Original Research Article

ON-FARM EVALUATION OF POTATO GENOTYPES AT HIGH HILLS OF KARNALI PROVINCE, NEPAL

ABSTRACT

An on-farm varietal trial was carried out to evaluate promising genotypes of ~~potato~~ potatoesreceived from the National Potato Research Program (NPRP), Khumaltar at Urthuchautara settlement of Patrashi Rural Municipality of Jumla, Nepalat an altitude of 2430 meters above mean sea levelduring two consecutive years 2019 and 2020. Four promising potato genotypes: PRP 226567.2, PRP 136769.1, CIP 395077.242, CIP 393617.1, and two check cultivars i.e. Desiree and Jumli Local were tested in Randomized Complete Block Design (RCBD). Eachtreatmentwas replicated four times. Compost was used at the rate of 20 ~~ton~~ tonsper hectare (t/ha) and there was no use of chemical fertilizer. ~~Well sprouted~~Well-sprouted tubers of 25-50 g were planted at 60cm x 25cm spacing. Observations were recorded on vegetative parameters as well as yield attributes. Among different parameters observed ~~all~~ most all the vegetative as well as yield and yield attributing parameters were found significant among each other whereas emergence at 45 DAP and plant height during 2020 were found non-significant. The highest tuber yield (30.88 t/ha) was recorded in PRP 226567.2 followed by PRP 136769.1 (23.89 t/ha). Based on the average of two-year results, PRP 226567.2(30.88 t/ha) and PRP 136769.1 (23.89 t/ha) were superior for the purpose of variety recommendation for high hills of Karnali province.

~~Key words~~Keywords:*On-farm trial, Potato genotypes, Parameters, Tuber yield*

1. INTRODUCTION

Potato (*Solanum tuberosum* L.) belongs to the family Solanaceae and is one of the most important tuber crops of Nepal. It is the world's number one non-cereal crop that feeds more than a billion people daily [1]. Potato ranked ~~as~~ second, third, and fourth position in terms of production, human consumption, and area coverage respectively in the world [2]. The crop is taken as a major source of income by the farmers of the hilly and mountain regions [3]. It is utilized as a major vegetable in terai and mid hills and used as a vegetable and staple food in high hills of Nepal. Potato is the most important crop for food security after rice, wheat and maize in the World [4]. It occupies the 5th position in area coverage and 2nd in total production and 1st in productivity among the food crops (rice, wheat, maize, millet and potato) grown in Nepal [5]. Total cultivated area under potato in Nepal was reported 198,788 ha and total production 33,25,231 ton with an averageproductivity of 16.73 t/ha which were higher than the data recorded in previous fiscal year (area: 1,88,098 ha, production: 31,31,830 tons, productivity: 16.65 t/ha [6].

Out of the total area under potato, around 20% is in the high hills and mountains, 41.5% in the mid-hills and 38.5% in Terai[7]. It is grown in entire ecological region of Nepal ranging from terai to mountainous regions including Karnali zone. Seed potato productivity is declining in high hills and mountains of Nepal which is considered as key constraint to potato production [8]. Low productivity of potato relies on various factors such as irrigation, fertilizer, varieties, diseases, insect pests and management practices [9]. The factors identified by National Potato Research Program (NPRP) were low yielding varieties, inadequate cultivation practices with the soil-cultivars-climate complex, inadequate control measures for major diseases and insect pests, insufficient soil fertility management practices [10,11]. Another reason behind the low productivity in high hill is due to lack of suitable location specific potato varieties. There is huge potential of potato crop that could contribute to the national economy.Government of Nepal, with recommendation of NPRP, has released and recommended 11 varieties for commercial cultivation in Nepal. However, these varieties are inadequate to mitigate the location-specific production issues raised by the farmers. There is always demand of high yielding varieties which are resistant of diseases and insect pests and even perform better in the drought and dry condition [12]. Apart from the high yielding varieties, area specific varieties and quality planting material is is important for commercial cultivation of potato. Farmers of high hills need high yielding, late blight resistant, white skinned tubers and good keeping quality. To identify such genotypes, an on-farm trial was conducted at the Outreach site Urthuchautara of the station. The paper explains genotypic variation and superiority among potato genotypes and recommends appropriate genotypes for high environment of Karnali province.

2. MATERIALS AND METHODS

On-farm varietal trial was conducted by Horticulture Research Station (HRS), Rajikot, Jumla at Urthuchautara settlement of Patrashi Rural Municipality in Jumla district. Experimental area is situated at 29°18'10"N and 82°13'42"E with the altitude of 2430 meters above mean sea level; with temperate climate. March-April is the main planting season of potato in Jumla and soil is sandy loam in nature. Maximum and minimum average temperature of potato growing season in 2019 were 18 ^{0}C to 26 ^{0}C and 1 ^{0}C to 16 ^{0}C. Total rainfall during growing season was 654 mm [13]. Similarly, during 2020 maximum and minimum average temperature were 17^{0}C to 25 ^{0}C and 1 ^{0}C to 16 ^{0}C and total rainfall was 708 mm [14].
Four different potato genotypes received from National Potato Research Program (NPRP), Khumaltar, Lalitpur along with two check varieties Desiree and Jumli Local were tested at Coordinate Farmer's Field Trial during 2019 and 2020. Genotypes: PRP 226567.2, PRP 136769.1, CIP 395077.242, CIP 393617.1, Desiree and Jumli Local were tested under the trial. The detail of the experiment material is given below in Table 1. The plot size was assigned 7.2 m^2 (3m x 2.4 m). The plots were fertilized with 20 ton compost per hectare. There was no use of chemical fertilizer. Well sprouted tubers of 25-50 g were planted with 60cm x 25cm spacing. Randomized Complete Block Design (RCBD) was used and each treatment (genotype) was replicated four times. Planting and harvesting were done on the 3rd week of March and 3rd week of September respectively. All the management practices were followed as per the NPRP recommendation. Observation on ground coverage was recorded as percentage covered by plant canopy in each plot at six weeks after planting. Late blight scoring was done in 1-9 scale where 1 was considered as no infection of disease (resistant) and 9 was given when the disease was observed up to stems i.e. highly susceptible. Similarly plant uniformity was observed in 1-5 scale, where 5 was given to almost uniform plats. The number of tubers and total yield was recorded from experimental plot and converted as per hectare. The data recorded for on-farm varietal trial were managed in a spreadsheet and analyzed using Genstat version 18 software for windows [15]. Analysis of variance (ANOVA) was used to determine statistically significant differences between means. The data for 2019 and 2020 were analyzed separately, and the results of two years are presented.
The significant mean data of observed variables were separated using Duncan's Multiple Range Test (DMRT) at 5% level of probability. Least significant differences (LSD) were determined for all significant data. Coefficient of Variation (CV), the ratio of standard deviation to mean which indicate the quality of sample data on estimating the dispersion of population, is expressed in percentage. Lower the value of CV, the more precise the estimate of mean.

Table 1: Tested Potato Genotypes and their Characteristics

SN	Genotypes	Original name	Source	Skin color	Shape	Eye depth	Maturity	Remarks
1	PRP 226567.2	Janakdev x LBR 40	NPRP	White	Long	Medium	Late (>120 days)	Pipeline
2	PRP 136769.1	Kufri Jyoti x LBR 44	NPRP	White	Round	Deep	Late (>120 days)	Pipeline
3	CIP 395017.242	CIP 393085.13 x CIP 392639.8	CIP	White	Round	Medium	Late (>120 days)	Pipeline
4	CIP 393617.1	DXY.15 x DXY.33	CIP	White	Oblong	Shallow	Late (>120 days)	Pipeline
5	Jumli local	Jumli Local	Nepal	White	Long	Shallow	Late (>120 days)	Local
6	Desiree	Urgenta x Depesche	CIP	Red	Long	Medium	Early (<100 days)	Released

[5]

3. RESULTS AND DISCUSSION

Among different parameters observed all most all the vegetative as well as yield and yield attributing parameters were found significant among each other whereas emergence at 45 DAP and plant height during 2020 were found non-significant.

3.1 Emergence Percentage

Emergence at 30 DAP was recorded maximum (76.82%) in PRP 136769.1 followed by CIP 395077.242 (75.52%) and PRP 226567.2 (74.74%) where as the lowest was recorded in Jumli Local (60.21%). Similarly, emergence at 45 DAP was recorded maximum (92.71%) in Jumli Local followed by PRP 136769.1 (92.45%), whereas the lowest (83.59 %) in CIP 393617.1 (Table 2). Plants emergence is a significant factor of any crop that affects stand establishment, population dynamics of crop and helps towards the final yield [16]. The lower emergence percentage might be due to the presence of some growth inhibitors in seed tuber. Benzothiazole, 1, 4-dimethyl naphthalene and 1, 6 dimethyl naphthalene are comparatively potent inhibitors of sprout growth in the tuber [17]. Variation in emergence of different potato genotypes was also reported by some researchers [18].

Table 2: Emergence (%) of potato genotypes at 30 DAP and 45 DAP at Patrashi Rural Municipality of Jumla during 2019 and 2020

SN	Genotypes	Emergence % at 30 DAP			Emergence % at 45DAP		
		2019	2020	Average	2019	2020	Average
1	PRP 226567.2	90.63 a	58.85 a	74.74 a	92.71 ab	90.62	91.67 a
2	PRP 136769.1	93.23 a	60.42 a	76.82 a	95.31 a	89.58	92.45 a
3	CIP 395077.242	84.9 ab	66.15 a	75.52a	85.42 b	93.23	89.32 a
4	CIP 393617.1	73.44 b	64.06 a	68.75 a	76.04 c	91.15	83.59 b
5	Desiree	82.29 ab	57.29 a	69.79 a	93.23 ab	89.06	91.15 a
6	Jumli Local	74.48 b	45.94 b	60.21 b	94.79 a	90.63	92.71 a
	Mean	83.2	58.8	71	89.6	90.71	90.15
	F test	*	**	**	**	NS	*
	CV (%)	9.6	10.7	7.1	6.4	4.8	4.1
	LSD (0.05)	12	9.45	7.59	8.59		5.56

Note: NS=Non Significant *= Significant at *P*=.05 **=Significant at *P*=.01 LSD=Least Significant Difference CV= Coefficient of Variation

3.2 Plant Height

Statistically highly significant difference was observed in plant height of tested genotypes of potato. The tallest plants (70.35 cm) were measured in PRP 226567.2 followed by CIP 393617.1 (64.27 cm), CIP 395077.242 (62.97 cm) and the dwarfest (52.92 cm) plants in Jumli Local (Table 3). Plant genotypic effect and the quality of plant materials might be the cause for differences in plant height between the varieties [19]. Significant variation in plant height among the tested potato genotypes was also observed by researchers [20]. Significant variation of potato genotypes in plant height may be due to reserve food material for the early growth of seed tubers and varietal characters and interactions of planting materials and the environment [21].

3.3. Number of main stem per hill

Number of main stem per plant was also found highly significant among the clones; maximum number (5.2) of main stem was counted in PRP 226567.2 followed by PRP 136769.1 (4.85) and Jumli Local (4) whereas the minimum number (3.3) in CIP 395077.242 (Table 3). Variation in number of main stem per hill depends on their genotypic character. Similarly highly significant variation among the potato genotypes was reported by some researchers too [22]. Quality of tuber used and presence of number of buds on the tuber might be the factors that influence the number of main stems per hill [23].

Table 3: Plant height and number of main stems of potato genotypes at Patrashi Rural Municipality of Jumla during 2019 and 2020

SN	Genotypes	Plant height			Number of main stem		
		2019	2020	Average	2019	2020	Average
1	PRP 226567.2	59.95 a	80.75	70.35 a	4.55 a	5.85 a	5.2 a
2	PRP 136769.1	48.4 bc	75.4	61.9 abc	4.15 ab	5.55 a	4.85 a
3	CIP 395077.242	51.8 ab	74.15	62.97 ab	2.7 c	3.9 b	3.3 b
4	CIP 393617.1	52.5 ab	76.05	64.27 a	3.3 bc	4.15 b	3.71 b
5	Desiree	38.6 c	69.45	54.02 bc	3.55 abc	3.9 b	3.73 b
6	Jumli Local	40.3 c	65.55	52.92 c	3.4 abc	3.7 b	3.55 b
	Mean	48.6	73.6	61.1	3.61	4.51	4.06
	F test	**	NS	**	*	**	**
	CV (%)	13.6	12.4	9.8	19.8	12.3	11.5
	LSD (0.05)	9.59		9.01	1.07	0.84	0.7

Note: NS=Non Significant *= Significant at *P*=.05 **=Significant at *P*=.01 LSD=Least Significant Difference CV= Coefficient of Variation

3.4 Ground Coverage Percentage

Highly significant variation was observed among the tested potato genotypes for groundcoverage at six weeks of Planting. The highest (76.25%) ground coverage was found in PRP 226567.2 followed by CIP 395077.242 (61.25%), CIP 393617.1 (61.25%) whereas the lowest (43.75%) in Jumli Local (Table 4). Well-developed foliage with a maximum ground cover of a plant indicates its good growth and development [24]. The ability of plants to produce leaves and stems per plant depends upon the genetic makeup of the crop which affects ground cover. The variation in ground coverage percentage in different genotypes of potato might be due to varietal characters. Significant variation among the potato genotypes has been also reported by some researchers [20].

3.5 Uniformity (1-5 scale)

Statistically highly significant differences were observed among the tested potato genotypes. Highly uniform (4.88) plants were observed in PRP 226567.2 followed by Desiree (4.37), PRP 136769.1 (4.25) and CIP 393617.1 (4.25) whereas the least uniform (3.25) plants were observed in Jumli local (Table 4). Similar type of significant variations was studied by some researchers [25,26].

Table 4: Ground cover (%) and uniformity (1-5 scale) of potato genotypes at Patrashi Rural Municipality of Jumla during 2019 and 2020

SN	Genotypes	Ground coverage (%)			Uniformity		
		2019	2020	Average	2019	2020	Average
1	PRP 226567.2	65 a	72.5 ab	68.75 a	4.75 a	5 a	4.88 a
2	PRP 136769.1	51.25 ab	61.25 b	56.25 b	4.25 abc	4.25 a	4.25 ab
3	CIP 395077.242	52.5 ab	70 ab	61.25 ab	3.75 bcd	4.5 a	4.12 b
4	CIP 393617.1	45 b	77.5 a	61.25 ab	3.5 cd	5 a	4.25 ab
5	Desiree	50 ab	60 bc	55 b	4.5 ab	4.25 a	4.37 ab
6	Jumli Local	40 b	47.5 c	43.75 c	3.25 d	3.25 b	3.25 c
	Mean	50.6	64.8	57.7	4	4.38	4.19
	F test	*	**	**	*	**	**
	CV (%)	18.4	12.9	10.5	13.9	12	10.1
	LSD (0.05)	14.03	12.6	9.1	0.84	0.79	0.64

Note: NS=Non Significant *= Significant at *P*=.05 **=Significant at *P*=.01 LSD=Least Significant Difference CV= Coefficient of Variation

3.6 Insect pest damage percentage and Late blight occurrence

Overall damage caused by insects (Blister beetle, Leaf minor) was minimalamong the genotypes. Insect damage percentage was maximum (3%) in genotype Jumli local followed by Desiree (2.75%), and CIP 393617.1 (2.63%) whereas minimum (1.87%) in genotype CIP 395077.242 (Table 5). Similar types of insect pests and their damage has been reported by some researchers in Jumla [27]. Occurrence of late blight was maximum (5.25) in Jumli local followed by Desiree (3.75) whereas minimum (1.25) in PRP 226567.2 and PRP 136769.1 (1.25). Similar type of occurrence pattern of late blight was observed by earlier researchers [26].

Table 5: Insect damage (%) and late blight scoring (1-9 scale) of potato genotypes at Patrashi Rural Municipality of Jumla during 2019 and 2020

SN	Treatment	Insect damage (%)			Late blight reading (1-9 scale)		
		2019	2020	Average	2019	2020	Average
1	PRP 226567.2	1.75 abc	2.25 c	2c	1.25 e	1.25 c	1.25 d
2	PRP 136769.1	2 abc	2.5 c	2.25 bc	1.5 de	1 c	1.25 d
3	CIP 395077.242	1.5 bc	2.25 c	1.87 c	4 bc	1.25 c	2.63 c
4	CIP 393617.1	1.25 c	4 a	2.63 ab	4.5 ab	2.5 b	3.5 b
5	Desiree	2.5 a	3 bc	2.75 ab	2.75 cd	4.75 a	3.75 b
6	Jumli Local	2.25 ab	3.75 ab	3 a	5.5 a	5 a	5.25 a
	Mean	1.87	2.96	2.42	3.25	2.62	2.94
	F test	*	**	**	**	**	**
	CV (%)	25.6	17	15.6	25.9	16.4	16.2
	LSD (0.05)	0.72	0.76	0.57	1.27	0.65	0.72

Note: NS=Non Significant *= Significant at *P*=.05 **=Significant at *P*=.01 LSD=Least Significant Difference CV= Coefficient of Variation

3.7 Total number of tubers per hectare

All most all the tested genotypes were late in maturity except Desiree. Total number of tubers per hectare was found highly significant among each other. Maximum number of tuber (697569) was counted in PRP 226567.2 followed by PRP 136769.1 (582465) and the lowest number (289757) in CIP 393617.1 (Table 6). Different varieties of potato showed variable performance of tuber number per plot [28]. Similar type of variable was also studied at Dailekh District of Nepal where the potato genotypes significantly differed on tuber number per plot [29]. Some researchers [20] also reported significant variation in number of tubers of different genotypes of potato. Tuber number is function of stem population but is influenced by genotypes and several other factors, which control vegetative growth [30]. Significant variations in the numbers of tubers among the genotypes could be related to the genotype's tolerance to the trial site's climatic circumstances, its genetics, or the quality of the potato seed [19].

3.8 Tuber Yield and other characteristics

Statistically highly significant difference was studied in tuber yield per hectare among the tested genotypes. The highest tuber yield was recorded in PRP 226567.2 (30.88 t/ha) followed by PRP 136769.1 (23.89 t/ha) and Desiree (21.42 t/ha) whereas the lowest (9.25 t/ha) in Jumli local (Table 6). Tuber characteristics (tuber shape and tuber color) differed among different tested potato genotypes. CIP 393617.1 was oblong, PRP 136769.1 and CIP 395077.242 were round whereas PRP 226567.2, Desiree and Jumli Local were long in shape. PRP 226567.2, PRP 136769.1, CIP 395077.242, CIP 393617.1 and Jumli Local were white whereas Desiree was red in tuber color. Potato genotypes vary in flesh and skin color, eye depth and tuber shape [31]. Significant variation in tuber yield among the potato genotypes might be the genotypic effect. Potato varieties significantly influenced the yield of tuber per plant [32]. Tuber yield is the product of intercepted photosynthetically active radiation (PAR) and efficiency to convert into dry matter. For potato, the ability of the leaf to convert the PAR into carbohydrates and the storage capacity of the tubers affect growth of tubers, tuber size and tuber yield [33]. Tuber yield is affected by environmental factors such as soil temperature, moisture, light intensity, use of fertilizer, disease and pest control [34]. Differential result of potato varieties in tuber yield was also reported by many scholars in Ethiopia [35]. Similar result of differential performance of total tuber yield (t/ha) of potato was reported 29,36].

Table 6: Number of tubers per hectare and tuber yield (t/ha) of potato genotypes at Patrashi Rural Municipality of Jumla during 2019 and 2020

SN	Treatment	Tuber number per ha			Tuber yield (t/ha)		
		2019	2020	Average	2019	2020	Average
1	PRP 226567.2	696528 a	698611 a	697569 a	32.54 a	29.21 a	30.88 a
2	PRP 136769.1	683333 a	481597 b	582465 b	27.97 ab	19.81 b	23.89 b
3	CIP 395077.242	296875 b	368056 b	332465 c	12.03 c	16.55 b	14.29 c
4	CIP 393617.1	273958 b	305556 b	289757 c	13 c	13.32 b	13.16 c
5	Desiree	393403 b	358333 b	375868 c	23.16 b	19.68 b	21.42 b
6	Jumli Local	388542 b	422569 b	405556 c	11.97 c	6.53 c	9.25 c
	Mean	455440	439120	447280	20.1	17.52	18.81
	F test	**	**	**	**	**	**
	CV (%)	18.9	24.9	16.7	29	23.5	19.3
	LSD (0.05)	129515	165125	112378	8.8	6.2	5.47

Note: NS=Non Significant *= Significant at *P*=.05 **=Significant at *P*=.01 LSD=Least Significant Difference CV= Coefficient of Variation

The candidate manuscript does not have a robust scientific discussion, I suggest the authors incorporate the suggested paragraphs, in this way it would improve the scientific quality of the manuscript:

Potatoes are an important staple food crop worldwide, and genetic improvement is crucial for increasing productivity and enhancing food security. On-farm evaluations of potato genotypes have become a popular approach for selecting the best-performing genotypes in farmers' fields under real-

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world conditions. This approach allows for the evaluation of the performance of genotypes under the influence of various agri-environmental factors, such as soil type, climate, and management practices.

On-farm evaluations of potato genotypes can provide valuable information on the adaptability of genotypes to specific environments[37]. This information can be used to develop potato varieties that are well-suited to local conditions and can withstand environmental stresses such as drought[38, 39, 40], high temperature[41, 42], or disease[43]. In addition, on-farm evaluations provide an opportunity for farmers to actively participate in the selection process, ensuring that the selected genotypes meet their specific needs and preferences.

The influence of agri-environmental factors on the performance of potato genotypes has been extensively studied in on-farm evaluations[44]. For example, studies have shown that soil type and nutrient availability can significantly affect potato yield and quality. Potato genotypes that perform well in one soil type may not perform as well in another, emphasizing the need for a tailored approach to variety selection based on soil characteristics[45, 46]. Similarly, studies have shown that the impact of climate variables such as temperature, precipitation, and solar radiation can vary between genotypes and regions, highlighting the importance of understanding the interaction between genotypes and climate[47,48, 49].

Management practices such as irrigation, fertilization, and disease control can also influence the performance of potato genotypes[50, 51]. For example, studies have shown that irrigation can significantly increase potato yield in drought-prone areas, while over-fertilization can lead to reduced yield and quality. Similarly, disease-resistant genotypes can significantly reduce the use of pesticides and improve the sustainability of potato production.

In conclusion, on-farm evaluations of potato genotypes provide a valuable approach for selecting the best-performing genotypes under real-world conditions. The influence of agri-environmental factors such as soil type, climate, and management practices on the performance of potato genotypes should be considered in the selection process to ensure the development of varieties that are well-suited to local conditions and can withstand environmental stresses. Future research should focus on identifying the specific genotypic traits associated with adaptability to specific agri-environmental conditions to guide the development of more resilient potato varieties.

4. CONCLUSION

Among the different parameters observed, almost all the vegetative and yield attributing parameters were found significant among each other except emergence at 45 DAP and plant height in 2020. The existence of significant variation among potato genotypes in their tuber yield and other yield related traits indicates the possibility of selection of appropriate genotype. Based on the tuber yields, PRP 226567.2 and PRP 136769.1 were superior to other genotypes. The results were obtained from the trial in which compost only was the source of nutrients. Thus, the results are also important and encouraging in organic production point of view. We did not observe their post-harvest storability and processing qualities, which are important for future research. In addition, their sensory evaluation is also important to draw a package of varietal characters. These genotypes should be proposed for variety release process recommending for Karnali province and similar environments of the country.

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I suggest adding recent references which address the issue in question, suggested citations are for genuine scientific reasons that emphasize the current topic of study in context.

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