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Superior Buckwheat Genotypes for the River-Basin Areas of Sudurpaschim Province

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ABSTRACT

Buckwheat is considered one of the climates smart crops, and it can play a significant role in food security in Nepal's hills and mountainous regions. Field experiments were conducted to identify suitable buckwheat genotypes for general cultivation in the mid-hills of far-western Nepal. The experiment was laid out in a randomized complete block design with three replications in both years. The experiments were conducted in the research field of the Directorate of Agricultural Research, Sudurpaschim Province, Bhagetada, Doti, during the two consecutive winters of 2019 and 2020. Eleven elite buckwheat genotypes received from the Hill Crops Research Program, Kabre, Dolakha, Nepal, were evaluated. The only released variety of sweet-type buckwheat, Mithe Fapar-1, was used as a standard check. There was a significant difference among the genotypes in both years. In 2019, genotypes Acc#5670 (1390 kg ha^{-1}), standard check - Mithe Fapar-1 (1250 kg ha^{-1}), PL-30 (1240 kg ha^{-1}), KLF-72-22-520 (1199 kg ha^{-1}), and Acc#6529 (1190 kg ha^{-1}) were identified as higher yielder. In 2020, Acc#5670 (1556 kg ha^{-1}), GF-5283 (1,434 kg ha^{-1}), Acc#2234 (1,399 kg ha^{-1}), Acc#2213 (1361 kg ha^{-1}), and Acc#6529 (1312 kg ha^{-1}) were found superior among the tested genotypes. Likewise, combined over 2019 and 2020 data revealed that the genotypes Acc#5670 (1473 kg ha^{-1}), Acc#2234 (1275 kg ha^{-1}), Acc#2213 (1261 kg ha^{-1}), Acc#6529 (1251 kg ha^{-1}), and the genotype GF-5283 (1247 kg ha^{-1}) were found, high yielder. Genotypes found superior in these field experiments are valuable resources for the buckwheat breeding program of Nepal (Hill Crops Research Program) and especially for the mid-hills of Sudurpaschim Province. The superior genotypes can further be evaluated to develop location-specific genotypes for the regions.

Keywords: Buckwheat, climate change resilience, mountainous environments, mid-hills, gluten.

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INTRODUCTION

Buckwheat (*Fagopyrum tataricum* – Tite Fapar and *Fagopyrum esculentum* – Midhe Faper) is the sixth most important cereal crop in terms of area (13,875 ha) and production (15,917 t) in Nepal (MoALD 2023). Buckwheat can be grown from Terai to High hill regions in Nepal and is one of the essential food crops for the people of Mustang, Manang, Karnali zone, Bajhang, Bajura, Darchula, Solukhumbu of Nepal (Pokharel et al., 2016b). The cultivation area of buckwheat in Nepal is gradually increasing, even in some terai districts like Jhapa, Chitawan, Rupandehi, and Nawalparasi (MoALD 2022). Because of its short growing habits (70-90 days), farmers can quickly harvest the crop as a cash/catch crop after rice harvesting (Kartik/Mangsir) and before maize planting (Falgun/Chaitra) with the existing soil moisture of the soil in the terai regions of Nepal (Pokharel et al 2016a). Buckwheat is also considered a weed suppressant crop, can quickly be grown in poor land with minimum land preparation, and good crop growth can be expected even in poor agronomic management practices.

Buckwheat can be grown in low-rainfall areas (Bonafaccia and Kreft 1994). In Nepal, buckwheat is grown as a summer crop in the high hills, autumn and spring in the mid hills, and winter in Terai. The bitter type of buckwheat (*Fagopyrum tataricum*) has higher yield potential than the sweet type and can be grown as early maturing cash crops all over Nepal. However, bitter type buckwheat is rarely grown by the terai farmer despite its higher yield potentiality (MoALD 2023). In general, the bitter types of buckwheat are predominant in the high hills, whereas the sweet types are grown mainly in the mid hills and Terai (Baniya et al 2001).

In Nepal, the buckwheat yield is still low in the farmers' field compared to the research field. Farmers can get more yield by growing high-yielding varieties and improving cultivation practices. Replacing the local variety with the improved one is challenging because there are minimal varietal options for the farmers of remote hilly regions, and the seed of improved varieties is not readily available. Therefore, Hill Crops Research Program (HCRP, Dolakha) focuses on developing high-yielding varieties with improved agronomical practices to address buckwheat growers' problems. It would be a great job to contribute to food security and income generation of the subsistent farmers in remote, hilly eco-zones of the country if improved varieties could be released and distributed in these areas. Considering these facts, the principal objective of this study was to evaluate and identify superior buckwheat genotypes in the hilly regions of the far-western mid-hills of Nepal.

MATERIALS AND METHODS

2.1 Buckwheat genotypes

A total of 11 advanced buckwheat genotypes, including one standard check (Mithe Fapar-1), were received from the Hill Crops Research Program, Kabre, Dolakha (HCRP, Dolakha). The recommended check, Mithe Fapar-1, was used as a standard check in both the years. Mithe Fapar-1 was released in 2072 B.S. This genotype was imported from abroad and evaluated in different locations of Nepal. This variety was recommended for mid and high hills (up to 3000 meters above sea level). Mithe Fapar-1's characteristics are red stem, white flowers, black/brown seeds, resistance to powdery and downy mildew, early maturity (72 days), and an average yield of 1.2 t ha^{-1} (HCRP 2018). Other buckwheat genotypes tested in this experiment were selected from field experiments viz. National Observation Nursery, Initial Evaluation Trial (IET), and Coordinated Varietal Trials. All the tested genotypes were a collection of local germplasms from different parts of the country and exotic germplasms mainly from Japan, India, and Canada (HCRP 2018).

2.2 Experimental sites

HCRP Dolakha provides the seeds of different field trial sets like Initial Evaluation Trials (IET), Coordinated Varietal Trials (CVT), Farmers Field Trials (FFT) to different Disciplinary Divisions, National Commodity Programs, Directorate of Agriculture Research (DoAR) and Agriculture Research Stations (ARS) located throughout the country and with various partners (governmental organizations, agricultural institutions, local and international non-governmental organizations and community-based organizations, farmers' groups, individual farmer and private companies). DoAR Doti was one of the testing sites for different activities. Based on the field trial protocol and field experimentation guidelines provided by HCRP, Dolakha, a buckwheat varietal screening experiment was conducted at the Directorate of Agriculture Research, Bhagetada's research field Dipayal, Doti (DoAR Doti). DoAR Doti is situated at 29.2604 N, 80.9318 E, and 540 meters above sea level.

2.3 Field experiment

Field experiments were conducted during the autumn season of 2019 (2018/19) and 2020 (2019/20). Randomized complete block designs with three replications were followed to test the varietal performance. The seed rate was applied at the rate of 50 kg ha-1. A plot size of 6-meter square was maintained, spacing was kept 25 cm between rows and seed was sown continuously in the row. Chemical fertilizer was applied at the rate of 30:30:20 kg N, P, and K per ha, respectively. A total dose of N and P was applied at the seed sowing time. A total dose of nitrogen (Urea), phosphorous (Diammonium Phosphate - DAP), and potash (Muriate of Potash - M.P.) were applied at seed sowing; buckwheat being the short-duration crop, nitrogen dose was not splitted. Other field practices and research principles were followed as per guidelines provided by HCRP Dolakha for conducting the field experiments.

2.4 Data collection, data analysis, and report writing

Data were collected as per HCRP Dolakha's field trial management guidelines. Days to maturity were calculated based on the days taken to reach the buckwheat genotypes to physiological maturity from the seed sowing date. It was assumed based on 75% buckwheat grains converted into brown colour, and the leaves of the lower parts of the crops turned yellow. Likewise, plant height was calculated by measuring the height of the plant from the base/ground level to the tip of the flower cluster of the buckwheat crop and averaging the five plants per plot. The number of flower clusters was calculated by averaging the number of flower clusters of five plants. An average number of seeds/cyme was calculated by averaging the seeds of five plants/cyme. Threshing of the individual plot was done, and the seed was packed in a separate bag. 1000-grain weight (g) was counted from the individual bag thrice, and the average value was estimated. Grain yield (kg ha^{-1}) was calculated by weighing the total seed weight in a plot and converting it to kg/hectare.

Collected data were entered, averaged, tabulated and regular analyses were done using the Microsoft Office Excel Software. Statistical analysis, analysis of variance (ANOVA), and mean separation were performed using the statistical software CROPSTAT for Windows version 7.2.2007.3. For report writing, Microsoft Office Word was used.

RESULTS

Findings of the field experiments in 2018/19 and 2019/20 are presented in this chapter. The combined statistical analysis result of 2018/19 and 2019/20 revealed that the days to 75% maturity, plant height (cm), 1000-grain weight (g) and grain yield (kg ha^{-1}) were significantly different among the tested genotypes. Research results of each parameter are presented below.

In 2019, plant height (cm), thousand-grain weight (gm), and grain yield (kg ha^{-1}) were found to be statistically significant among the tested genotypes. There was no significant difference among the genotypes for days to maturity, number of flowers cluster/plants, and number of seeds/cymes. The standard check, Mithe Fapar-1, reached 75% physiological maturity at 70 days after sowing (DAS). All the genotypes were at par with the standard check (Table 1) for days to maturity. Likewise, genotype Acc#493 was found to be the tallest (98 cm), and genotype Acc#2213 was the shortest (52 cm) among the tested genotypes. The rest of the genotypes had similar plant height with the standard check, Mithe Faper-1 (89 cm). Similarly, 1000-grain weight (gram) ranged from 27 grams (Genotype GE-5283 and the standard check, Mithe Fapar-1) to 21 grams (Genotypes KIF-72-22-520).

There was a significant difference ($P<0.05$) for grain yield among the tested genotypes. Grain yield ranged from 1044 kg ha^{-1} (Acc#493) to 1390 (Acc#5670). Three genotypes viz. Acc#5670 (1390 kg ha^{-1}), PC-30 (1240 kg ha^{-1}), and Mither Fapar-1 (1250 kg ha^{-1}) yielded more than 1200 kg ha^{-1} grain yield. A detail of the research result is presented in Table 1.

Table 1: Grain yield and yield attributing characters of buckwheat genotypes tested in 2018/19 at the research field of DoAR Sudurpaschhim Province, Doti.

Name of the genotype	Days to maturity	Plant height (cm)	Number of flowers cluster/ plant	1000-grain weight (g)	Grain yield (kg ha^{-1})
ACC# 5670	67	90	107	25	1390
ACC2# 2213	67	52	78	21	1160
ACC# 6529	70	87	120	24	1190
ACC# 2234	65	92	100	24	1150
PC-30	67	89	103	26	1240
GE-5283	66	81	132	27	1060
CBBP-01	72	82	114	23	1080
KLF-72-22-520	69	75	96	21	1199
PL-15	67	76	84	25	1152
ACC#493	68	98	116	23	1044
Mithe Fapar-1 (Standard Check)	70	89	102	24	1250
Mean	68	83	105	25	1152
LSD (0.05)	4.1	26.1	31.3	3.9	216
F test	ns	**	ns	*	*
CV (%)	4.2	8.5	28.8	9.2	17.3

In 2020, days to maturity did not differ significantly among the genotypes (Figure 1). Days to maturity ranged from 66 DAS (PL-30) to 72 DAS (Acc#-2213) (Figure 1). The standard check Mithe Faper matured in 68 DAS. Likewise, there was no significant difference among the genotypes for plant height. Plant height differed from 80 DAS (Acc#5670) to 96 DAS (KLF-72-22-520). On the other hand, there was a significant difference among the genotypes for 1000-grain weight (Figure 1). The standard check Mithe Faper-1 had 24.6 g of 1000-grain weight (TKW). The thousand-grain weight ranged from 21.7 to 27.5 g (Figure 1). Genotypes GF-5283 (27.5 g), Acc#5670 (25.4 g), and Acc#2213 (25.2 g) were found in bold-grain type genotypes.

There was a significant difference among the tested genotypes regarding the grain yield (kg ha^{-1}). The grain yield ranged from 987 kg ha^{-1} (KLF-72-22-520) to 1556 (Acc#5670). Genotypes Acc#5670 (1556 kg ha^{-1}), Acc#2213 (1361 kg ha^{-1}), Acc#6529 (1312 kg ha^{-1}), Acc#2234 (1399 kg ha^{-1}), and GF-5283 (1434 kg ha^{-1}) were identified as high yielder among the tested genotypes. The standard check Mithe Fapar-1 yielded 1087 kg ha^{-1} grain yield. Most of the genotypes yielded higher grain yield compared to the standard check "Mithe Fapar-1" (1087 kg ha^{-1}).

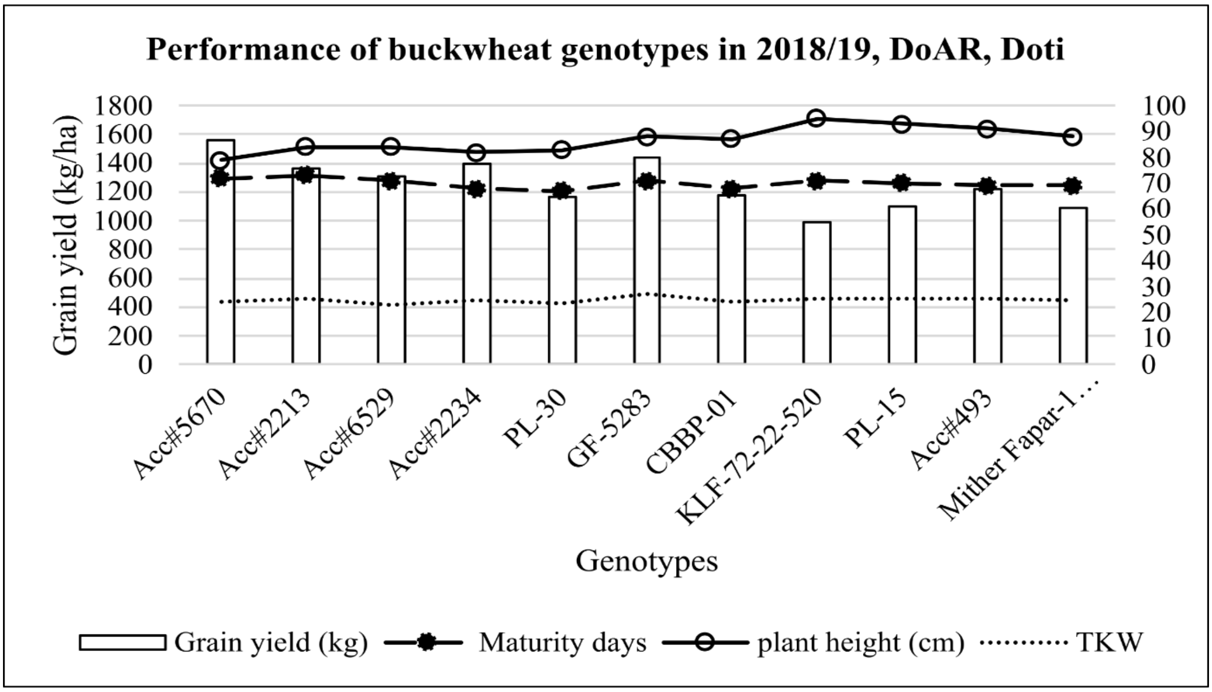

Figure 1. Performance of the buckwheat genotypes evaluated at DoAR Sudurpaschim Province, Bhagetada, Doti, in 2019/20.

DISCUSSION

Buckwheat is a significant crop in terms of food and nutritional security in Nepal. About 34 food dishes are made of buckwheat in Nepal, like dhido, roti, dal, green and dry leafy vegetables and pickles, soup, tea, wine etc. Bitter type of buckwheat contains 100 times more rutin than sweet type and abundant quantity of magnesium. It contains 12 amino acids, of which lysine and arginine are not found in other cereals. Due to health consciousness, the importance of buckwheat is realized, and food habits are now changing (FAO 2021).

Table 2. Some nutritional compounds available in buckwheat genotype (percentage basis)

Nutrients	Sweet type	Bitter type
Carbohydrate	73	68
Protein	11	13
Oil	1.9	2
Fibre	1.3	1.5
Ash	1.5	1.9
Iron	0.01	0.01
Calcium	0.03	0.04
Phosphorous	0.3	0.2

Source: www.fao.org

It is predicted that hill and mountain regions are more vulnerable to climate change, and minor crops like barley, buckwheat, and finger millets are climate change resilience crops (FAO 2021). In most developed countries, buckwheat is not eaten mainly to satisfy people's hunger but is eaten because of its taste and nutritional quality.

It is mainly combined with knowledge about the importance of food products for human health (Lathar 1992). However, in our country, people living in the high hills, like Mustang, Manang, Solukhumbu, and Karnali regions, use buckwheat as one of the staple foods. Buckwheat has a significant content of rutin (quercetin-3-retinoid) and other polyphenols, which are very important to lower blood sugars and works as anti-carcinogenic compounds (Lathar 1992). Nowadays, even in Nepal too, people who have diabetes and high blood pressure have started to use buckwheat flour for medicinal purposes.

Buckwheat breeding is quite complex because of the complicated genetic system of self-incompatibility. This is the primary reason for slow progress in genetic achievements for higher buckwheat yield. Hill Crops Research Program (HCRP), Dolakha, aims to promote and develop improved buckwheat technologies in Nepal. HCRP has been working on this crop since its establishment (1972). HCRP uses the germplasms collected locally and abroad for field experiments (Pokharel et al 2016b).

In Nepal, local landraces of buckwheat have been cultivated for many years by most of the farmers as there is only one variety of sweet type, "Mither Fapar-1", and two varieties of bitter type (Tite Fapar-1 and Tite Faper-2) has been released so far. This indicates the limitation of varietal options to the farmers of the region. The buckwheat yield is still low in the farmers' field compared to the research field. Farmers can get more yield simply by growing high-yielding varieties and improving cultivation practices. Replace the local variety with the improved one is challenging because there are limited varietal options for the farmers of remote hilly regions, and the seed of improved varieties is not readily available (Pokharel et al 2016a). Therefore, Hill Crops Research Program (HCRP), Dolakha, focuses on developing high-yielding varieties with improved agronomical practices to address buckwheat growers' problems. It would be a great job to contribute to food security and income generation of the subsistent farmers in remote, hilly eco-zones of the country if improved varieties could be released and distributed in these areas. Considering these facts, we conducted two field experiments at DoAR, Doti. The findings of this study will be valuable assets to the buckwheat breeders and buckwheat breeding program in Nepal to develop superior genotypes, especially to the far west and similar environments of Nepal.

CONCLUSION

The genotypes found superior from the two years' results need further verification in the farmer field. The result of this study gives an idea for selecting a select variety for the farmers' field trials. The findings of this study will increase the varietal options for the region's farmers. Likewise, location-specific genotypes found promising from this experiment are also appropriate for the regions and could be recommended for the region as location-specific genotypes. So, based on the combined results, genotypes Acc#5670 (1473 kg ha^{-1}), Acc#2234 (1275 kg ha^{-1}), Acc#2213 (1261 kg ha^{-1}), Acc#6529 (1251 kg ha^{-1}), and the genotype GF-5283 (1247 kg ha^{-1}) are recommended for further Research.

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AUTHORS' CONTRIBUTION

BB Pokharel conducted the research, did data analysis and prepared original final draft of manuscript. Other coauthors helped in carrying out research.

CONFLICT OF INTEREST

The authors declare no competing interests relevant to the content of this article.

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