

Buckwheat cultivation potentially

enhance cropping intensity and income security of low input hill agro-ecologies under climate change

Krishnappa Rangappa*, Amit Kumar, Prabha Moirangthem, Jayanta Layek, Ayam Gangarani Devi, Pankaj Baiswar, L. Joymati Chanu, Samarendra Hazarika and Vinay Kumar Mishra

ICAR Research Complex for North Eastern Hill Region, Umiam, Meghalaya 793 103

Standardisation and intensification of diversified climate resilient farming systems having crops with increased climate stress resilience for more adaptability under fragile hill agro-ecologies of low population states of Eastern Himalaya Region (EHR) is need of the hour. Buckwheat, one of the forgotten and underutilised crop with year round cultivation prospects harbouring inherent stress adaptive mechanisms to overcome prevailing low moisture stress cum low pH soil induced low nutrient environments of hill slopes, is emerging as one of ideal crop for increasing cropping intensity and food security of hill inhabitants of EHR. Development and promotion of scientific cultivation practices with adoption of proper time of sowing between October to mid-December at mid-hills of Ribhoi district, April-May months in East Khasi hills, Garo hills and Jaintia hills of Meghalaya is paramount for achieving economic yield to the tune of 1.5–1.80 t/ha wherever the crop is suitable to cultivate anytime of the year for higher green biomass (1.26–3.84 t/ha). Enhanced low moisture stress tolerance ability and pronounced rhizosphere acidification with exudation of low molecular weight organic acids like oxalic acid by cultivated buckwheat cultivars under low phosphorus (P) conditions of acid soil has increased solubilisation of fixed forms of P vis a vis for enriching the soil with desirable root microbiome make the crop more productive under marginal hill environments of EHR. Some cultivars, viz. IC377275, IC26591, IC14890, IC37288 and Himpriya shown promising yields of 1.89 t/ha, 1.71 t/ha, 1.63 t/ha, 1.55 t/ha, 1.53 t/ha, respectively with adoption of scientific cultivation packages in hill slopes. Holistic understanding of interactive effects of acid soil and moisture deficit stress and strengthening of further crop improvement of robust crops like buckwheat could aid in enhancing food security and cropping intensity in EHR.

Keywords: Fragile hills, Low pH, Low moisture stress, Rhizospheric acidification, Yield

EASTERN Himalaya Region (EHR) of India is distinctly characterized by diverse edapho-climatic conditions, rich bio-diversity and unavoidable geographical constraints. Majority of farming in this region is considered as primarily rainfed and current cropping intensity being low ($\approx 120\%$) indicating huge scope for developing resilient cropping systems with higher productivity. Around 85% of total rainfall (240-250 cm per annum) is received during *kharif* months. During second season, crop lands/fallows after rice and maize cultivation remain uncultivated. For increasing cropping intensity, there is need of developing stress adaptable

crops with higher yield under moderate to severe water scarcity and low pH soils that prevail in hill slopes. Low nutrient conditions also frequently occur owing to unprecedented erosion of top soil and predominance of traditional cultivation of exhaustive crops like turmeric and non-adoption of scientific package of practices are challenges for enhancing food and livelihood security in the region.

Buckwheat (*Fagopyrum esculentum* Moench), one of the lesser known gluten free short duration pseudo-cereal having multipurpose utility is found suitable for sustainable cultivation under marginal and degraded



Buckwheat crop at blooming stage with full canopy

Palani hills of Tamil Nadu.

Nutritive value

Grains of buckwheat majorly contains quality protein ($\approx 11-13\%$) that are rich in lysine and tryptophan, antioxidant like flavonoids, viz. rutin and quercetin, unique source of vitamins, nutri-elements like zinc and Fe, polyphenols and digestive fibre because of which this crop is considered as promising crop in the region especially with

scientific organic mode of cultivation. It emerged as good food for keeping heart health by lowering cholesterol, blood pressure, blood sugar (with low glycemic index) and promotes healthy digestion with improved gut health. Slowly digested starch of its groats is valuable for diabetics because it aid in flattening of glycaemic response curve with prolonged endurance and extended duration of satiety. Increased content of the rutin in their foliage have more relevance for increased fragility of capillaries which is associated with hypertension/haemorrhage/purpura and bleeding from kidney.

Types of buckwheat

There are two species such as Common buckwheat (*F. esculentum* Moench) and Tartary buckwheat (*F. tataricum* Gaertn). Achenes of *F. tataricum* are grooved with acute angles while achenes of *F. esculentum* are not grooved without such sharp acute angles. Former buckwheat has bigger grains with smooth husks growing well at lower altitudes while the later has tougher husks and suitable to grow at high altitudes. Tartary buckwheat has more levels of rutin and other bioactive compounds and harbour substantial adaptability to cooler and low moisture environments than common buckwheat.

Agro-climatic suitability of buckwheat for hill slopes of NEH region

Even though buckwheat could be able to grow in different type of soil, it is more favourably suited to sandy loam, loam and silt loams of hill slopes with proper drainage. It increasingly grows better in acid soils with reduced soil moisture. As it is low temperature loving plant and preferably grow well under moderate to low moisture conditions of the soil, crop like buckwheat suits well to grow under rice and maize based fallows where the productivity of other crop like pulses is challenging. During the low moisture stress or low nutrient stress condition, buckwheat crop has a mechanism to adopt with extensive root growth and other physiological adaptations.

It is often preferred to grow as rapid crop of contingency under vagaries of climate change. In Ribhoi district of Meghalaya, winter months like sowing in October/ November/December is preferred because the crop could produce yield upto 9.7 q/ha and 11.0 q/ha with shorter duration even with adverse conditions like low moisture and unexpected frost damages. In

lands of mountain ecosystem. Round and hollow knotted stem, commonly visible tinged with red and greenness bears heart shaped leaves with reticulate venation and dimorphic flowers arranged in compound raceme inflorescence. The flowers of different type of colours from white or light green to pink or red and the seeds are triangular in shape which is actually called as 'achene' having dark brown and tough rind. This form of seed is considered as a fruit rather than a grain with a exclusion from Gramineae or Poaceae even with similarity of grains. The husk of seed is ideally used as filling for pillows or mattresses, sometimes as cushioning in packaging and as prime item for heating, etc. Buckwheat is necessarily cross pollinated through bees, hoverflies, butterflies, wasps, and ants which is highly essential for improved seed production due to its self-incompatible and distylous flowers that exists in two forms: pin (long pistil, short stamens) and thrum (short pistil, long stamens). Even though pollination happens through wind, insect activity is crucial for maximizing seed yield which offers scope for quality honey production. However flowers of buckwheat act as good source of nectar for honey owing to their long flowering period.

It is a versatile pseudo-cereal with its gluten-free nutty flavour for myriad nutritional benefits and culinary purposes ideally for both sweet and savory dishes, viz. pancakes, crepes, gluten-free baked goods, as well as whole groats for porridges, salads, soba noodles and even in preparation of alcoholic drinks. Many efforts were also made to promote it for tea, sprouts, bio-greens and tender shoots are used as leafy vegetable which offers a unique sustainable and healthy alternative to traditional grains. The flowers and green leaves are also used for extraction of rutin which generally used in medicine and green leaves are used good fodder for cattle and hill goats. Because of its fast growing ability, it can escape weed competition. Sprouts of buckwheat could act as a fresh salad, vegetable and various other purposes like natural vegetable juice source. The products of buckwheat are used in regular diets of some tribes of Arunachal Pradesh as other staples like rice could not be properly cultivated due to prevailing low temperatures. In India, it is cultivated in states of high altitude regions, viz. Jammu and Kashmir, Himachal Pradesh, Uttarakhand, Sikkim, Arunachal Pradesh, West Bengal, Meghalaya, Assam, Manipur, and Nagaland and in some stretches of southern states like Nilgiris and

addition, it is known for nonchemical weed suppression as it grows faster and also its shade the weeds or out competes weeds for increased nutrient and water uptake with denser crop stands.

Table 1. Vegetative growth and yields of local buckwheat (var. Gossigaon local) in Meghalaya

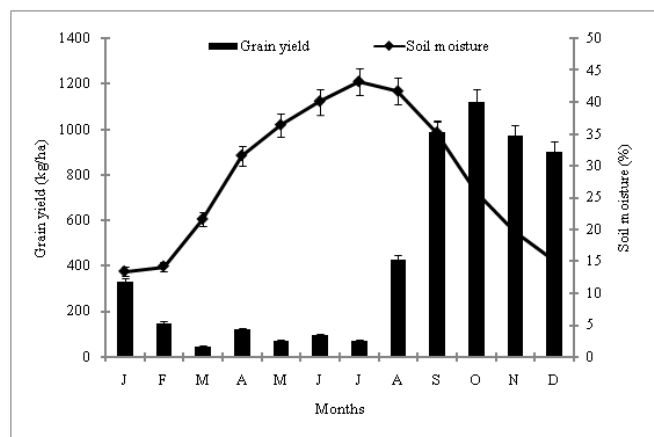
Sowing time	Plant height (cm)	Duration (days)	Grain yield (q/ha)	Straw yield (q/ha)
October	87.8	132	9.73	10.2
November	54.6	143	11.0	10.1

It nicely fit into low input agriculture of hill slopes or jhum cultivated areas of eastern Himalaya with fewer incidences of disease and pests and with less external inputs like nutrient manures and irrigation for the successful cultivation. Small and marginal farmers of this region practicing *jhum* cultivation (in ≈ 1.38 mha) could effectively cultivate this crop with substantial stress tolerance. Low soil moisture conditions of hill slopes like 12.0–15.0% was more preferred over excess moisture (18.0–28.0%). Apart from remunerative crop yields with low inputs, it is more helpful in preventing soil erosion and restoration of soil fertility across hill slopes. Appropriate technology transfer with needful policy interventions for adequate value addition and marketing might help in popularising this crop in eastern Himalayan conditions.

The results of one experiment conducted in our institute farm showed that lowest yield observed in the months of May (0.123 t/ha) and April sowing (0.132 t/ha) owing to incidence of high intensity rainfall. As low temperature and low humidity prevails during *rabi*, planting in October to December months results in more economical yields (0.973 to 1.1 t/ha) with increased harvest index. The water content in the soil was higher (44.0%) in July and lower in the months of January (14.5%) and February (15.1%).

Buckwheat is robust moisture stress tolerant crop of EHR

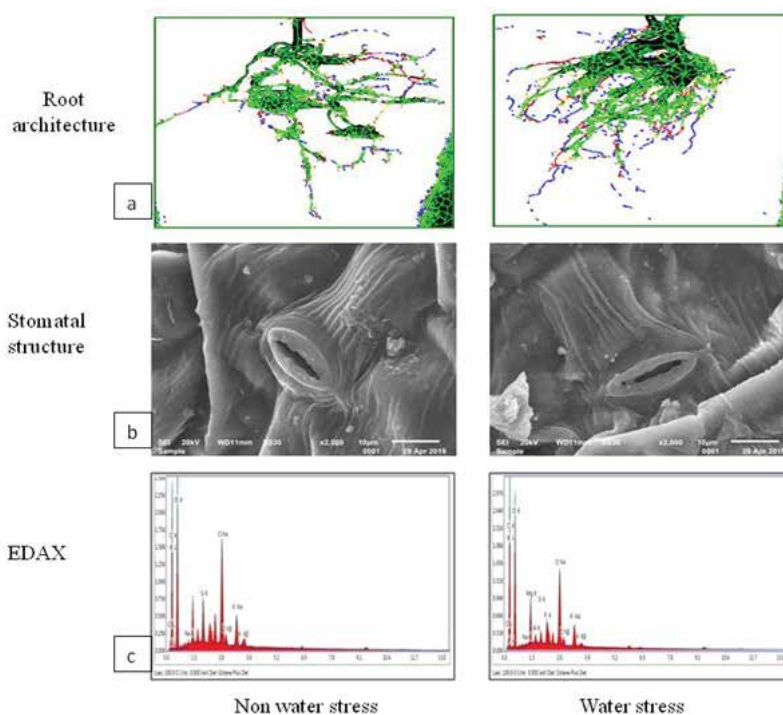
During winter months, buckwheat cultivation undergone varied levels of water deficit and imminent low pH induced edaphic impacts on its crop physiology. Usually water deficits over lesser time, plants produce more biomass per unit of water consumed by lowering loss of water rate; whereas under longer moisture deficit, the conductivity of stomata is lowered with corresponding changes in root growth, pore structure and cuticle deposition. Root architecture and stomatal characteristics with leaf cuticle features significantly altered under water deficits (10–15% soil moisture) of hill slopes. Since the root system is slowly



Trends of buckwheat grain yield with associated changes in soil moisture

explored as key source for water deficit stress tolerance and adaptation, fibrous roots with a deeper taproot distributed in the upper surface of soil significantly help in soil binding and check erosion during the rainy season.

The leaf contents particularly chl b and carotenes could able to scavenge free radicals to reduce oxidative stress and thereby confer tolerance to water deficit conditions with minimal effects on leaf photosynthetic machinery. Modulation of carbon metabolic machinery under varying radiation levels of slopy terrains is pivotal for robust crop such as buckwheat. Under water deficit, the pore dimensions slightly reduced or shown partial closure (at lower side) but in water sufficient conditions pore remains open. Pore dimensions and extent of distribution on the epidermis could reasonably alter photosynthetic parameters. Changes in wax deposits could overcome free escape of vapours of moist liquid through living surfaces of canopy and accordingly vary



Root architecture, stomatal structure and EDAX (Energy dispersive x-ray analysis) of high yielding buckwheat under water stress and non-water stress conditions

the nutrient uptake and accumulation in leaves under water deficit and water sufficient circumstances.

Enhanced phosphorus uptake in low pH status of hill slopes

Phosphate availability in low pH of hill slopes is important limitation for higher productivity as active phosphate ions binds to other elements such as Fe and Al in addition to low mobility of ions making available phosphate levels lower than the plant requirement. Even though higher doses of P rich manures incorporated into the soil, phosphate ions get precipitated to form inorganic and organic complexes. This means that almost all plant P uptake comes from the soluble soil Pi pool, suggesting that Po must first be converted to the Pi forms for plant uptake. In addition to white lupin, buckwheat (BW) has been classified as P uptake efficient. Even when total soil P may be high, >80% still exists in forms that are unavailable to plants, with inorganic phosphorus (Pi) in most top soils between 25% and 75% and organic P (Po) within the same range. Various mechanisms involved in efficient P uptake by plants such as lupins and robust crops like as *Fagopyrum* under low phosphate levels along with adequate variability in rhizospheric level modulation including exudation of low molecular weight organic acids such as oxalic acids secreted to dissociate fixed forms of phosphate complexes in concomitance with favourable physiological traits.

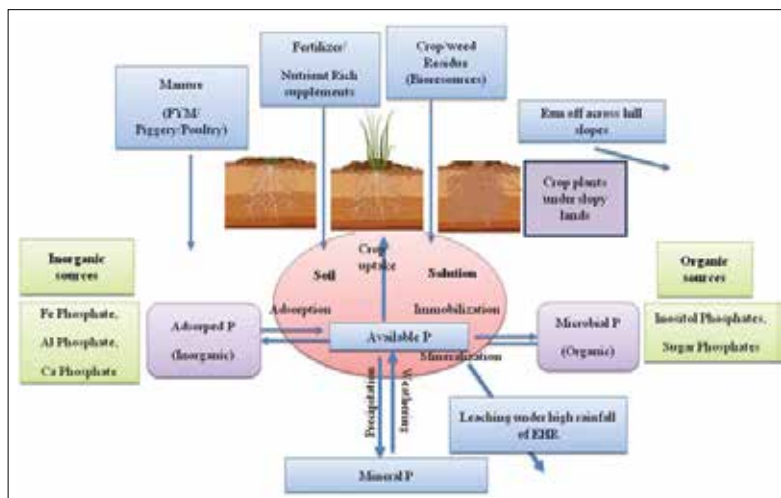
In the study conducted by Jasper and David (2011), it was shown that buckwheat can significantly solubilize phosphorus (P) from sparingly soluble soil P to subsequent crops. Calcium-bound P contributed the most P (72% of inorganic pool) to the available fraction, and P uptake by buckwheat (40 kg/ha) was significantly greater than wheat (16 kg/ha) from the inorganic pools, whereas wheat uptake was significantly greater from the organic pool. Following harvest, more P was found in available P pools after buckwheat suggesting potential solubilisation of P to subsequent crops compared with wheat. Buckwheat is often called a P scavenger because it can take up soil P more efficiently than other plants. In its growing stage, the roots of buckwheat

exude substances that help to solubilise P that may otherwise be unavailable to plants. The roots of buckwheat were also found to have a high storage capacity for inorganic P. As a result, when buckwheat plants are incorporated in the soil, they decay quickly, making phosphorus and other nutrients available to the succeeding crop.

The ability of buckwheat roots to acquire phosphorus (P) was characterized by morphological features, and chemical changes in the rhizosphere. Root exudates of low-P plants have lower pH values than exudates of high-P plants and increased the solubility of FePO_4 and MnO_2 to a greater extent. Enhanced hydrolysis of glucose-6-phosphate by exudates from low-P plants was due to an increased "soluble" acid phosphatase activity. And root surface phosphatase activity was also slightly enhanced with P deficiency. In the rhizosphere soil of buckwheat, some depletion of organic P forms was also observed. The mechanisms conferring P efficiency have to be associated with either the acquisition of P nutrient from the environment or the movement and distribution within the plant, or the utilization in metabolism. Efficient acquisition of P under insufficient supply like acid soils of HER may be due to a higher ability to explore the soil by a more extensive root system (with rapid development, higher root to shoot ratio, finer and longer roots and root hairs), or a greater ability to absorb P from a dilute solution (i.e. an efficient uptake mechanism). Exudation of reducing, chelating, and/or acidifying substances by the roots, resulting in solubilization of soil P, may also be of importance.

As buckwheat known for P solubilisation, some studies were conducted to confer its potential in intercropping systems. Intercropping of buckwheat can improve the productivity of cropping systems due to increased soil nutrient availability and plant nutrient use efficiency. A 2-year field experiment was conducted to determine the effects of different intercropping ratios and fertilizer types on nitrogen (N) and phosphorus (P) concentrations and yields of fenugreek and buckwheat at the research farm of Shahrekord University, Iran (Aliyeh *et al.* 2018). The treatments consisted of sole

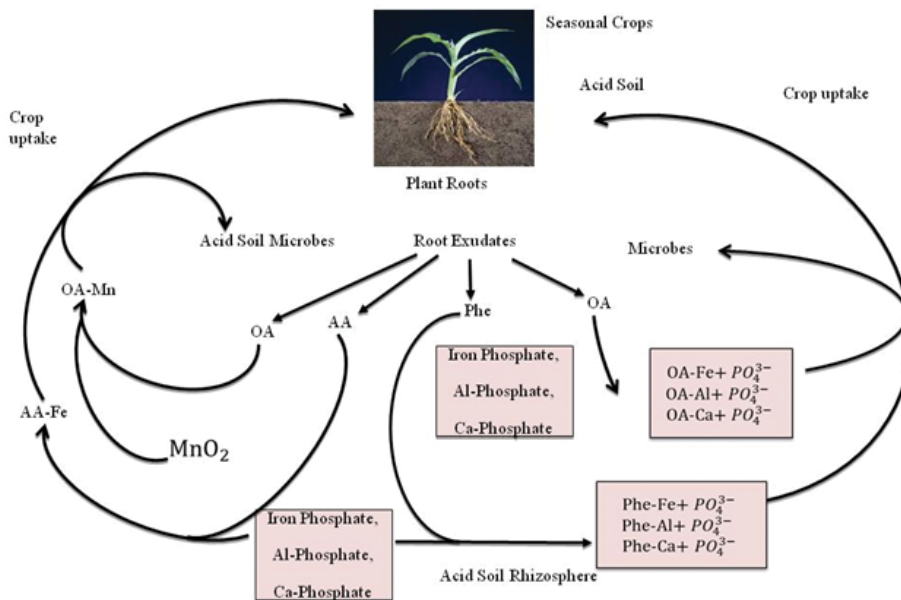
cropping of fenugreek (F), buckwheat (B) and three intercropping ratios (F:B = 1:2, 1:1 and 2:1) under three fertilizer types: chemical fertilizer (CF), integrated fertilizer (IF) and broiler litter (BL). At flowering and at harvest, intercropping increased total above-ground dry matter, total seed yield, N and P concentrations (plant) and uptake. The applied N use efficiency (ANUE) and applied N recovery efficiency (ANRE) in the intercropped plots were also higher as compared to the sole cropping. The intercropping ratio of F:B (2:1) was the most suitable for improving the tested nutrient variables. The IF and BL showed significant benefits as compared to CF, total seed yield, NC and PC in the plant, as well as N and P uptake in sole and intercrops. For ANUE and ANRE, CF proved to be more effective.



Fate of added phosphorus in acid soil: P fixed either through adsorption, immobilization and precipitation

SUMMARY

Specialised stress adaptive mechanisms apparent in buckwheat up-regulated under stressful environments of hill slopes of EHR designate the crop as more suitable for cultivation in the region for higher grain productivity during winter months (mid-September to October) but found better for producing higher green biomass during all through the year. Root morphological traits, photo-protective pigments and stomatal modifications were emanated as beneficial stress rescue mechanisms in buckwheat to overcome inimical moisture stress and soil acidity conditions of hill slopes of EHR under changing climate. In view of its increased resilience and sustained productivity under marginal hill environments, it was found remunerative and potential stress tolerant crop for increased cropping intensity and food security with prevailing low input agriculture in the region.

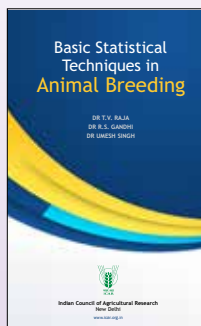


Effects of root exudate components on nutrient availability and uptake by plants and rhizosphere microbes. OA; organic acids; AA, amino acids including phytosiderophores; Phe, phenolic compounds.

Therefore 2:1 fenugreek–buckwheat intercropped system with the application of IF and BL can successfully be implemented for improving productivity, N and P contents of fenugreek and buckwheat as well as the nutrient land equivalent ratio (compared with sole cropping with CF) under semi arid growing conditions of Iran.

*Corresponding author email: krishphysiology@gmail.com

BASIC STATISTICAL TECHNIQUES IN ANIMAL BREEDING



This publication has been designed to cover most of important topics of Animal Breeding which includes some of the basic statistical techniques applied in animal breeding, population genetics and principles of animal breeding. The content of this book is in accordance with syllabus of most of the undergraduate and post graduate courses of Veterinary Science and Animal Husbandry, Animal Science, Dairy Science and Biological Sciences. This book will be useful for Undergraduate and Post-graduate students, teachers of Animal Breeding and Genetics in State Agricultural Veterinary Universities and other educational institutions and also scientists who are associated with animal sciences research.

TECHNICAL ASPECTS

Pages: v + 220; Price: ₹ 700.00, US\$ 90.00; Postage: ₹100

ISBN No.: 978-81-7164-291-5

For obtaining copies, please contact:

Business Unit

ICAR-Directorate of Knowledge Management in Agriculture
Krishi Anusandhan Bhawan – I, Pusa, New Delhi 110012
Tel: 011-25843657; email: businessuniticar@gmail.com
website: www.icar.org.in

SCAN QR Code to Purchase Online

