Nepal Agriculture Research Journal
Vol. 16, No 1, pp. 35-42, 2025
DOI: https://doi.org/10.3126/narj.v16i1.80447

Nutrient management study on tartary buckwheat in Dolakha condition of Nepal

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ARTICLE INFO

Research Paper

Received: February 19, 2025
Revised: February 29, 2025
Accepted: March 25, 2025
Published: June 25, 2025

Contents available at
http://www/sasnepal.org.np

ABSTRACT

Buckwheat (*Fagopyrum* spp) is a sixth staple food crop in Nepal. It's productivity is low in Nepal as compared to other countries. One of the factors of low productivity is poor nutrient management. A field experiment was carried out to study the effect of nutrient management on grain yield of tartary buckwheat at Hill Crops Research Program, Kabre, Dolakha. The field experiment consists of seven fertilizer treatments with different nutrient combination doses, replicated thrice and laid out in randomized complete block design. The tested variety was Tite Phapar-1 and experiments were conducted during 2019, 2020 and 2022. Seven fertilizer treatments were FYM 5 t ha^{-1}, 30:30:30 $N:P_2O_5:K_2O$ kg ha^{-1}, 30:60:30 $N:P_2O_5:K_2O$ kg ha^{-1}, 60:30:30 $N:P_2O_5:K_2O$ kg ha^{-1}, 60:60:30 $N:P_2O_5:K_2O$ kg ha^{-1}, 90:30:30 $N:P_2O_5:K_2O$ kg ha^{-1} and 90:60:30 $N:P_2O_5:K_2O$ kg ha^{-1}, respectively. The results of the experiment showed that grain yield, no. of flower cluster per plant, no. of seeds per cyme were significantly affected by nutrient doses. Tite Phapar-1 variety of buckwheat produced the highest grain yield (2.05 t ha^{-1}) when applied 90:30:30 $N:P_2O_5:K_2O$ kg ha^{-1} followed by 60:60:30 $N:P_2O_5:K_2O$ kg ha^{-1} (1.754 t ha^{-1}) and 60:30:30 $N:P_2O_5:K_2O$ kg ha^{-1} (1.74 t ha^{-1}). Among these three nutrient doses, there was no significant different on grain yield. Therefore, it was concluded that 60:30:30 N: $P_2O_5:K_2O$ kg ha^{-1} could be recommended for Tite Phapar-1 cultivation under Kabre, Dolakha condition and similar soil types and ecology of Nepal.

Keywords: Buckwheat, nutrient dose, Tite Phapar-1, yield

Cited as: Baral BR, S Subedi, JB Adhikari, SB Gurung and NB Dhami. 2025. Nutrient management study on tartary buckwheat in Dolakha condition of Nepal. Nepal Agriculture Research Journal 16(1): 35-42. DOI: https://doi.org/10.3126/narj.v16i1.80447

INTRODUCTION

Buckwheat (*Fagopyrum* spp) is a sixth staple food crop in Nepal. It occupies 3 % area of the total cereal crops cultivated. The area of buckwheat production in Nepal is 13,875 ha, with a production of 15,917 mt and the yield of 1.15 t ha^{-1} (MoALD 2022). Among the seven provinces, Bagmati province has 29.38% of total buckwheat area, followed by Karnali

province (19.08%), Koshi Province (18.41%), Lumbini province (16.32%), Gandaki province (13.92%) and Sudurpaschim province (2.87%). Similar trend was found in production where Bagmati province produced 22.60%, followed by Karnali province (19.40%), Koshi Province (19.09%), Lumbini province (18.90%), Gandaki province (16.98%) and Sudurpaschim province (3.03%). The area and production of buckwheat in Madhesh province is nil (MoALD 2022).

It is considered as an alternate cereal and poor man's crop, representing an important food supply in remote mid-hills and mountains. It is the best crop in higher altitude in terms of adaptation to different climatic variables, water stress regimes and less fertile soil and easily fitted to different cropping patterns due to its short life cycle.

In addition to food purpose, buckwheat has medicinal value and source of household income. It is supplemental to the staple food for diabetes patients. The leaf produced rutin, an important pharmaceutical product which is used to brew tea for the treatment of hypertonia. The food items prepared from buckwheat in Nepal are Dhindo (thick porridge), Roti (bread), Momo (like Dumpling), Lagar (very thick bread), Dheshu (thicker than Lagar), fresh vegetables, dried vegetables, Chhyang or Jaand (local beer), Raksi (alcohol), salad (leaves), pickle (fresh and dry leaves), soup, Ryale roti, Noodle, Sel roti, bhat (rice), sausage, Dorpa dal, tea, vinegar, jam, macaroni, biscuit, cakes etc.

Globally there are eighteen different species of buckwheat. Out of these, *Fagopyrum esculentum* Moench (common buckwheat) and *Fagopyrum tataricum* Gaertn (tartary buckwheat) are under cultivation. Common buckwheat is cross pollinated crop and its cultivation ranges from 60m in Terai to 2200 m in mid hill. It can be successfully grown in low rainfall areas. It is grown as early maturing catch crops in Nepal. Tartary/Bitter type buckwheat is self-pollinated crop and is predominantly cultivated in high hills and mountains (upto 4500 masl).

The productivity of buckwheat in farmer's field is very low and one of the factors for low yield is associated with nutrient management. Location and variety specific nutrient management is necessary to harness production potential. There is very limited study on fertilizer response study in tartary buckwheat. Therefore, this study was carried out with the objective to assess the fertilizer response by tartary buckwheat under loamy soil of mid hill at Hill Crops Research Program (HCRP), Kabre, Dolakha condition.

MATERIALS AND METHODS

Experimental site and climatic condition

A field experiment was conducted at Hill Crops Research Program, Baiteshwor-4, Kabre, Dolakha of Nepal during summer season of 2019, 2020 and 2022. Agro climatically, this location represents mid hill region of the country and characterized by warm temperate climate with moderate rainfall. Geographical site is located at 86^0 9‘ E Longitude and 27^0 38‘N Latitude at an elevation of 1740 m above mean sea level. Soil texture is loamy and soil pH is 5.2 highly acidic with soil organic matter content 2.43%(low), total nitrogen content of 0.10% (Low), available phosphorus content of 89.03 ppm (Very high) and exchangeable Potassium content of 233.46 ppm (Very high).

The total nitrogen was determined by Kjeldhal distillation unit (Bremner and Mulvaney 1982), available phosphorus (P) by modified Olsen‘s method (Olsen et al 1954) by using

spectrophotometer and available potassium (K) by ammonium acetate method (Jackson 1967). Organic matter content was determined by Walkley and Black method (Walkley and Black 1934), pH (1:1 soil: water suspensions) by Beckman Glass Electrode pH meter (Jackson 1973) and soil texture by hydrometer method (Bouyoucos 1927). Based on many years climatic data, average annual rainfall was 2323 mm. Similarly, average minimum temperature was 7.0^{o}C and average maximum temperature was 27.5^{0}C. Generally, November and December fall under drought.

Experimental set up and cultural practices

The field experiment consists of seven fertilizer treatments, replicated thrice and laid out in randomized complete block design. The tested variety was Tite Phapar-1 and treatments were FYM 5 t ha^{-1}, 30:30:30 N:P_2O_5:K_2O kg ha^{-1}, 30:60:30 N:P_2O_5:K_2O kg ha^{-1}, 60:30:30 N:P_2O_5:K_2O kg ha^{-1}, 60:60:30 N:P_2O_5:K_2O kg ha^{-1}, 90:30:30 N:P_2O_5:K_2O kg ha^{-1} and 90:60:30 N:P_2O_5:K_2O kg ha^{-1}, respectively. Among the fertilizers, total dose of P and K fertilizers as well as half dose of N was applied at sowing time and remaining half dose applied after weeding. Seed sowing was done on September first week of each year with spacing of row to row 25 cm and plant to plant continuous. The seeding was done with the seed rate of 60 kg ha^{-1}. The total plot size was 10 m^2. Plant population was maintained with thinning on week after emergence keeping plant to plant 5 cm distance. Weeding was done one month after sowing. The crop was harvested on the third week of November each year.

Observation, data recording and data analysis

Agronomic and morphological data such as plant height (cm), days to 50% heading, days to 75% maturity, no. of primary branches per plant, no. of floral cluster per plant, no. of seeds per cyme, thousand grains weight(g), grain moisture content (%) and grain yield (t ha^{-1}) were recorded. Analysis of variance (ANOVA) was carried out to assess the treatments effects and mean comparisons among treatment means were done by the least significant difference (LSD) test at 5% levels of significance (Gomez and Gomez 1984).

RESULTS

Effect of fertilizers on growth and yield attributes

There was significant effect of fertilizers dose on days to 50% heading during 2022 but not significant effect in 2019 (Table 1). There was not much difference on mean heading days due to fertilizer dose. The days to 75% maturity was not affected by the fertilizer application. The plant height was significantly affected by fertilizer treatments during 2022 but not during 2019 and 2020 (Table 2). During 2022, the highest plant height was recorded on 60:30:30 N:P_2O_5:K_2O kg ha^{-1}. The no. of primary branches per plant was not significantly affected by fertilizer doses in all the three years (Table 2). The floral cluster per plant was significantly affected by fertilizer dose during 2022 but not on 2019 (Table 3). During 2022 the highest no. of floral cluster per plant was recorded on 60:30:30 N:P_2O_5:K_2O kg ha^{-1} and the lowest no. of floral clusters per plant was recorded on FYM 5 t ha^{-1} treatment. The no. of seeds per cyme was significantly affected by fertilizer dose during 2019 but not differed during 2020 and 2022 (Table 3). During 2019, the highest number of seeds per cyme was recorded from 90:30:30 N:P_2O_5:K_2O kg ha^{-1}. Thousand grains weight was not significantly affected by fertilizer doses (Table 4).

Table 1. Effect of fertilizers application on phenology of tartary buckwheat at HCRP, Kabre, Dolakha during 2019 and 2022.

Treatments	DTH			DTM		
	2019	2022	Mean	2019	2022	Mean
FYM 5 t ha^{-1}	49.0	32.0	40.5	87.0	75.3	81.2
30:30:30 N:P_2O_5:K_2O ha^{-1}	47.0	32.3	39.7	88.0	75.0	81.5
30:60:30 N:P_2O_5:K_2O ha^{-1}	50.0	33.0	41.5	86.0	74.0	80.0
60:30:30 N:P_2O_5:K_2O ha^{-1}	47.0	32.0	39.5	88.0	76.0	82.0
60:60:30 N:P_2O_5:K_2O ha^{-1}	46.0	33.0	39.5	88.0	74.7	81.4
90:30:30 N:P_2O_5:K_2O ha^{-1}	47.0	32.3	39.7	88.0	75.7	81.9
90:60:30 N:P_2O_5:K_2O ha^{-1}	46.0	32.3	39.2	87.0	75.7	81.4
Grand mean	47.0	32.4	39.7	88.0	75.1	81.6
P value	0.57	0.02		0.28	0.70	
LSD(0.05)		0.7				
CV (%)	10.8	1.2		1.1	2.1	

Note:DTH=Days to 50% heading, DTM=Days to 75% maturity, LSD=Least significant difference at 5% level, CV%=Coefficient of variance

Table 2. Effect of fertilizers application on plant height and no. of primary branches per plant of tartary buckwheat at HCRP, Kabre, Dolakha during 2019 to 2022

Treatments	Plant height (cm)				NPB/plant			
	2019	2020	2022	Mean	2019	2020	2022	Mean
FYM 5 t ha^{-1}	70.0	57.9	58.7	62.2	2.0	4.1	2.3	2.8
30:30:30 N:P_2O_5:K_2O ha^{-1}	57.0	60.9	62.3	60.1	3.0	4.3	2.7	3.3
30:60:30 N:P_2O_5:K_2O ha^{-1}	55.0	49.0	87.7	63.9	2.0	3.7	4.0	3.2
60:30:30 N:P_2O_5:K_2O ha^{-1}	60.0	55.7	114.7	76.8	3.0	4.4	4.0	3.8
60:60:30 N:P_2O_5:K_2O ha^{-1}	59.0	51.3	76.7	62.3	2.0	5.2	3.3	3.5
90:30:30 N:P_2O_5:K_2O ha^{-1}	67.0	69.6	57.0	64.5	3.0	5.0	3.0	3.7
90:60:30 N:P_2O_5:K_2O ha^{-1}	70.0	65.5	65.7	67.1	4.0	4.9	3.0	4.0
Grand Mean	61.0	58.6	74.6	64.7	2.7	4.5	3.1	3.4
P value	0.15	0.33	0.007		0.07	0.1	0.16	
LSD (0.05)			27.6					
CV(%)	10.8	19.4	20.8		23.4	14.0	25	

Note: NPB= No. of primary branches per plant, LSD=Least significant difference at 5% level, CV(%)=Coefficient of variance

Table 3. Effect of fertilizers application on No. of floral cluster and seeds per cyme of tartary buckwheat at HCRP, Kabre, Dolakha during 2019 to 2022.

Treatments	FC/Plant			Seeds/Cyme			
	2019	2022	Mean	2019	2020	2022	Mean
FYM 5 t ha^{-1}	5.3	8.7	7.0	7.5	16.6	22.0	15.4
30:30:30 N:P_2O_5:K_2O ha^{-1}	4.7	10.7	7.7	7.1	12.9	22.0	14.0
30:60:30 N:P_2O_5:K_2O ha^{-1}	3.7	14.3	9.0	8.0	17.5	25.0	16.8
60:30:30 N:P_2O_5:K_2O ha^{-1}	5.0	24.0	14.5	8.1	14.9	27.3	16.8
60:60:30 N:P_2O_5:K_2O ha^{-1}	5.3	10.7	8.0	7.6	14.4	25.3	15.8
90:30:30 N:P_2O_5:K_2O ha^{-1}	5.7	10.0	7.9	8.9	17.5	21.7	16.0
90:60:30 N:P_2O_5:K_2O ha^{-1}	6.0	9.3	7.7	6.6	16.5	18.0	13.7
Grand mean	5.1	12.5	8.8	7.7	15.8	23.0	15.5
P value	0.21	0.002		0.03	0.10	0.21	
LSD(0.05)		6.03		1.29			
CV(%)	20.1	27.1		9.4	12.5	17.9	

Note: FC=Floral cluster per plant, LSD=Least significant difference at 5% level, CV%=Coefficient of variance

Effect of fertilizers on grain yield

The highest mean grain yield (2.05 t ha^{-1}) was obtained from 90:30:30 N:P_2O_5:K_2O kg ha^{-1} and was not significantly different from 90:60:30 N:P_2O_5:K_2O kg ha^{-1}, 60:60:30 N:P_2O_5:K_2O kg ha^{-1} and 60:30:30 N:P_2O_5:K_2O kg ha^{-1} treatment (Table 4). Increased P doses from 30 to 60 kg P_2O_5 ha^{-1} did not significantly increase grain yield and in contrast reduced grain yield in combination with 90 kg N ha^{-1} (Figure 1). The lowest grain yield was obtained from 5 t ha^{-1}. FYM applied treatment. Increasing P dose on same N dose did not significantly increased grain yield.

Table 4. Effect of fertilizers application on thousand grains weight and grain yield of tartary buckwheat at HCRP, Kabre, Dolakha during 2019 to 2022.

Treatments	Thousand grains wt.(g)			Grain yield (t ha^{-1})			
	2019	2022	Mean	2019	2020	2022	Mean
FYM 5 t ha^{-1}	23.1	19.3	21.2	1.72	1.079	0.978	1.259
30:30:30 N:P_2O_5:K_2O ha^{-1}	22.3	18.7	20.5	1.89	1.094	1.253	1.412
30:60:30 N:P_2O_5:K_2O ha^{-1}	23.7	19.3	21.5	1.90	1.194	1.102	1.399
60:30:30 N:P_2O_5:K_2O ha^{-1}	23.7	18.7	21.2	1.59	1.214	2.436	1.747
60:60:30 N:P_2O_5:K_2O ha^{-1}	23.5	18.0	20.8	2.59	1.405	1.267	1.754
90:30:30 N:P_2O_5:K_2O ha^{-1}	24.5	20.0	22.3	2.90	1.994	1.257	2.050
90:60:30 N:P_2O_5:K_2O ha^{-1}	24.2	19.3	21.8	2.25	1.821	0.794	1.622
Grand mean	23.5	19.0	21.3	2.11	1.40	1.298	1.603
P value	0.29	0.33		0.02	0.005	0.05	
LSD(0.05)				0.75	0.472	0.96	
CV(%)	4.6	5.2		19.9	19	21.9	

Note: Wt = Weight, g = gram LSD=Least significant difference at 5% level, CV%=Coefficient of variance

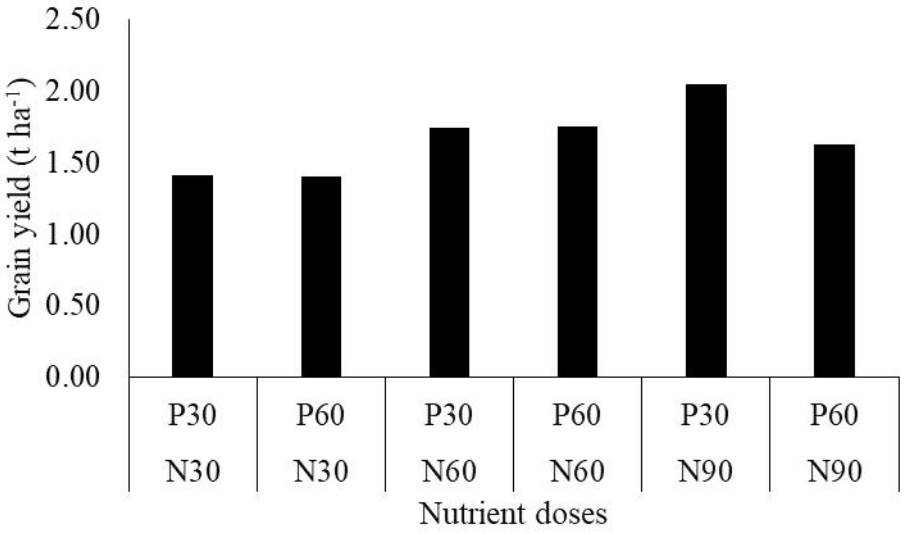

Figure 1. Buckwheat grain yield response of N and P doses with combinations at HCRP, Kabre Dolakha. Mean over the three years. N30=30 kg N ha^{-1}, N60=60 kg N ha^{-1}, N90=90 kg N ha^{-1}, P30=30 kg P_2O_5 ha^{-1}, P60=60 kg P_2O_5 ha^{-1}

DISCUSSION

There was significant effect of fertilizers dose application on days to 50% heading during 2022 and but not significant effect on 2019. The days to 75% maturity was not affected by the fertilizer application. The negligible effect of fertilizer dose on heading days and maturity days may be due to shorter duration of crop as compared to other crops. Therefore, the difference in days to maturity was not noticeable. The plant height was significantly affected by fertilizer treatments during 2022 but not during 2019 and 2020 (Table 2). During 2022, the highest plant height was recorded on 60:30:30 N:P_2O_5:K_2O kg ha^{-1}. Increased N dose from 30 to 60 kg N ha^{-1} has increased plant height but not at 90 kg N ha^{-1}. The possible reason might be due to optimum nitrogen supply may have played important role in plant growth and development. Similar result was reported by Xiang et al (2020) a higher N rate resulted in stronger growth, higher physiological activity, and improved yield performance of drought-stressed tartary buckwheat.

The no. of floral cluster per plant was significantly affected by fertilizer dose during 2022 but not during 2019. During 2022, the highest no. of floral cluster was found from 60:30:30 N:P_2O_5:K_2O kg ha^{-1} and the lowest was recorded from FYM 5 t ha^{-1}. The no. of floral cluster was low at 30 kg N ha^{-1} and at 90 kg N ha^{-1} doses might be due to the higher dose of N more vegetative growth favors and at 30 kg N ha^{-1} the N demand was not sufficient as per crop demand for floral development. When nitrogen is deficient, it delays both vegetative and reproductive phonological development, reduces leaf emergence rate, yield, and yield components such as the number of floral cluster per plant, the number of seeds per head, the single seed weight, and the number of seeds per plant. Moreover, nitrogen deficiency reduces the radiation interception, radiation use efficiency, dry matter partitioning to reproductive organs, leaf area index, protein content of the plant, and the seed (Dordas and Sioulas 2008).

The highest mean grain yield was obtained from 90:30:30 N:P_2O_5:K_2O kg ha^{-1} and was not significantly different from 90:60:30 N:P_2O_5:K_2O kg ha^{-1}, 60:60:30 N:P_2O_5:K_2O kg ha^{-1} and 60:30:30 N:P_2O_5:K_2O kg ha^{-1}. Increased P doses from 30 to 60 kg P_2O_5 ha^{-1} did not significantly increase grain yield and in contrast reduced grain yield in combination with 90 kg N ha^{-1}. No increase of grain yield from increased P doses from 30 to 60 was due to very

high available P_2O_5 in experiment plot soil. The increased grain yield at 60 kg N ha^{-1} and 90 kg N ha^{-1} was due to more N uptake from fertilizer applied N and there was very low total N in experimental plot soil. The grain yield of buckwheat is contributed by yield attributes such as average number of floral clusters per plant, no. of seeds per cyme, 1000 grains weight. Higher yield attributes under 60 and 90 kg N ha^{-1} level might be due to fulfillment of crop need with increased nitrogen levels. The higher value of growth and yield attributes under 60 kg N ha^{-1} and 90 kg N ha^{-1} reflected in significantly higher grain yield. These results are in the line with Zhao et al (2012), who reported that yield and quality of tartary buckwheat increased and then decreased with the increase of fertilizer doses. Among all nutrient elements, nitrogen is the most sensitive element that affects the growth and yield of tartary buckwheat and has a strong relationship with the uptake of phosphorous and potassium. Tartary buckwheat has N demand of 3 to 4 kg for 100 kg grains (Zhao et al 2016). Xiang et al (2020) reported that N application effectively ameliorated the adverse effects of drought stress. An adequate N fertilizer application under drought stress could promote increased antioxidant activity, as well as photosynthesis ability, which ultimately results in high-yield of tartary buckwheat.

The increase in grain yield in response with increasing rate of nitrogen could be attributed to enhanced availability of the nutrient for uptake by the plants and increased photo assimilate production that would eventually lead to improved partitioning of carbohydrate to the grains. Grain yield is a complex character depending upon a large number of environmental, morphological and physiological characters. The highest grain yield of any crop is the result of all positive relationships of the yield components. Improvement in buckwheat yield with fertilizer application can be attributed to the stimulating effects of nutrients on plant growth that provides ideal condition for crop as the fertilizer N supply to plants need, which ultimately increased the grain yield of crop.

CONCLUSION

Tite Phapar-1 variety of buckwheat produces the highest grain yield (2.05 t ha^{-1}) when applied 90:30:30 N:P_2O_5:K_2O kg ha^{-1} followed by 60:60:30 N:P_2O_5:K_2O kg ha^{-1} (1.754 t ha^{-1}) and 60:30:30 N:P_2O_5:K_2O kg ha^{-1} (1.74 t ha^{-1}). Among these three nutrient doses, no significant difference was obtained on grain yield. Therefore, it was concluded that 60:30:30 N:P_2O_5:K_2O kg ha^{-1} could be recommended for Tite Phapar-1 cultivation under Kabre, Dolakha condition and similar soil types and ecological conditions of Nepal.

Acknowledgements

We are grateful to Hill Crops Research Program, Kabre and its staffs for providing facilities and assistance during conducting field experiments and thankful to Nepal Agricultural Research Council for financial assistance.

Authors' Contributions

All authors listed have made a substantial, direct and intellectual contribution to the experimentation, data recording, and analysis and manuscript preparation.

Conflicts of Interest

The authors have no relevant conflict of interests.

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