and 1511 have been stored. He reports that they have rescued some genetic resources from extinction and at the same time obtained some rare buckwheat genetic resources.

A field experiment was conducted with 21 local genotypes of buckwheat tostudy the diversity pattern based on quantitative and qualitative characters. There exists significant variation among the buckwheat genotypes for all the parameters studied. Multivariate techniques were used to classify 21 buckwheat genotypes. All the genotypes were grouped into five different clusters. Cluster IV had the maximum (six) and cluster II had the minimum (one) genotype. The highest inter cluster distance was observed between I and II. The lowest inter cluster distance was found between the cluster III and V. Days to first germination, days to first flowering, first node distance from the soil level, plant height, branches per plant, inflorescence per plant, grains per raceme and total grains per plant have been found to contribute maximum towards genetic divergence among the buckwheatgenotypes. The clustering pattern of genotypes revealed that genotypes collectedfrom the same place did not form a single cluster. Considering diversity pattern and other agronomic performance the genotypes $G_{21,}$ G_9, G_8 and G_{10} might be selected as promising genotypes for future hybridization program (Debnath *et al*., 2008).

The genetic diversity within the available germplasm is primary requisite for designing of any breeding program. This helps to choose desirable parents for establishing new breeding population. Better knowledge on genetic diversity or genetic similarity could help to sustain long term selection gain. Knowledge of genetic diversity among existing cultivars of any crop is essential for long term success of breeding program and maximizes the exploitation of the germplasm resources. Genetically diverse parents are able to produce considerable variability, which can enhance the scope of selection. More diverse the parents, greater are the chances of obtaining high heterotic F_1 s and broad spectrums of variability in segregating generations. Such a study also permits to select the genetically divergent parents to obtain the desirable recombinant in the segregating generations (Debnath *et al*., 2008).

Genetic diversity of plant genetic resources for food and agriculture is a unique and irreplaceable source for further crop genetic improvement. The aim of this paper was the field evaluation of buckwheat genetic resources in the Czech Republic. In the case of the 77 common buckwheat (*Fagopyrum esculentum* Moench.) genotypes, most had reddish- green stems (80%), cordate leaves (82%), white flowers (87%), and grey ovate achenes (44% and 57%, respectively). Vegetative growth duration ranged from 104 to 131 days. The 1000 seed weight (TSW) varied from 18.6 to 33.2 g. In the 15 tartary buckwheat (*Fagopyrum tataricum* Gaertn.) genotypes, there were no remarkable differences in morphological traits. Vegetative growth duration was 101 to 148 days, and the TSW varied from 8.10 to 20.0 g. Similarity/dissimilarity dendograms were calculated using the results of the field evaluation. Principal component analysis was also performed. The dendrograms showed high diversity in the morphological and phenological characteristics evaluated. Performance of the buckwheat varieties, particularly, their developmental stages, depended highly on the weather conditions of the year. Only days to flowering seemed to be affected by variety. Because the evaluation was made according to the IPGRI buckwheat descriptors the characteristics are compatible with data from other gene banks (Cvepková *et al*., 2009).

A total of 97 buckwheat landraces (66 accessions of *F.esculentum* and 31 accessions of *F. tataricum*) collected in various exploration trips from different buckwheat growing regions of NE India have been included in this study. The collection sites of the accessions are presented in Fig.13. In the current study, a total of 97 accessions of *Fagopyrum esculentum* and *F. tataricum* were characterized for 16 morphological descriptors. Significant variations were observed for agronomically important traits including days to 50% fl owering, days to 80% maturity, primary branches plant-1, plant height and 100-seed weight. Wide range of variation was noted for most of the traits in both species. Characterization of buckwheat accessions from Northeast will facilitate in selec adapted to Northeast cropping system (Misra *et al*., 2019).

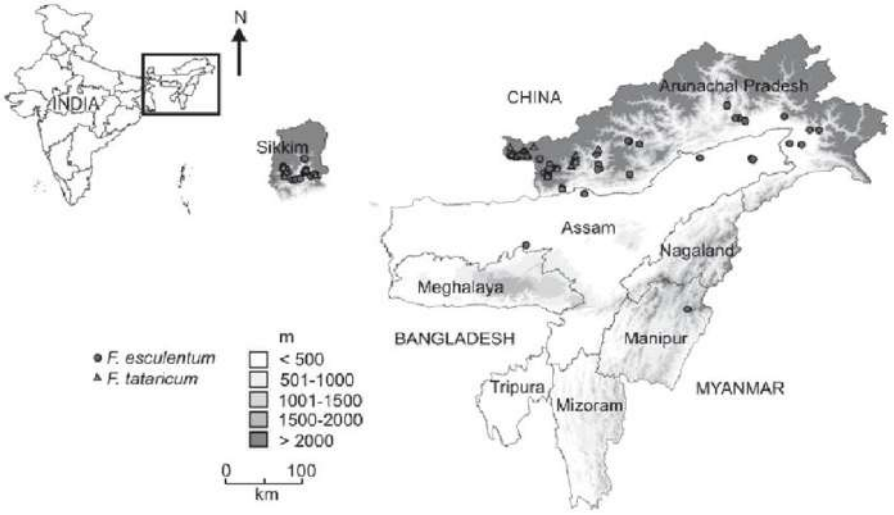


Fig. 13. Collection sites of buckwheat (*Fagopyrum* spp.) landraces from NE India. *F. esculentum* and *F. tataricum* accessions showed separately. Alittude ranges are Indicated by different grey shades

Morphological and molecular characterization of 112 Tartary buckwheat accessions from 29 populations were assessed based on 10 morphological traits of seeds and 10 SSR markers, respectively. The coefficient of variation and Shannon index showed diversity within the morphological characteristics of the seeds. All accessions were divided into three categories according to phylogenetic dendrogram analysis, which was consistent with folk nomenclature and taxonomy. Genetic analysis using SSR markers identified 45 alleles with a mean value of 4.5 alleles per locus. The high average PIC value (0.459) indicated polymorphism of the SSR markers. The genetic similarity coefficient of the 112 Tartary buckwheat accessions showed a high level of genetic diversity ranging from 0.130 to 0.978. The genetic structure analysis revealed high genetic differentiation (Nei = 0.255). The folk nomenclature, folk taxonomy, and sociocultural norms may also contribute to a significant influence on the diversity of folk nomenclature and taxonomy. The assessment of the genetic diversity of Tartary buckwheat landraces and detection of SSR loci associated with traits could be used as scientific guidance for selecting Tartary buckwheat seed for improved production relative to local farmers and consumer preferences. Local traditional knowledge (seed exchange network) and culture also contribute to breeding and the maintenance of the genetic diversity of Tartary buckwheat (Song *et al.*, 2022).

BREEDING

Breeding objectives (Campbell, 1997).

The major objective in buckwheat breeding programmes worldwide has been the improvement of seed yield. Other objectives that have been stressed in various breeding programmes include:

- increased seed size (1000-seed weight)
- increased seed-shattering resistance
- early maturity
- easier dehulling ability
- determinant flowering
- increased groat percentage
- seed coat colour
- flower colour
- leaf size, both small and large
- lodging resistance.

Breeding principles: Common buckwheat is a self-incompatible species and this therefore dictates the breeding patterns most used on it. Owing to its outcrossing characteristics, all lines that are being developed must be kept in isolation, either spatial or in cages, from each other (see Figs. 4 and 5). Tartary buckwheat crop improvement programmes can be handled in the same manner as other self-pollinating crops. It is thus much easier to generate and maintain the high numbers of segregating progeny and advanced lines that are required in a plant breeding programme. The self-incompatibility of buckwheat is of the dimorphic, sporophytic type and thus seed production is dependent on cross-pollination between 'pin' (long pistil, short stamen) and 'thrum' (short pistil, long stamens) flowers. Flower forms with reduced style length have been found and self-fertile homomorphic lines have been developed (Marshall 1969). Certain of the lines that were developed were especially adapted to self-pollination since the flowers have equal pistil and stamen heights. However, the introduction of this character into other buckwheat lines almost always results in severe inbreeding depression. This is probably due to a large number of deleterious recessive genes being carried along with the thrum gene, as this gene never occurs in the homozygous state (Campbell, 1997).

Breeding System: *Fagopyrum* is a genus of about 15 species, most of them indigenous to eastern Asia. The species are of different ploidy levels, and represent two types of breeding system, self-compatibility and self-incompatibility, with theeconomically most important species, *F. esculentum* being self-incompatible. Domesticated species are mainly cultivated in temperate and subtropical areas (Gondola and Peter, 2010).

Breeding: Buckwheat is neglected and underutilized at present, both as a nutritious food and as a viable alternative crop plant, particularly in the developed countries. In contrast with the important cereal crop species, only little crop improvement efforts have been focused on buckwheat during the past few decades. Today buckwheatis still mostly grown as a primitive crop, in a similar way it was grown hundreds of years ago, with yield levels practically unchanged (Campbell 1997; Gondola1 and Peter, 2010). The goal of breeders is to improve the properties of cultivated buckwheat with methods of classical breeding, with the support of biotechnological methods or a combination of both. The key problems in buckwheat breeding are the unknown mode of inheritance of most traits, associated with crop yield and the synthesis of medicinal compounds, low seed yield, shedding of seeds, differential flowering and seed set on branches, and unknown action of genes responsible for the synthesis of buckwheat metabolites of pharmaceutical and medicinal interest. We reviewed the possibility to use transcriptomics, genomics, interspecific hybridization, tissue cultures and plant regeneration, molecular markers, genetic transformation, and genome editing to aid in both the breeding of buckwheat and in the identification and production of metabolites important for preserving human health (Luthar *et al*., 2021).

Among the pseudo-cereals grown in India, buckwheat (*Fagopyrum* spp.) is very important. *Fagopyrum esculentum* Moench, which is known as common buckwheat, is the most cultivated species in the hilly region of India out of the 20 species of buckwheat. Besides this, *F. tataricum* Gaertn (Tartary buckwheat) also have limited area under cultivation. At remote locations of mountains ecosystems, buckwheat is a livelihood driven crop for small and marginal farmers. Common buckwheat is a short duration, multipurpose and nutritious crop, which can withstand changing climatic conditions and fit well in multiple cropping systems. Owing to relatively low input requirement and less infestation of insect-pests and diseases, it is the most suitable for organic production systemof hilly regions of higher elevation. Buckwheat grains are primarily used for human consumption and also for livestock, poultry and piggery feeds. Rural population of hilly region of India use buckwheat sprouts and as pan cakes especially in breakfast, however, the recommended intake of buckwheat sprouts are less than 40 g/day. Furthermore, buckwheat is also grown as a cover crop, green manure crop, fodder crop, fertility restoring crop, honey crop and medicinal plant. The crop is also a good source of rutin (quercetin-3-rutinosid) and fagopyrin that are known to be used in preventing various human disorders. Tartary buckwheat contains 100-fold more rutin as compared to common buckwheat. Owing to improvement in productivity and profitability of others crops, area and production of buckwheat is declining. Hence, there is an urgent need to develop appropriate policy and scientific interventions for exploitation of this climate resilient super food crop for livelihood security of ever increasing population especially in the hill regions (Babu *et al*., 2018).

Some of the problems that are frequently encountered inthe production of common buckwheat can only be solved with genetic improvement. Examples of these are (Gondola1 and Peter, 2010):

lack of frost tolerance, shattering of seeds, lack of resistance to lodging, indeterminate growth habit, low rate of seed-set (in cross-pollinated flowers) and Lack of fertilization was the major cause of low seed set, rather than abortion of the embryo. Buckwheat (*Fagopyrum* spp.) has attracted considerable interest amongst global scientific community due to its nutritional and pharmaceutical properties. The gluten free nature of buckwheat, nutritionally balanced amino acid composition of its grain protein, and high levels of anti-oxidants, such as rutin, makes buckwheat an important crop with immense nutraceutical benefits. However, a key challenge in buckwheat cultivation is the variation in yield between years, which impacts the entire value chain. Current information on buckwheat indicates existence of significant phenotypic variation for agronomic and nutritional traits. However, genetic bottlenecks in conventional breeding restrict effective utilization of the existing diversity in mainstreaming buckwheat cultivation. Availability of high density buckwheat genome map for both the cultivated species viz. *F. esculentum* and *F. tataricum* would add to our understanding of genetic basis of their agronomic traits (Chettry *et al*., 2021).

Indian Council of Agricultural Research, New Delhi started a systematic research programme on under-utilized crops after creation of All India Coordinated Research Project (AICRP) on Underexploited and Unexploited Crops in 1982. Considering the importance of buckwheat, AICRP included this miracle crop under the Umbrella of All India Coordinated Research Network on Potential Crops (AICRN-PC) during 1984. More than 150 germplasm accessions/ breeding lines were tested for adaptability and yield potentials on various locations across the India (Babu *et al*., 2018).

Interspecific hybridization: Although the genus *Fagopyrum* contains at least 15 species of buckwheat, only two are utilized as food or feed and wild buckwheat *(F. cymosum),* mainly found as tetraploid, is used on a sporadic basis as a green vegetable or as cattle forage. The development of hybrids between two different species of buckwheat has now been demonstrated several times. *Fagopyrum cymosum* and *F. tataricum* hybrids as well as *F. cymosum* by *F. esculentum* hybrids have been produced at the tetraploid level. *Fagopyrum esculentum* by *F. homotropicum* hybrids have proven to be fertile at the diploid level. *Fagopyrum esculentum* by *F. tataricum* hybrids have been developed at the tetraploid level and are presently being developed at the diploid level. This will allow movement of characteristics from one species to another in the development of improved cultivars. As common buckwheat has many characteristics that are desirable for its use as food many efforts have been made to produce interspecific hybrids by using it and the other two species as parents. Most of these results have not been successful (Campbell, 1997).
Varieties: In India 3 improved varieties of tartary buckwheat, *viz.,* 'Himpriya', 'Himgiri' and 'Sangla B-1' and 2 of common buckwheat, *viz.,* 'VL Ugal-7' and 'PRB-1' have been released by different research organizations (Babu *et al*., 2018).

Cultivation: Buckwheat is one of the minor crops belonging to the family Polygonaceae. Buckwheat is believed to be cultivated first in the Himalayan region of India, from where it spread to China, Middle Asia and the Caucasus and later on to other European areas. Common buckwheat, the principal species *Fagopyrum esculentum* appears to have been derived from *F. cymosum,* a wild species of Asia. In Bangladesh, buckwheat is cultivated in the north-west region especially in Thakurgaon, Panchagar and parts of Dinajpur and Rangpur districts during the rabi (October to March)season (Debnath *et al*., 2008).

Harvesting and threshing*:* Buckwheat is an indeterminate crop and did not have synchronized maturity hence; swathing is a necessary operation to minimize the shattering losses. Shattering causes about 20–25% yield loses in buckwheat. Some re- searchers have pointed out that tartary buckwheat is more prone to shattering losses than common buckwheat. Hence, the crop should be cut when 70–80% of the seeds have turned brown (physiological maturity) and place in windrows to facilitate drying till the seed head reaches to 16–18% moisture content. Thereafter make the bundles to minimize the shattering losses of grain. Swathing should be done in the early morning when the dew is present, or in foggy weather to reduce the shattering losses. The harvesting time of buckwheat varies according to agro-ecological conditions and type of genotypes grown. The harvesting period is not limited in Tartary buckwheat as compared to common buckwheat. However, under normal conditions it can usually be harvested approximately 90–100 days after sowing. However, under unfavourable conditions the crop duration increases up to 5 months. During the harvesting period, seeds of all stages, namely, mature seeds, immature seeds, and a few flowers are present at the same time period. Yield potential of buckwheat mainly depends on genotypes and environment interaction. However, well managed buckwheat crops yielded about 1000–1500 kg grain/ha. Buckwheat should not be stored for longer time because grain is susceptible to rancidity. The seeds must be well dried. Over matured seeds when come in contact with high moisture, germinate quickly as the seeds have vivipary characteristics. Buckwheat can be stored safely at 13% moisture content for longer time. When short-term storage is required buckwheat can be stored at lower temperature about 10^0C with <15% moisture in grain. The drying temperature of grain should not exceed 45ºC otherwise grain quality is badly hampered (Babu *et al*., 2018). Timely harvesting of buckwheat is essential to prevent shattering of grains. Generally late harvesting was observed in high altitude while early harvesting was done in the mid and low altitude areas. Yield of 12-14 q/ha is expected from well managed crop. The plant shows irregular time of maturity because of indeterminate growth habit. If the harvesting is delayed, shattering will start which may cause huge loss. Careful handling of the crop is very important because grain shattering results in losses up to 25 per cent. Due to its gradual formation and maturity, harvesting is done periodically and finally the crop is cut and then threshed when the rest of the seeds are fully matured. The harvesting period is not limited in Tartary (Tithey) buckwheat (*F. tataricum*) as compared to common (Mithey) buckwheat (*F. esculentum*). The 'Mithey' type matures earlier than 'Tithey' type. After harvesting the seeds must be well-dried and kept at about 14 per cent or less moisture for the safe storage of buckwheat grains. Over-matured seeds when in contact with high moisture, germinate very quickly as the seeds have vivipary characteristic (Hayder, 2021).

USES

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 to crowd out weeds and as a source of buckwheat honey (Campbell, 1997). Common buckwheat is consumed in many 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 being ascribed medicinal qualities. In China it has been reported that buckwheat is used for the production of vinegar (Campbell, 1997). 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 (Campbell, 1997).

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. It is often possible to obtain a crop of buckwheat honey after an earlier flow has been harvested from another crop. Relatively pure buckwheat honey is dark-coloured and has a strong flavour that is relished by some people but is disliked by others. 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. 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 (Campbell, 1997).

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. 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 (Campbell, 1997).

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 (Campbell, 1997).

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 (Campbell, 1997). Most of the farmers in east and south are not familiar with the principal product of buckwheat, *i. e*. flour. Buckwheat produces grains and fodder and is also a source of succulent green leafy vegetable. The whole grains (achenes), middling or flour are fed to the livestock and poultry. Its leaves and flowers are used as a commercial source of rutin, a glucoside, which is used as medicine to check capilary hemorrhages, help reduce blood pressure, prevent frostile gangrene and act as a protection against the after-effect of atomic radiation. Buckwheat is also a good honey crop which can produce 112-168 kg of honey per hectare in about 30 days. In India, the flour of buckwheat is used in various preparations like making bread, pancake, porridge, soup "Halua' etc., especially during the religious festivals. Though it is a minor crop it has a tremendous nutritional and medicinal value. But unfortunately research information especially for genetic improvement of this crop is almost unavailable in this country (Debnath *et al*., 2008).

Buckwheat is a multi-purpose crop, for nearly all parts of the plant are used in a large variety of ways. The **leaf** provides *rutin* (vitamin-P), a pharmaceutical product. As a rutin – containing plant buckwheat, also named *Fagopyri herba*, has traditionally been used to brew tea to treat hyper-tonia. The **flower** produces nectar for honey-bees. Buck- wheat has many uses in cooking. The dehulled **grains** are eaten boiled. **Flour** can be made from the grain either entireor dehulled. The flour is prepared in various ways to make bread, pancakes and other traditional foods as well as special diets. Beer is brewed from the grain, and the grain is also distilled into spirits. Buckwheat **hulls** are used as filling for a variety of upholstered goods, including pillows. The **straw** makes good livestock feed. As a fast growing plant, buckwheat also makes good green manure even in cases when the gap period between two main crops is short (Gondola and Peter, 2010).

Multifarious uses of buckwheat

Buckwheat as a soil productivity restoring crop*:* Buckwheat perform multitude functions as a break crop (breaksthe life cycle of insect, pests and diseases), green manurecrop, smother crop (suppress weeds), nutrient conservingcrop (enhanced nutrients uptake, reduces nutrients leaching and immobilization), gourd crop (protecting main cropfrom wild animal), cover crops (soil protection against water and wind erosions) and as land reclamation crop. Buckwheat is an ephemeral green manure crop which germinates in 3–5 days, flowerswithin 30–45 days and matures completely within 90–110days. During its growth period, itreaches a height of 70–80 cm, and produces about 5–7 tonnes of biomass/ha. Nutrients release patterns of buckwheat biomass after green manuring largely depend on growth stage at which crop is incorporated in to the soil. Early flowering or late vegetative stage is the right stage for green manuring and after cutting the residue is either left on the surface or incorporated into the soil, depending on the purpose. Mulch left on the surface helps in maintaining soil stability, and suppress weeds. Green manure crop of buckwheat tightens up the on-farm nutrient cycle by soaking up the leachable nutrients. Green manuring of buckwheat improves soil aggregate stability and scavenges nutrients especially phosphorus and calcium. Buckwheat residues had a narrow C:P ratio (175) with high P concentration (2.7 g/kg), which enhances P availability in residue amended soil. Buckwheat had high carbon: nitrogen ratio (C:N = 34), hence causes immobilizing of nitrogen duringdecomposition and reduces soil N availability. When buckwheat residue is incorporated into the soil, it rapidlybreaks down and releases nutrients for uptake by the subsequent crop especially potassium. In addition, buckwheat also has thepotential to suppress root pathogens and insect-pests cycle. (Babu *et al*., 2018).

Buckwheat as a "Natural Phosphorus Pump": Buckwheat has an excellent ability to scavenge phosphorus, calcium and some minor nutrients from the soil, which otherwise are unavailable to other crops, and return it in a more plant-friendly form to other crops in the system, hence considered as a ''natural phosphorus pump''. Phosphorus (P) uptake of buckwheat is about ten times higher than wheat. Buckwheat produces exudates with a lower *p*H in P deficient conditions, acidify rhizospheric soil and absorb P beyond its metabolic requirement, showed luxury consumption of P. Similarly, buckwheat has high P-uptake efficiency in calcareous soils but is less effective in soils dominated by Fe and Al phosphates. The roots of buckwheat have a high storage capacity for inorganic P. As a result, when buckwheatplants are incorporated in the soil, they decay quickly, making phosphorus and other nutrients available to the succeeding crop. Under phosphorus deficient condition, buckwheat root increasesthe release of protons and P solubilizing substances and enhances P uptake. The roots exudatesof buckwheat contains several mild acids *e.g.* phosphatases and has the ability to extract phosphorus from organic sources and make available to succeeding crops. These acids also mineralize theslow release organic fertilizers like rock phosphate and make available to plant (Babu *et al*., 2018).

Buckwheat as a body building/protective/quality food: The economic importance of buckwheat is mainly due to high nutritive value of its grains and the presence of rutinin foliage. In general buckwheat grain contains about 10–14% protein which is more than most of the cereals. Buckwheat protein is also superior in quality than cereals, due to high concentration of most essential amino acids especially lysine, threonine, tryptophan and the sulfur containing amino acids, with about 80% digestibility. Buckwheat may be a valuable supplement to cereal grains as its high lysine content com-pensates for the limiting lysine content in diets consistingpredominantly of cereals. Prolamins content in buckwheatgrain is very low as compared with other cereals includingwheat. Buckwheat flour is free from gluten and used in treating the celiac disease in human being. Buckwheat grains contain a high quality slowly digested starch, helps to treat diabetics. Buckwheat flour also contains a good proportion of high quality fat. Palmitic, oleic and linolenic acids constitute about95% of the total fatty acids in buckwheat grains. Buckwheat grain is very rich in trace elements like Zn, Cu, Mn and Se as compared to cereal crops (Babu *et al*., 2018).

Buckwheat as a medicinal plant: Buckwheat grain has very pleasant aroma and salicylaldehyde (2– hydroxybenzaldehyde) is mainly responsible for buckwheat aroma. Rutin (quercetin-3-rutinosid) constituent of buckwheat is used in preventingedema, haemorrhagic diseases, and stabilizing high bloodpressure. Rutin content in buckwheat various with genotypes and growing condition. However, rutin content in buckwheat foliage range 3–6%of dry weight. Generally, tartary buckwheat contains about100 fold more rutin than common buckwheat. Rutin is mainly located

in flowers and in green parts of buckwheat plant. In seeds there is less rutinthan in leaves, but there could be some rutin as well in buckwheat flours, more in the dark than in the light ones. The rutin content was higher than quercetin in buckwheat seeds, range from 0.05 to 1.35% of buckwheat seeds, while quercetin content varied from 0.01 to 0.17%. Rutin is used in medicine in the treatment of increased capillary fragility with associated hypertension, leading to hemorrhage, purpurea and bleeding from kidney. Rutin also has potent anti-carcinogens properties. *Fagopyrin* is a naphthodianthrone substance with photo-sensitizing effect, from the foliage of common buckwheat (*Fagopyrum esculentum*). The chemical structure of Fagopyrin is similar to that of hypericin, differing only in the presence of two symmetrically placed 2-piperidinyl groups in fagopyrin. The photosensitizing effectof fagopyrin is recently uses in photodynamic therapy forthe treatment of microorganism and cancer cells. Peoples of hilly region of India also used buckwheat sprout especially in breakfast, however, the recommended intake of buckwheat sprouts is less than 40 g perday. Buckwheat also contains plentifulCu, which can improve the function of Fe and prevent hypohemia in human beings (Babu *et al*., 2018).

Buckwheat for sustaining livelihood security of hill regions: Buckwheat is a multipurpose crop but in India primarily grown for its grains. However, tender shoots andleaves are also used as leafy vegetables. The seed is usedin a number of culinary preparations as well as alcoholic drinks; the husk is used in stuffing pillows. The grain is generally used as human food, the flour used in the preparation of chapattis, pancakes, biscuits and noodles etc. People in main land consume buckwheat during religiousfasting days. It is also used as a livestock, poultry and piggery feeds. Tartary buckwheat also used in place of teain hill region The straw is fed to cattle immediately after threshing, when it is still green/fresh. Buckwheat flower produces a good quality of honey and can also cultivate for honey crop. Buckwheat crops can also be grown as an insect trap crop with other economically important cropsto reduce the insect-pests infestation in main crops (Babu *et al*., 2018).

The use of pure rutin from buckwheat is considered safe and harmless. However, there is a danger of the disease fagopyrism when grains are consumed in large amounts. Other uses of the crop are documented here on the basis of common knowledge in this region . In Turtuk valley flour is made from the seeds thatis used in bread making , pancakes, and muffins /Marzanetc.)young leaves are use as a Vegetables. Buckwheat is used in Turtuk valley and other parts of the world for controlling diabetes, heart disease and high cholesterol, being rich in fiber it is used for regular bowel movements. However, the scientific evidence/s to support these uses are not available.Buckwheat can provide agronomy benefits to crop rotation for breaking up diseases cycle (Hayder, 2021).

Buckwheat flour

Buckwheat flakes (fast cooking) (right) Crispbread made of buckwheat flour

Fig. 14 . Culinary Uses

The fruit is an achene, similar to sunflower seed, with a single seed inside a hard outer hull. The starchy endosperm is white and makes up most or all of buckwheat flour. The seed coat is green or tan, which darkens buckwheat flour. The hull is dark brown or black, and some may be included in buckwheat flour as dark specks. The dark flour is known as *blé noir* (black wheat) in French, along with the name *sarrasin* (saracen). Similarly, in Italy, it is known as *grano saraceno* (saracen grain). The grain can be prepared by simple dehulling, milling into farina, to whole-grain flour or to white flour. The grain can be fractionated into starch, germ and hull for specialized uses. Buckwheat groats are commonly used in western Asia and eastern Europe. The porridge was common, and is often considered the definitive peasant dish. It is made from roasted groats that are cooked with broth to a texture similar to rice or bulgur. The dish was taken to America by Jewish, Ukrainian, Russian, and Polish immigrants who called it *kasha*, and they mixed it with pasta or used it as a filling for cabbage rolls (stuffed cabbage), knishes, and blintzes; buckwheat prepared in this fashion is thus most commonly called *kasha* in America. Groats were the most widely used form of buckwheat worldwide during the 20th century, eaten primarily in Estonia, Latvia, Lithuania, Russia, Ukraine, Belarus, and Poland, called *grechka* (Greek [grain]) in Belarusian, Ukrainian and Russian languages. Buckwheat noodles have been eaten in Tibet and northern China for centuries, where the growing season is too short to raise wheat. A wooden press is used to press the dough into hot boiling water when making buckwheat noodles. Old presses found in Tibet and Shanxi share the same basic design features. The Japanese and Koreans may have learned the process of making buckwheat noodles from them. Buckwheat noodles play a major role in the cuisines of Japan (*soba*) and Korea (*naengmyeon*, *makguksu* and *memil guksu*). *Soba* noodles are the subject of deep cultural importance in Japan. The difficulty of making noodles from flour with no gluten has resulted in a traditional art developed around their manufacture by hand. A jelly called *memilmuk* in Korea is made from buckwheat starch. Noodles also appear in Italy, with *pasta di grano saraceno* in Apulia region of Southern Italy and *pizzoccheri* in the Valtellina region of Northern Italy (Wikipedia, 2023)

Buckwheat pancakes are eaten in several countries. They are known as buckwheat *blini* in Russia, *galettes bretonnes* in France, *ployes* in Acadia, *poffertjes* in the Netherlands, *boûketes* in the Wallonia region of Belgium, *kuttu ki puri* in India and *kachhyamba* in Nepal. Similar pancakes were a common food in American pioneer days. They are light and foamy. The buckwheat flour gives the pancakes an earthy, mildly mushroom-like taste. Yeasted patties called *hrechanyky* are made in Ukraine. Buckwheat is a permitted sustenance during fasting in several traditions. In India, on Hindu fasting days (Navaratri, Ekadashi, Janmashtami, Maha Shivaratri, etc.), fasting people in northern states of India eat foods made of buckwheat flour. Eating cereals such as wheat or rice is prohibited during such fasting days. While strict Hindus do not even drink water during their fast, others give up cereals and salt and instead eat non-cereal foods such as buckwheat (*kuttu*). In the Russian Orthodox tradition, it is eaten on the St. Philip fast. Buckwheat honey is dark, strong and aromatic. Because it does not complement other honeys, it is normally produced as a monofloral honey (Wikipedia, 2023).

In recent years, buckwheat has been used as a substitute for other grains in gluten-free beer. Although it is not an actual cereal (being a pseudocereal), buckwheat can be used in the same way as barley to produce a malt that can form the basis of a mash that will brew a beer without gliadin or hordein (together gluten) and therefore can be suitable for coeliacs or others sensitive to certain glycoproteins.

Buckwheat whisky is a type of distilled alcoholic beverage made entirely or principally from buckwheat. It is produced in the Brittany region of France and in the United States. Buckwheat *shōchū* is a Japanese distilled beverage produced since the 16th Century. The taste is milder than barley shōchū. Buckwheat tea, known as *kuqiao-cha* in China, *memil-cha* in Korea and *soba-cha* in Japan, is a tea made from roasted buckwheat. Buckwheat hulls are used as filling for a variety of upholstered goods, including pillows and zafu. The hulls are durable and do not insulate or reflect heat as much as synthetic filling. They are sometimes marketed as an alternative natural filling to feathers for those with allergies. However, medical studies to measure the health effects of pillows manufactured with unprocessed and uncleaned hulls concluded that such buckwheat pillows do contain higher levels of a potential allergen that may trigger asthma in susceptible individuals than do new synthetic-filled pillows (Wikipedia, 2023)

The flour of buckwheat is used largely in pancakes, bread, porridge, soup and 'halwa'. Tender shoots are used as vegetables and the whole buckwheat grain may be used in poultry scratch feed mixtures. Flowers are a rich source of honey. The crop has soil binding ability, checks soil erosion and is also a good source of green manure (Kamili,. 2023) (Fig. 12).

NUTRITIONAL VALUE

Table 2. Nutritional value per 100 g buckwheat seeds (Wikipedia, 2023)

Energy	**1,435 kJ (343 kcal)**	
Carbohydrates	71.5 g	
Dietary fiber	10 g	
Fat	3.4 g	
Saturated	0.741 g	
Monounsaturated	1.04 g	
Polyunsaturated	1.039 g	
omega-3	0.078 g	
omega-6	0.961 g	
Protein	13.25 g	
Vitamins	Quantity	%DV†
Thiamine (B1)	9%	0.101 mg
Riboflavin (B2)	35%	0.425 mg
Niacin (B3)	47%	7.02 mg
Pantothenic acid (B5)	25%	1.233 mg
Vitamin B6	16%	0.21 mg
Folate (B9)	8%	30 µg
Vitamin C	0%	0 mg
Minerals	Quantity	%DV†
Calcium	2%	18 mg
Copper	55%	1.1 mg
Iron	17%	2.2 mg
Magnesium	65%	231 mg
Manganese	62%	1.3 mg
Phosphorus	50%	347 mg
Potassium	10%	460 mg
Selenium	12%	8.3 µg
Sodium	0%	1 mg
Zinc	25%	2.4 mg
Other constituents	Quantity	
Water	9.8 g	

Buckwheat contains diverse phytochemicals, including rutin, tannins, catechin-7-O-glucoside in groats, and fagopyrins, which are located mainly in the cotyledons of the buckwheat plant. It has almost no levels of inorganic arsenic (Wikipedia, 2023). Salicylaldehyde (2-hydroxybenzaldehyde) was identified as a characteristic component of buckwheat aroma. 2,5-dimethyl-4-hydroxy-3(2H)-furanone, (E,E)-2,4-decadienal, phenylacetaldehyde, 2-methoxy-4-vinylphenol, (E)-2-onenal, decanal and hexanal also contribute to its aroma. They all have odour activity value of more than 50, but the aroma of these substances in an isolated state does not resemble buckwheat (Wikipedia, 2023). With a 100-gram serving of dry buckwheat providing 1,440 kilojoules (343 kilocalories) of food energy, or 380 kJ (92 kcal) cooked, buckwheat is a rich source (20% or more of the Daily Value, DV) of protein, dietary fiber, four B vitamins and several dietary minerals, with content especially high (47 to 65% DV) in niacin, magnesium, manganese and phosphorus (table). Buckwheat is 72% carbohydrates, 10% dietary fiber, 3% fat, 13% protein, and 10% water (Wikipedia, 2023). As buckwheat contains no gluten, it may be eaten by people with gluten-related disorders, such as celiac disease, non-celiac gluten sensitivity or dermatitis herpetiformis. Nevertheless, buckwheat products may have gluten contamination (Wikipedia, 2023). The whole grain (nut) contains 65% carbohydrates, 10.3% proteins, 2.4% fat, 2.4% mineral matter, 8.6% fibre, 0.07% calcium, 0.03% phosphorus and 11.3% moisture (Kamili,. 2023). Carbs are the main dietary component of buckwheat. Protein and various minerals and antioxidants are also present. The nutritional value of buckwheat is considerably higher than that of many other grains. The nutrition facts for 3.5 ounces (100 grams) of raw buckwheat are: Calories: 343, Water: 10%, Protein: 13.3 grams, Carbs: 71.5 grams, Sugar: 0 grams, Fiber: 10 grams and Fat: 3.4 grams (Arnarson, 2023). It also contains the following vitamins and minerals:

Manganese: Found in high amounts in whole grains, manganese is essential for healthy metabolism, growth, development, and your body's antioxidant defenses.

Copper: Often lacking in the Western diet, copper is an essential trace element that may benefit heart health when eaten in small amounts.

Magnesium: When present in sufficient amounts in your diet, this essential mineral may lower your risk of various chronic conditions, such as type 2 diabetes and heart disease.

Iron: Deficiency in this important mineral leads to anemia, a condition characterized by reduced oxygen-carrying capacity of your blood.

Phosphorus: This mineral plays an essential role in the growth and maintenance of body tissues. Compared to other grains, the minerals in cooked buckwheat groats are particularly well absorbed. This is because buckwheat is relatively low in phytic acid, a common inhibitor of mineral absorption found in grains and seeds. It also contains other plant compounds. Buckwheat is rich in various antioxidant plant compounds, which are responsible for many of its health benefits. In fact, it provides more antioxidants than many other cereal grains, such as barley, oats, wheat, and rye. Tartary buckwheat has a higher antioxidant content than common buckwheat. Here are some of buckwheat's main plant compounds:

Rutin. The main antioxidant polyphenol in buckwheat, rutin may lower your risk of cancer and improve inflammation, blood pressure, and your blood lipid profile.

- **Quercetin.** Found in many plant foods, quercetin is an antioxidant that may have a variety of beneficial health effects, including lowering your risk of cancer and heart disease.
- **Vitexin.** Animal studies indicate that vitexin may have a number of health benefits. However, excessive intake may contribute to an enlarged thyroid.
- **D-chiro-inositol.** This is a unique type of soluble carb that reduces blood sugar levels and may benefit diabetes management. Buckwheat is the richest food source of this plant compound.

Potential adverse effects: Cases of severe allergic reactions to buckwheat and buckwheat-containing products have been reported. Buckwheat contains fluorescent phototoxic fagopyrins. Seeds, flour, and teas are generally safe when consumed in normal amounts, but fagopyrism can appear in people with diets based on high consumption of buckwheat sprouts, and particularly flowers or fagopyrin-rich buckwheat extracts. Symptoms of fagopyrism in humans may include skin inflammation in sunlight-exposed areas, cold sensitivity, and tingling or numbness in the hands (Wikipedia, 2023)

HEALTH BENEFITS

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. The leaf of Tartary buckwheat is a drug used in traditional Chinese medicine. According to the *Chinese Materia Medicine Dictionary* the therapeutic function of the leaf and stem includes treating choking, ulcer, haemostasis and for bathing wounds. The book *Classified Materia Medica for Emergency* indicates 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. Other reports from China indicate that Tartary buckwheat shows a hypoglycaemic effect. Tartary buckwheat noodles can be obtained at the present time 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. This effect was believed to be due to Tartary buckwheat containing many microelements, vitamins and vitamin B, 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 (Campbell, 1997).

Diets that contain buckwheat have been linked with lowering cholesterol and reducing high blood pressure. Buckwheat intake is associated with lower total serum cholesterol, lower low-density lipoprotein cholesterol (LDL-the form linked to cardiovascular disease), and a high ratio of HDL (health-promoting cholesterol) to total cholesterol. Buckwheat's lipid-lowering activity is largely due to rutin and other flavonoid compounds that protect against disease by extending the action of vitamin C and acting as antioxidants. Buckwheat also contains magnesium which relaxes blood vessels, improving blood flow and nutrient delivery while lowering blood pressure-the perfect combination for a healthy cardiovascular system. The nutrients in buckwheat also contribute in diabetes management. It lowers blood sugar levels and has a great ability to satisfy hunger (Wikipedia, 2023) Like other whole-grain pseudocereals, buckwheat is linked to a number of benefits (Arnarson, 2023).

Improved blood sugar control: Over time, high levels of blood sugar may lead to various chronic diseases like type 2 diabetes. Thus, moderating the rise in blood sugar after meals is important for maintaining good health. As a good source of fiber, buckwheat has a low to medium GI. This means that it should be safe to eat for most people with type 2 diabetes. In fact, studies link buckwheat intake to lower blood sugar in people with diabetes. This is supported by a study of rats with diabetes, in which buckwheat concentrate was shown to lower blood sugar levels by 12–19%. This effect is thought to be due to the unique compound D-chiro-inositol. Studies indicate that this soluble carb makes cells more sensitive to insulin, the hormone that causes cells to absorb sugar from your blood. In addition, some components of buckwheat seem to prevent or delay the digestion of table sugar. Overall, these properties make buckwheat a healthy choice for people with type 2 diabetes or those who want to improve their blood sugar balance.

Heart health: Buckwheat may also promote heart health. It boasts many heart-healthy compounds, such as rutin, magnesium, copper, fiber, and certain proteins. Among cereals and pseudocereals, buckwheat is the richest source of rutin, an antioxidant that may have a number of benefits. Rutin may cut your risk of heart disease by preventing the formation of blood clots and decreasing inflammation and blood pressure. Buckwheat has also been found to improve your blood lipid profile. A poor profile is a well-known risk factor for heart disease. A study in 850 Chinese adults linked buckwheat intake to lower blood pressure and an improved blood lipid profile, including lower levels of LDL (bad) cholesterol and higher levels of HDL (good) cholesterol. This effect is believed to be caused by a type of protein that binds cholesterol in your digestive system, preventing its absorption into your bloodstream.

Potential downsides: Apart from causing allergic reactions in some people, buckwheat does not have any known adverse effects when eaten in moderation.

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