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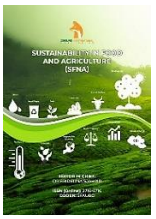

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RESEARCH ARTICLE

YIELD EVALUATION OF DIFFERENT VARIETIES OF POTATO IN BAJHANG DISTRICT OF NEPAL

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ABSTRACT

A field experiment was carried out in Bithadchir rural municipality of Bajhang district, Nepal in 2021 in the title "Yield evaluation of different varieties of potato in Bajhang district". The experiment was carried out to find out the best varieties for the hills and high-hills of Nepal based on their availability, suitability and previous record of performance and to assist the farmers to increase the potato production and ensure their food security. One factorial RCBD experimental design was used to evaluate the yield of different varieties. The varieties used as a treatments are Cardinal, Desire, Axona, Blue Danube and Bajhang Local. The results from our experiment shows that cardinal had maximum tuber weight per plant (515.75 gm), highest large grade tuber percentage (37.95%) and also the highest productivity (29.47 t/ha). Moreover, highest number of tubers (14.55) with maximum medium grade tuber percentage (34.71%) was found in Bajhang local. Similarly, being a native variety of the region, the growth parameters (number of main stems per hill, leaves and leaflet numbers, and canopy diameter) and also some yield parameters (number of tubers per plant, tuber size grade) of Bajhang local were also impressive. Therefore, the findings of our research conclude that Cardinal is the best variety under study in terms of yield and variety Bajhang local cultivation should also be promoted due to its wide adaptability in the existing local microclimate.

KEYWORDS

Evaluation, Bajhang, Variety, Yield

1. INTRODUCTION

The remarkable adaptability of the potato plant *(Solanum tuberosum L.)*, combined with its relative ease of cultivation and high nutritional value, has resulted in constant growth in potato consumption, especially in developing nations, which account for more than 50% of total global production (FAO STAT, 2020). Being the first non-cereal crops and the fourth most important crops, it is an important food security crop that can substitute for cereal crop considering its high yield and great nutritive value (Zhang et al., 2017; Bharati et al., 2020). In addition, it contains carbohydrate, protein, mineral and essential amino acid which makes it a complete food and can plays a significant factor in uplifting the health conditions of rural populations in developing country like Nepal (Kafle and Shah, 2012). In Nepal, potato can be grown from 100 masl of terai to 4400 masl of the high hills providing ample opportunities for the farmers to grow potato year round by utilizing different micro-climate available at different topography (Ghimire and Sakh, 2016). According to the statistical data published by MoALD, 2022, 3,325,231 Metric tonnes of potato is produced in 198,788 hectare of land with a productivity of 16.73 Mt/Ha. In terai region of Nepal, potato is mainly consumed as a vegetable while in high-hills and mountainous region, it is majorly consumed as a staple crop because people of hilly and mountainous region has a limited access to cereal crops (Subedi et al., 2019).

Bajhang district represents the hills and high hills of Nepal where 24, 580 Metric tonnes of Potato is produced in an area of 1,600 hectare with a productivity of 15.36 Mt/ha (MoALD, 2022). It is considered as a potential district for the potato production of the country. However, lack of seed tubers of suitable varieties in desired bulks during the growing season is hampering the farmers from getting benefits on a large scale. National potato development board under the Nepal Agricultural Research Council (NARC) has been engaged in generation of improved varieties of potato and till now more than ten improved varieties of potato have been developed (AITC, 2022). However, due to the lack of site-specific research at different agro-ecological zones of Nepal, the developed varieties are not being explored to its actual potentialities. Therefore, evaluation of suitable potato varieties in a different ecological niche is the dire need of present context in Nepal. So that farmers can be recommended and motivated to cultivate those varieties suiting their climatic conditions. Hence, in this research we evaluated the performance of different varieties in the Bajhang district. In addition to this, the findings of our research are documented to recommend the best varieties to farmers having higher adaptability and productivity.

2. MATERIALS AND METHODS

2.1 Experimental Site

The research experiment was carried out in Bithadchir rural municipality of Bajhang district, Nepal in 2021. The research site is shown in figure 1.

Bajhang district is one of the potential district for the potato production in the large scale. However, due to the lack of adequate assurance and good quality potato tuber, the production is decreasing. Therefore, this research

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is carried out to evaluate the performances of different varieties of potato to recommend the farmers so that the production as well as productivity rises up.

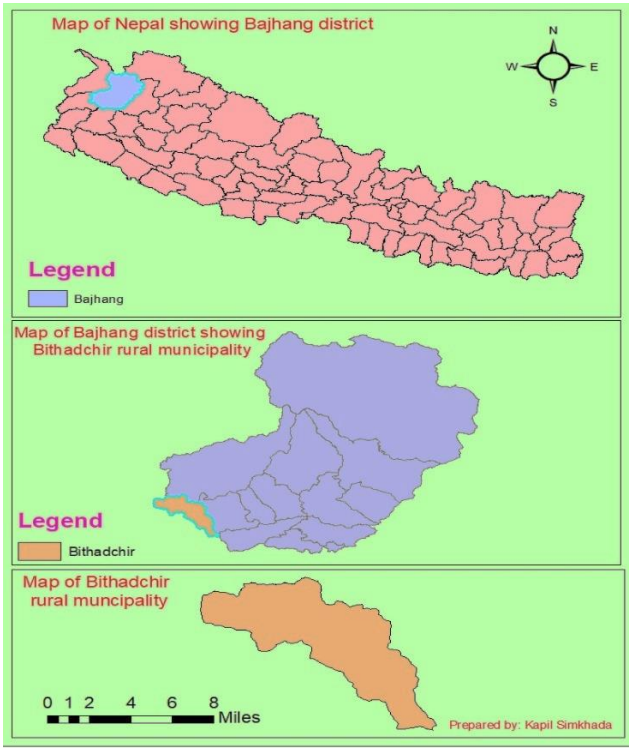

Figure 1: Research site

2.2 Soil Characteristics of The Research Site

A farmers' field at Bithadchir rural municipality was chosen as a research site. A soil test of the site was carried out prior to the research to analyze the soil condition. The results obtained from the sample of the field after analysis in soil and fertilizer testing laboratory, Sundarpur is given in the table 1.

Table 1: Soil Characteristics of Research Plot at Bithadchir, Bajhang, 2021

Particular	Content	Rating
Soil pH	6.91	Neutral
Soil Organic Matter (%)	2.22	Low
Total Nitrogen (%)	0.11	Medium
Available Phosphorus (kgha^{-1})	4.68	low
Available Potassium (kgha^{-1})	18	low

Source: Soil and Fertilizer Testing Laboratory, Sundarpur

2.3 Treatment Details and Experimental Design

Figure 2: Different varieties of potato used as the treatments for the research

The different varieties that were using by the farmers are collected and evaluated with the help of Agriculture Knowledge Center (AKC), Bajhang. Based on the availability, suitability and previous record of performance, the different varieties (Cardinal, Blue Danube, Desire, Axona and Bajhang Local) are used as treatments for the evaluation which are shown in the figure 2.

2.4 Treatment Details

The different varieties that were using by the farmers are collected and evaluated with the help of Agriculture Knowledge Center (AKC), Bajhang. Based on the availability, suitability and previous record of performance, the different varieties are used as treatments for the evaluation which are shown in figure 2.

2.5 Experimental Design

Table 2: Experimental Design Used in Study Site at Bithadchir Rural Municipality, 2021

Particulars	Trial details
Design	Randomized Complete Block Design
Total number of replications	4
Total number of varieties	5
Plot size	2.8×1.25 m^2
Spacing between replication	1 m
Spacing between plots within replication	0.5 m
Total number of plots	20
Number of rows per plot	4
Number of plants per row	5
Total number of plants per plot	20
Row to row spacing	70 cm
Plant to plant spacing	25 cm
Number of sample plants taken per plot	5

2.6 Experimental Procedure

A number of procedures were carried out in the field for the potato production from sowing to harvesting of the tubers. Firstly, potato seed tubers of size ranging from 30 to 50 gm were used as planting material and was sown on 23rd February, 2021. To make soil free from large soil clods and weeds, about 3-4 deep ploughing followed by harrowing were done. After sowing, ridges and furrows were made on the field and complete plantation procedure was followed.

Moreover, recommended doses of fertilizers for potato as FYM: 20 ton/ha, Urea: 132.3 kg/ha, DAP: 217.4 kg/ha, MOP: 100 kg/ha were applied. All the fertilizer doses were incorporated into the field before sowing except nitrogen which was used half dose as basal dose and half dose after 40 days of plantation. Furthermore, the research site lacked irrigation facility due to shortage of water and irrigation canals. Therefore, flooding was not done. However, irrigation was given twice at 30 DAS and 50 DAS with the use of rose can. Finally, the potatoes were harvested manually after 110 DAS on 22nd June, 2021.

2.7 Growth Parameters

2.7.1 Plant Height (cm)

Plant height record was taken from five tagged plants per plot. The distance from the soil surface to the top most growth point of above ground at full flowering determines the plant height (Zelalem et al., 2009). Accordingly, plant height data were collected at 45, 60 and 75 and 90 DAS.

2.7.2 Number of Main Stems per Hill

The number of main stems produced per hill were recorded by counting the main stems which came out from the seed (Zelalem et al., 2009). The data were collected at 45, 60, 75 and 90 DAS.

2.7.3 Number of Leaves per Plant

Numbers of green leaves per plant were counted from same plants selected for taking observations of plant height. The data were taken at 45, 60, 75 and 90 DAS. Photo-synthetically active green leaves were considered as effective leaves.

2.7.4 Number of Leaflets per Plant

Counting of leaflets of tagged plants were done at 45, 60, 75 and 90 DAS. Secondary and rudimentary leaflets were excluded while counting.

2.7.5 Canopy Length per Plant

The canopy length covered by rosette of each selected sample plant was measured from adjacent side to their opposite side with the help of scale at 45, 60, 75 and 90 DAS.

2.8 Yield Parameters

2.8.1 Number of Tubers per Plant

It is explained as total number of tubers harvested from each plant irrespective of its size.

2.8.2 Mean Weight of The Tuber per Plant (gm)

It is calculated by dividing the weight of total tubers harvested from sampled plants by the number of those plants.

2.8.3 Number of Tubers by Grade Basis (%)

According to the weight of tuber, three different grades of tubers were categorized. They were small grade (<25 gm), medium grade (25-50 gm) and large grade (>50 gm).

2.8.4 Tuber Yield per ha (t/ha)

Tuber yield per ha for different varieties of potato were calculated, evaluated and analyzed.

2.9 Statistical Analysis

The collected data were systematically arranged and entered in MS Excel. Then the arranged data were analyzed using the software, R studio. The means were compared by using Duncan's multiple Range Test (DMRT) at 5% level of significance. Statistical analysis is used to measure the effectiveness of treatments on above mentioned growth and yield parameters.

3. Results and Discussions

3.1 Growth Parameters

3.1.1 Plant Height (cm)

The result of statistical analysis showed that there was significant effect of different varieties on plant height at all days of observations. Cardinal was observed with the maximum plant height of 14.02 cm, 19.44 cm, 30.02 cm and 39.10 cm at 45, 60, 75, and 90 DAS respectively as shown in table 3. At 45 DAS, Bajhang local had minimum plant height of 7.33 cm. At 60 DAS, the minimum plant height was found in Axona (10.04 cm) which was statistically on par with Blue Danube (10.47 cm) and Desire (10.62 cm). At 75 DAS, the minimum plant height was observed in Desire (14.02 cm) which was on par with Blue Danube (15.17 cm). At 90 DAS, the lowest plant height was observed in Desire (17.14 cm).

Table 3: Plant Height (cm) of Different Potato Varieties at Bithadchir, Bajhang, 2021

Variety	Plant height (cm)			
	45 DAS	60 DAS	75 DAS	90 DAS
Blue Danube	7.56^{cd}	10.47^{c}	15.17^{d}	19.56^{d}
Cardinal	14.02^{a}	19.44^{a}	30.02^{a}	39.10^{a}
Axona	7.90^{bc}	10.04^{c}	19.90^{c}	28.23^{c}
Desire	8.09^{b}	10.62^{c}	14.02^{d}	17.14^{e}
Bajhang local	7.33^{d}	11.77^{b}	26.06^{b}	37.38^{b}
LSD	0.40^{***}	1.1^{***}	1.51^{***}	1.36^{***}
SEm (±)	0.57	0.80	1.40	2.01
CV%	2.93	5.73	4.66	3.12
Grand Mean	8.98	12.47	21.03	28.28

Note: Means in the column with same letter (s) in superscript indicate no significant difference between treatments at 0.001 level of significance.

3.1.2 Number of Main Stems per Hill

Number of main stems per hill was found statistically significant among the varieties. At 45 DAS, Axona was observed with the highest number of main stems per hill (2.63) and the lowest was found in Blue Danube (2.13). At 60 DAS, maximum number of main stems per hill was observed in Cardinal (3.03) which was statistically on par with Axona (2.95) and Bajhang local (2.83) and the minimum was found in Blue Danube (2.38) which was statistically similar with Desire (2.45). At 75 DAS and 90 DAS, number of main stems per hill were found similar results which is also similar to the 60 DAS except for Bajhang local as shown in the Table 4. At 60-70 DAS after tuber showing, saturation in the development of main stems occurs. This is the reasons for equal number of main stems per hill.

Table 4: Number of Main Stems per Hill of Different Potato Varieties at Bithadchir, Bajhang, 2021

Variety	Number of main stems per hill			
	45 DAS	60 DAS	75 DAS	90 DAS
Blue Danube	2.13^{c}	2.38^{b}	2.38^{b}	2.38^{b}
Cardinal	2.53^{ab}	3.03^{a}	3.03^{a}	3.03^{a}
Axona	2.63^{a}	2.95^{a}	2.95^{a}	2.95^{a}
Desire	2.25^{bc}	2.45^{b}	2.45^{b}	2.45^{b}
Bajhang local	2.33^{bc}	2.83^{a}	2.90^{a}	2.90^{a}
LSD	0.27^{*}	0.32^{**}	0.33^{**}	0.33^{**}
SEm (±)	0.05	0.07	0.07	0.07
CV%	7.41	7.62	7.71	7.71
Grand Mean	2.37	2.73	2.74	2.74

Note: Means in the column with same letter (s) in superscript indicate no significant difference between treatments at 0.001 level of significance.

3.1.3 Number of Leaves Per Plant

The result of statistical analysis showed that there was significant effect of different varieties on number of leaves per plant as shown in table 5. At 45 DAS, the highest number of leaves per plant was found in Axona (15.37) and the lowest was observed in Bajhang local (9.12) which was statistically on par with Blue Danube (9.48). At 60 DAS, the maximum number of leaves per plant was observed in Axona (22.83) which was on par with Cardinal (22.22) and the minimum was found in Blue Danube (15.53). At 75 DAS, the highest number of leaves per plant was found in Cardinal (32.58) which was statistically on par with Bajhang local (31.49) and the lowest was observed in Blue Danube (19.00). At 90 DAS, Bajhang local was observed with the maximum number of leaves per plant (48.5) and the minimum was found in Blue Danube (22.2). The statistical result shows that the number of leaves per plant was rapidly increased from 60 DAS to 90 DAS in Bajhang local. It is due to the favorable micro-climate for the local variety.

Table 5: Number of Leaves per Plant of Different Potato Varieties at Bithadchir, Bajhang, 2021

Variety	Number of leaves per plant			
	45 DAS	60 DAS	75 DAS	90 DAS
Blue Danube	9.48^{c}	15.53^{d}	19.00^{d}	22.20^{d}
Cardinal	12.75^{b}	22.22^{a}	32.58^{a}	37.87^{b}
Axona	15.37^{a}	22.83^{a}	29.25^{b}	36.70^{b}
Desire	12.45^{b}	19.76^{b}	22.61^{c}	25.42^{c}
Bajhang local	9.12^{c}	17.83^{c}	31.49^{a}	48.50^{a}
LSD	1.57^{***}	1.73^{***}	2.20^{***}	2.71^{***}
SEm (±)	0.55	0.64	1.21	2.14
CV%	8.61	5.71	5.29	5.15
Grand Mean	11.83	19.63	26.99	34.13

Note: Means in the column with same letter (s) in superscript indicate no significant difference between treatments at 0.001 level of significance.

3.1.4 Number of Leaflets Per Plant

The number of leaflets per plant showed significant result among varieties at all days of observation as shown in the table 6. The highest number of leaflets per plant was observed in Axona (94.30) and the lowest was found in Cardinal (33.82) at 45 DAS. At 60 DAS, the maximum number of leaflets per plant was recorded in Axona (137.69) and the minimum was observed in Desire (65.78). Bajhang local (252.46) and Desire (100.38) was found to have the highest and lowest number of leaflets per plant respectively at 75 DAS. Moreover, at 90 DAS, the maximum number of leaflets per plant was observed in Bajhang local (416.02) and the minimum was recorded in Desire (121.69). The statistical data shows that up to 60 DAS, number of leaflets per plant was highest in Axona and Blue Danuble. But after the 60 DAS, record at 75 DAS and 90 DAS shows that the number of leaflets were highest in Bajhang local.

Table 6: Number of Leaflets per Plant of Different Potato Varieties at Bithadchir, Bajhang, 2021

Variety	Number of leaflets per plant			
	45 DAS	60 DAS	75 DAS	90 DAS
Blue Danube	87.39^{b}	129.28^{b}	166.62^{c}	193.99^{d}
Cardinal	33.82^{e}	98.00^{c}	169.93^{c}	281.04^{c}
Axona	94.30^{a}	137.69^{a}	189.06^{b}	303.51^{b}
Desire	65.78^{c}	78.23^{d}	100.38^{d}	121.69^{e}
Bajhang local	43.56^{d}	103.03^{c}	252.46^{a}	416.02^{a}
LSD	4.79^{***}	8.18^{***}	8.97^{***}	11.11^{***}
SEm (±)	5.32	4.95	10.96	22.44
CV%	4.78	4.86	3.31	2.74
Grand Mean	64.97	109.25	175.69	263.25

Note: Means in the column with same letter (s) in superscript indicate no significant difference between treatments at 0.001 level of significance.

3.1.5 Canopy Length (cm)

At 45 DAS, canopy length was found highest in Axona (24.65 cm) which was on par with Blue Danube (24.61 cm) and the lowest was observed in Cardinal (14.28 cm) which was on par with Bajhang local (15.59 cm). At 60 DAS, maximum canopy length was recorded in Axona (34.55 cm) which was on par with Blue Danube (34.53 cm) and the minimum was observed in Desire (24.55 cm). At 75 DAS, the highest canopy length was found in Axona (44.08 cm) which was on par with Cardinal (42.52 cm) and Bajhang local (42.11 cm) and the minimum was found in Desire (28.56 cm). At 90 DAS, Bajhang local (52.75 cm) was found to have maximum canopy length and the minimum canopy length was found in Desire (32.02 cm). The canopy length at different DAS is shown in the table 7.

The statistical data shows that the Bajhang local has the highest canopy length at 90 DAS. It may be due to the easy local adaptation of the variety due to favorable microclimate as compared to the other imported varieties.

Table 7: Canopy Length (cm) per Plant of Different Potato Varieties at Bithadchir, Bajhang, 2021

Variety	Canopy length (cm)			
	45 DAS	60 DAS	75 DAS	90 DAS
Blue Danube	24.61^{a}	34.53^{a}	39.73^{b}	42.29^{c}
Cardinal	14.28^{c}	31.70^{b}	42.52^{a}	47.10^{b}
Axona	24.65^{a}	34.55^{a}	44.08^{a}	49.19^{b}
Desire	19.85^{b}	24.55^{c}	28.56^{c}	32.02^{d}
Bajhang local	15.59^{c}	30.58^{b}	42.11^{ab}	52.75^{a}
LSD	3.11^{***}	2.58^{***}	2.42^{***}	2.30^{***}
SEm (±)	1.04	0.87	1.28	1.63
CV%	10.21	5.37	3.99	3.34
Grand Mean	19.79	31.18	39.4	44.67

Note: Means in the column with same letter (s) in superscript indicate no significant difference between treatments at 0.001 level of significance.

3.2 Yield Parameters

3.2.1 Number and Weight of Tubers per Plant

There was a significant effect of different varieties on the number and weight of tubers per plant as shown in the table 8. The highest number of tubers per plant was observed in Bajhang local (14.55) followed by Blue Danube (11.00). The number of tubers per plant in Cardinal (9.75) and Axona (9.35) were statistically on par and the lowest was observed in Desire (7.50).

On the other hand, maximum weight of tubers per plant was recorded in Cardinal (515.75 gm) and the minimum was observed in Desire (274.98 gm). Moreover, Cardinal (515.75) was found statistically on par with the variety Axona.

Table 8: Number and weight of tubers (gm) per plant of potato varieties at Bithadchir, Bajhang, 2021

Variety	Number of Tubers per Plant	Weight of Tubers per Plant (gm)
Blue Danube	11.00^{b}	334.90^{c}
Cardinal	9.75^{c}	515.75^{a}
Axona	9.35^{c}	502.58^{ab}
Desire	7.50^{d}	274.98^{d}
Bajhang local	14.55^{a}	491.10^{b}
LSD	0.52^{***}	20.38^{***}
SEm (±)	0.53	22.34
CV%	3.26	3.12
Grand Mean	10.43	423.86

Note: Means in the column with same letter (s) in superscript indicate no significant difference between treatments at 0.001 level of significance.

3.2.2 Number of Tubers by Grade Basis (%)

From the experiment, the effect of different varieties on tuber size distribution was found to be significant as shown in table 9. Maximum percentage of small grade tubers was observed in Blue Danube (60.92%) and the minimum was found in Desire (33.33%) which was on par with Axona (34.22%). The percentage of medium grade tubers was highest in Bajhang local (34.71%) and lowest in cardinal (20.00%). Similarly, the highest percentage of large grade tubers was recorded in Cardinal (37.95%) and the lowest percentage was in Blue Danube (10.88%).

Table 9: Percentage of Number of Tubers on Grade Basis of Potato Varieties at Bithadchir, Bajhang, 2021

Variety	Tuber Size Distribution by Weight in Percentage (%)		
	Small (<25gm)	Medium (25-50 gm)	Large (>50 gm)
Blue Danube	60.92^{a}	28.20^{c}	10.88^{d}
Cardinal	42.06^{c}	20.00^{d}	37.95^{a}
Axona	34.22^{d}	29.42^{c}	36.35^{ab}
Desire	33.33^{d}	32.01^{b}	34.66^{b}
Bajhang local	46.39^{b}	34.71^{a}	18.90^{c}
LSD	1.71^{***}	2.14^{***}	1.70^{***}
SEm (±)	2.25	1.14	2.44
CV%	2.56	4.81	3.98
Grand Mean	43.38	28.87	27.75

Note: Treatment means in the column with same letter (s) in superscript indicate no significant difference between treatments based on DMRT at 0.001 level of significance.

3.2.3 Tuber Yield Per ha (t/ha)

The yield per ha of tuber was found maximum in Cardinal (29.47 t/ha) which was statistically similar with Axona (28.72 t/ha) as shown in the table 10. The minimum tuber yield per ha was found in Desire (15.71 t/ha). Moreover, the statistical data shows that the Bajhang local has the yield of 8.06t/ha. The higher yield of Cardinal and axona is due to the higher number of large sized tubers. Moreover, Bajhang local has also high yield as it contains higher number of medium-sized tubers. This shows that more the tuber size, the more it will contribute to the yield.

Table 10: Tuber Yield of Different Potato Varieties in Bajhang, 2021

Variety	Yield (t/ha)
Blue danube	19.14^{c}
Cardinal	29.47^{a}
Axona	28.72^{ab}
Desire	15.71^{d}
Bajhang local	28.06^{b}
LSD	1.16^{***}
SEm (±)	1.28
CV%	3.12
Grand Mean	24.22

Note: Means in the column with same letter (s) in superscript indicate no significant difference between treatments at 0.001 level of significance.

4. Conclusion

Cardinal had maximum tuber weight per plant (515.75 gm), highest large grade tuber percentage (37.95%) and also the highest productivity (29.47 t/ha). Thus, the findings of the research conclude Cardinal is the best variety under study in terms of yield. Moreover, highest number of tubers (14.55) with maximum medium grade tuber percentage (34.71%) was found in Bajhang local. Similarly, being a native variety of the region, the growth parameters (number of main stems per hill, leaves and leaflet numbers, and canopy diameter) and also some yield parameters (number of tubers per plant, tuber size grade) of Bajhang local were also impressive. Therefore, variety Bajhang local cultivation should be promoted due to its wide adaptability in the existing microclimate.

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Conflict of Interests

The authors declare that there is no conflict of interests regarding the publication of this article.

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