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9. Buckwheat

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Abstract:

This chapter provides a comprehensive overview of buckwheat cultivation, emphasizing its significance as a crop in diverse agro-climatic conditions. Buckwheat (Fagopyrum esculentum Moench) is highlighted for its adaptability to low fertility soils and rainfed areas, making it a resilient crop for regions with limited water resources.

The chapter delves into various aspects of buckwheat farming, including optimal fertilization practices, weed and water management, and effective cropping systems suitable for different elevations, particularly in the Himalayan region. Additionally, the text discusses the relatively low incidence of pest and disease issues in buckwheat cultivation and outlines recommended practices for harvesting and threshing to minimize yield losses due to shattering. The insights provided in this chapter aim to enhance the understanding and implementation of sustainable buckwheat farming practices to improve crop yield and quality.

9.1 Introduction:

Millets are small-seeded grasses that play a crucial role as food staples in many regions of the world, especially in Asia and Africa. Known for their ability to withstand harsh growing conditions, millets are nutritionally rich and provide numerous health benefits. Among these, buckwheat is particularly significant, despite often being mistaken for a cereal grain. As one of pseudo and minor-cereal, buckwheat holds the potential to address the growing food demands of a rapidly expanding population, particularly in hilly areas under changing climatic conditions. The name ‘buckwheat’ is derived from Anglo-Saxon terms ‘boc’ (due to its seed's resemblance to a small beech nut) and ‘whoet’ (wheat) (Robinson 1980). Buckwheat is an ancient dicotyledonous crop belonging to the *Polygonaceae* family. Of the 20 species in the genus *Fagopyrum*, only two namely *Fagopyrum tataricum* (Tartary buckwheat), grown at lower altitudes and *Fagopyrum esculentum* (common buckwheat) thrives at higher elevations across India (Chauhan *et al.*, 2010). Buckwheat is particularly well-suited for cultivation at higher altitudes where the growing season is brief.

It performs well in various cropping systems due to its short growing period (3-4 months) and its ability to adapt to low temperatures and moisture-stressed conditions (Luitel *et al*., 2017).

Globally, buckwheat is cultivated over an area of 2.4 million hectares, with an average production of 2.4 million tones and a productivity rate of 1000 kg/ha. Russia leads in both the cultivation area (1.12 million hectares) and production (1.19 million tones) of buckwheat, while France boasts the highest productivity at 3735 kg/ha. In India, buckwheat is primarily grown in the Himalayan region, with greater diversity observed in the western Himalayas (Rana, 2004). Its cultivation spans from Jammu and Kashmir in the north to Arunachal Pradesh in the east and Tamil Nadu in the south. The main regions for buckwheat cultivation in India include Jammu & Kashmir, Himachal Pradesh, Uttarakhand, West Bengal (particularly in Kalimpong, Coochbehar, New Jalpaiguri, and Darjeeling), Sikkim, Assam (Upper Assam), Arunachal Pradesh, Nagaland, Meghalaya (at higher elevations), Manipur, Kerala, Tamil Nadu (in the Nilgiris and Palani hills), and Chhattisgarh. Of the two widely cultivated species, Tartary buckwheat is typically grown at higher altitudes above 2500 meters, whereas common buckwheat is usually found at lower altitudes (up to 1000 meters).

Buckwheat is gaining recognition as a health food due to its abundance of nutrients such as protein, high lysine content, fiber, minerals, vitamins and the bioflavonoid rutin (Ikeda *et al*., 2008). Rutin and other flavonoids from buckwheat are increasingly sought after in the food, pharmaceutical and cosmetic industries because of their beneficial biological and physiological effects, including antioxidant, anti-inflammatory and anti-hypertensive properties. Additionally, buckwheat can be transformed into a variety of value-added products, such as cakes, instant powders, wine or vinegar enhancing the economic return for farmers.

Despite its high nutritional value, the global decline in buckwheat cultivation and production is concerning. Many farmers are opting to use their land for off-season vegetables, fruits and medicinal plants that offer higher economic returns. To make buckwheat a more attractive crop, increased investment in research and funding is needed for the development of better cultivars, improved crop management practices to boost yields, and expanded industrial and pharmaceutical applications. Although buckwheat remains an underutilized crop in India, it still plays a crucial role in ensuring food and nutritional security for people in remote rural areas.

9.2 Importance of Buckwheat:

Buckwheat possesses the capability to fix atmospheric nitrogen (Alekseyeva, 2002) and solubilize native soil phosphorus and potassium (Kontturi *et al*., 2004) making it a valuable crop in nutrient-poor soils. It is a versatile crop cultivated for various purposes, including human consumption, livestock feed, green manure (Tsuzuki, 2001), soil stabilization (Tundup *et al*., 2017) and as a smother crop (Xuan and Tsuzuki, 2004). It is also beneficial for attracting pollinators and natural pest enemies which helps in pest control (Valenzuela and Smith,2002). Its tender leaves can be used as leafy vegetables, and the plant is known for its high nectar yield, particularly in the morning.

The protein content of buckwheat seeds is high (11-14%) with a well-balanced amino acid profile, including lysine (5.5-6%) and arginine (9.2-10%) which are often deficient in cereals. Additionally, buckwheat grains are rich in minerals such as calcium (110 mg/100 g), magnesium (390mg/100 g), phosphorus (330 mg/100 g), potassium (450 mg/100 g), iron (4 mg/100 g), manganese (3.37 mg/100 g), copper (0.95 mg/100 g) and zinc (0.87 mg/100 g) (Campbell, 1997). It also contains biologically active compounds like rutin and quercetin known for their anti-diabetic, anti-inflammatory and cardiovascular benefits (Jiang *et al.*, 2007).

Tartary buckwheat, in particular, has higher concentrations of these compounds compared to common buckwheat. Due to its high nutritional value and bioactive compounds, buckwheat is a beneficial dietary food, particularly for those with celiac disease as it is gluten-free. In some regions of India, buckwheat grains are popped and consumed, and its leaves are used as vegetables. Buckwheat seeds are also used in various culinary dishes and alcoholic beverages. In northern India, buckwheat flour, known as "Kuttu Ka Atta," is consumed during religious fasts when cereals and pulses are restricted (Rana *et al*., 2011). Given its nutritional benefits and potential applications, buckwheat could serve as a valuable industrial food crop in agriculture.

9.3 Plant Biology:

Buckwheat is a summer fast growing annual with rather coarse, branched & hollow stems and large, broadly arrow-shaped leaves. The plants can grow between 40 and 120 cm in height. The plant produces many small self-sterile white or pink flowers that, when pollinated, quickly produce triangular seeds and change from light green to red-brown. Flower, panicles and leaves rise from the nodes 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. The fruit appears dark brown with pale brown triangular testa. Unlike cereals, endosperm is white, opaque and starchy. The seeds are pointed, broad at the base and range from triangular to nearly round in cross-section. Seeds consists of an outer hull, an inner seed coat and starchy endosperm enclosing the germ (Cawoy *et al*., 2009).

9.3.1 Climate:

Common buckwheat is a facultative short-day plant (Quinet *et al*., 2004) that thrives in cool, moist temperate regions, though its seeds can also germinate in very dry areas. It is typically cultivated under low-input conditions and is well-suited to highland areas, where extreme climates have led to significant genetic diversity among landraces and traditional varieties. The crop is sensitive to high temperatures and hot, dry winds, particularly when moisture is limited. Tartary buckwheat, on the other hand, is more resilient than common buckwheat, tolerating poor soil and extreme weather conditions better. Buckwheat can germinate and grow within a temperature range of 5°C to 42°C, with the optimal temperature for germination and growth being between 24°C and 26°C. However, temperatures above 30°C during the flowering stage can cause flower blasting, fruit desiccation, and reduced grain yield (Drazic *et al.*, 2016).

Adequate soil moisture is crucial for achieving good yields. Buckwheat wilts and grows very slowly under poor moisture conditions but often resumes growth and matures late once it receives sufficient moisture.

9.3.2 Varietal Development:

Varietal development in buckwheat involves the selection and breeding of cultivars with desirable traits such as high yield, disease resistance, adaptability to various growing conditions, and nutritional quality. This process aims to enhance the productivity and performance of buckwheat crops to meet the diverse needs of farmers and consumers. Through careful breeding programs and genetic research, new buckwheat varieties are developed to address specific challenges faced by growers and to capitalize on emerging market demands. Additionally, varietal development may focus on improving the nutritional content, flavor and processing characteristics of buckwheat to enhance its value and versatility in various food and industrial applications.

Table 9.1: Varieties of buckwheat

Variety	Species	Institute
Himpriya and Himgiri	*Fagopyrum tataricum*	NBPGR Regional Station, Shimla, Himachal Pradesh
VL7	*Fagopyrum esculentum*	VPKAS, Almora, Uttarakhand
PRB1	*Fagopyrum esculentum*	GBPUAT Hill Campus, Ranichauri, Uttarakhand
Sangla B1	*Fagopyrum tataricum*	CSKHPKV, Palampur, Himachal Pradesh

(Source: Rana *et al*., 2016)

9.3.3 Soil:

Buckwheat demonstrates remarkable resilience, thriving in diverse soil conditions including infertile, rocky and poorly tilled lands (Khanh *et al*., 2005), where other grain crops may struggle to grow. However, it is best suited for well-drained, slightly acidic sandy loam soils (Jung *et al*., 2015). Buckwheat does not fare well in saline or semi-arid regions. To prepare the land for buckwheat cultivation, thorough ploughing and proper levelling are essential (Horie *et al*., 2012). Typically, one deep ploughing followed by 2-3 harrowing's is sufficient for sowing the crop.

9.3.4 Seed and Sowing:

In India, the sowing of buckwheat typically commences with the onset of the monsoon and extends up to August (Hore and Rathi, 2002), though this timeframe can vary depending on regional climatic conditions.

At lower altitudes, buckwheat is commonly sown between May and August, while at higher altitudes, the optimal sowing window is April to May (Ratan and Kothiyal,2011). The recommended seed rate for buckwheat ranges from 35 to 40 kg/ha for grain crops and 50 to 60 kg/ha for cover, vegetable, or fodder crops (Hore and Rathi, 2002).

Overly dense plant stands can lead to spindly plants with short stems and reduced seed production, so thinning is advisable around 15 to 20 days after sowing to achieve the desired plant population (Tolaini *et al.*, 2016).

Achieving an optimum plant population is crucial for maximizing yields in indeterminate crops like buckwheat. Studies have indicated that the maximum grain yield of Tartary buckwheat in the rainfed hilly regions of India was achieved with a planting geometry of 40 cm × 10 cm (Rana *et al.*, 2005).

However, for common buckwheat, a planting geometry of 30 cm × 10 cm was found to be suitable. The recommended seeding depth for buckwheat is approximately 4 to 6 cm, although deeper seeding may be warranted under drier conditions (Bjorkman, 2012).

Table 9.2: Sowing Time of Buckwheat in Different Parts of India

Sr. No.	Regions	Sowing Time
1.	North-Western hills	June–July (Rainy season) ad March–April (spring season)
2.	North-Eastern hills including Assam	August–September, (October–November in Sikkim under intensive cropping systems)
3.	Nilgiri hills (Tamil Nadu)	April–May
4.	Plani hills (Tamil Nadu) and Kerala	January
5.	Chhattisgarh	September–November

(Source: Babu *et al.*, 2016)

9.3.5 Manures and Fertilizers:

Buckwheat is often considered a suitable crop for cultivation in soils with poor fertility conditions (Rana *et al*., 2003). Its nutrient requirements are relatively modest and it is typically grown on residual soil fertility (Radics and Mikohazi, 2010).

For optimal yield, it is recommended to apply 20 kg of nitrogen, along with 10 kg each of phosphorus and potassium per hectare. This fertilizer application is preferably done one day before sowing.

9.3.6 Weed Management:

Buckwheat is known for its rapid growth, typically emerging within 4–5 days after sowing. Consequently, the critical period for weed management falls between 20–30 days after sowing (DAS). In certain regions, higher seeding rates, often 2-2.5 times the normal rate, are employed to suppress weed growth and protect soil from erosion, especially in hilly areas of India (Choudhury and Prem, 2007).

Despite its effectiveness in weed suppression, controlling weeds during the establishment phase remains a challenge in various production systems. Common weed species in buckwheat fields include *Digitarias anguinalis*, *Amranthus retroflexus*, *Ambrosia temisiifolia* and *Chenopodium album*.

To minimize weed infestation, a single weeding session at 20–30 DAS is recommended. However, manual weeding can be laborious, time-consuming, and costly. To mitigate these challenges and enhance profitability, the application of alachlor at a rate of 1.50 kg/ha is suggested to minimize weed losses in buckwheat cultivation (Rana *et al.*, 2004).

9.3.7 Water Management:

Buckwheat has relatively low water requirements compared to major cereal crops like wheat, maize, and rice, making it well-suited for rainfed areas with limited water resources.

It typically requires about 225–315 liters of water to produce 1 kg of buckwheat seeds, in contrast to the 800–1000 liters needed for wheat seeds (Jacquemart *et al.*, 2012). In regions such as northeast India, where water availability is limited, buckwheat is commonly cultivated as a rainfed crop without irrigation.

However, to ensure profitable and high-quality buckwheat production, one or two irrigations can be beneficial, particularly during the flowering and grain formation stages if water resources permit. This supplemental irrigation can help optimize yields and enhance the overall quality of the crop.

9.3.8 Cropping Systems:

Buckwheat is a versatile, short-duration crop that is well-suited for intensive cropping systems, particularly in mid-hill and plain regions, where it serves as a catch crop (Baniya *et al.*, 2000).

In India, buckwheat is cultivated as a summer crop at higher altitudes, an autumn crop in mid-altitudes, and a winter crop in the plains and foothills. In high-hill areas with short growing seasons, mono-cropping of buckwheat is common.

In mid-hill regions, buckwheat is typically grown following maize in upland conditions and rice in lowlands. Various cropping systems based on buckwheat are prevalent, catering to different agro-climatic conditions and cropping patterns.

Table 9.3: Buckwheat Based-Cropping Systems Prevailing in The Himalayan Region

High Himalaya	Mid Himalaya	Lower Himalayan region and foot- hills
Buckwheat–Fallow	Buckwheat–Wheat	Potato–Buckwheat–Barley
Pea–Buckwheat	Buckwheat–Pea	Cabbage–Buckwheat–Wheat
Potato–Buckwheat	Buckwheat–Mustard	Tomato–Buckwheat–Pea
	Buckwheat–Lentil	Potato–Buckwheat–Mustard/Lentil
	Maize/Rice–Buckwheat	
	Maize (Green cobs)–Pahenlo dal–Buckwheat	

(Source: Babu *et al.,* 2016)

Insect-Pest and Diseases: Buckwheat is relatively free from serious insect-pest and disease problems.

9.3.9 Harvesting and Threshing:

As an indeterminate crop, buckwheat lacks synchronized maturity, necessitating the swathing operation to minimize losses from shattering. Shattering can lead to significant yield losses, estimated at around 20–25% in buckwheat (Campbell and Gubbels, 1986). Therefore, it is advisable to cut the crop when approximately 70–80% of the seeds have turned brown, indicating physiological maturity. The harvested crop should then be placed in windrows to facilitate drying until the seed head reaches a moisture content of 16–18%, after which it can be safely stored at 13% moisture content. Under normal conditions, buckwheat can be harvested approximately 90–100 days after sowing. A well-managed buckwheat crop typically yields around 10-15 quintals of grain per hectare.

9.4 Conclusion:

Despite its numerous benefits, farmers are increasingly losing interest in buckwheat cultivation due to its relatively low productivity and profitability when compared to high-value crops such as French beans, fruits, flowers, off-season vegetables, spices, and medicinal plants. This trend highlights the urgent need for the development of region-specific agronomic management practices, high-yielding buckwheat varieties, and advanced post-harvest technologies to enhance productivity and profitability for growers.

To increase buckwheat cultivation and production, appropriate policy and scientific interventions are essential. These measures would help buckwheat emerge as a superfood capable of feeding the growing population, especially in remote hilly regions, under changing climatic conditions.

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