Original Research Article

EVALUATION OF POTATO GENOTYPES UNDER HIGH HILL CONDITION OF NEPAL

ABSTRACT

Coordinated Varietal Trial (CVT) on different genotypes of potato received from National Potato Research Program (NPRP), Khumaltar, Lalitpur was carried out at Horticultural Research Station, Rajikot, Jumla at an altitude of 2396m above mean sea level during two consecutive years 2019 and 2020 to evaluate potato genotypes suitable for the high hills of Karnali province of Nepal. Nine different potato genotypes with two checks i.e. Desiree and Jumli Local were tested on Randomized Complete Block Design (RCBD). Each treatment was replicated four times. Compost was used at the rate of 20 ton per hectare. There was no use of chemical fertilizer. Well sprouted tubers of 25-50 g were planted with 60cm x 25cm spacing. The effects of different genotypes were recorded for both vegetative as well as yield parameters. Tested genotypes differed significantly for vegetative (emergence percentage at 30 days after planting & 45 days after planting, uniformity, ground coverage, plant height, number of main stem) as well as yield parameters (total number of tubers and tuber yield per ha). The highest tuber yield (20.9mt/ha) was hrvested from CIP 392797.22. The two year result showed that potato genotype CIP 392797.22 is suitable for cultivation in high hills of Karnali province to combat the effect of malnutrition as well as food and nutrition security.

Key words: *Coordinated Varietal Trial, Genotypes, Tuber yield, Jumli Local*

1. INTRODUCTION

Potato (*Solanum tuberosum* L.) is one of the most important food crops of Nepal. It is the third most important food crop after rice and wheat in the world [1]. In Nepal, it is the fourth important crop after rice, wheat and maize [2]. The crop is taken as a major source of income by the farmers in the hills and mountains [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 [4]. It is postulated that people at higher elevations consume almost twice the amount of potato than those in the lowland [5]. More energy and protein can be obtained from potato from per unit area and per unit time than other food crops [6]. It occupies the 5^{th} position in area coverage and 2^{nd} in total production and 1^{st} in productivity among the food crops (rice, wheat, maize, millet and potato) grown in Nepal [4]. Total cultivated area under potato in Nepal was reported 198,788 ha and total production 33,25,231 ton with an average productivity of 16.73 t/ha [7]. Potato is the most important crop for food security after rice, wheat and maize in the World [8] and MOALD has also considered potato as one of the important cash crop of Nepal. Out of total area under potato in Nepal, around 20% is in the high hills and mountains, 41.5% in the mid hills and 38.5% in terai [9]. It is grown in entire ecological region of Nepal ranging from terai to mountainous regions [10,11]. Demand of high yielding varieties resistance to major disease and pest has remained always very high since long in Nepal [12]. Low productivity of potato in Nepal is due to lack of quality planting materials, prevalence of insect pest and diseases, inadequate research on varieties for different locations [13] and adoption of new varieties of potato is relatively less in many parts of Nepal [14].

Lack of improved varieties, high seed demand during planting seasons and use of recycled seed tubers in the high hill and continuous growing of old, and degenerated varieties are the principal factors for limiting production of potato in the hills [15]. Similarly, low productivity of potatoes in the high hills of Karnali province has been identified as core problem resulting from several limiting factors such as inadequate

quantity of disease free, drought tolerant basic seed of recommended varieties to flush out the degenerated seed potatoes, inadequate knowledge regarding the new varieties and inadequate availability of quality seed potatoes of recommended varieties. Varieties available for cultivation in Jumla are limited. Identification of high yielding varieties for high hills would help increased potato production. This trail was conducted at the station to find out the suitable varieties of potato for Jumla conditions.

2. MATERIALS AND METHODS

2.1 Experimental site and climate

Experiment was conducted at Horticulture Research Station (HRS), Rajikot, Jumla. The experimental area is situated at 29°16'50"N to 29°12'20"N and 82°12'20"E to 82°12'40"E with the altitude of 2398 meters above mean sea level. Its climate is a temperate. March-April is the main planting season of potato in Jumla. 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 [16]. 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 [17].

2.2 Experimental Materials, Designs and Cultivation

Seed tubers of nine different potato genotypes (CIP 303381.106, CIP 393371.164, CIP 394600.52, CIP 393371.159, CIP 392797.22, CIP 392025.7, PRP 016567.6, PRP 296667.2 and PRP 146871.20) were received from National Potato Research Program (NPRP) and tested under Coordinated Varietal Trial (CVT) at HRS, Rajikot, Jumla during 2019 and 2020. Desiree and Jumli local were used as standard and local check respectively. The experimental plot size was 5.4 m^2 (3m x 1.8m). Experimental area was tilled three times and compost was used at the rate of 20 ton per hectare before one month of planting. There was no use of chemical fertilizer. Well sprouted tubers of 25-50 g were planted with 60cm x 25cm spacing. The experiment was designed at RCBD with four replications. Planting and harvesting was done on the last week of March and third week of September, respectively. All the management practices were followed as per the NPRP recommendation.

2.3 Data Collection and Analysis

Observations on emergence, plant height, uniformity, ground coverage, number of main stem, total tuber number and total tuber yield were recorded. Emergence was recorded by counting the emerged tubers at 30 and 45 days after planting (DAP). Plant uniformity was recorded at 45 days after tuber emergence using a 1 to 5 scale (1 = very poor, 2 = poor, 3 = fair, 4 = good, and 5 = very good). Ground cover was taken at six weeks after planting. Each plot was assessed for the percentage of ground cover by foliage and expressed in percentage. Plant height (cm) was measured from the soil surface to the top-most growth point of the main shoot apex when 50% of the plants produced flowers. For the number of main stems per plant, all the stems that emerged independently above the soil as a single stems were considered. The number of tubers and total yield was recorded from experimental plot and converted as per hectare. 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 insect damage was expressed on percentage.

In addition, maturity, tuber characters such as shape, color and eye depth were recorded by visual observation of tubers as mentioned in Potato Field Book [18]. The data for growth, yield and yield parameters were recorded and analyzed by using Genstat 18th edition [19].

3. RESULTS AND DISCUSSION

3.1 Emergence Percentage

Maximum emergence (86.45%) at 30 DAP was found in PRP 146871.20 followed by PRP 016567.6 (85.76%), CIP 303381.106 (84.03 %), Desiree (82.29%) and the lowest (55.56%) was in Jumli local. AT 45 DAP, PRP 146871.20 and CIP 303381.106 showed the maximum (96.53%) emergence followed by PRP 016567.6 (95.83%), Desiree (95.83%) and CIP 392025.7 (94.1%) whereas the lowest (88.54%) was in PRP 296667.2 (Table 1). Highly significant differences among potato genotypes indicate the presence of genetic variation among the tested potato genotypes [20]. Similar types of significant variations were also observed by some researchers [21].

Table 1: Emergence (%) of potato genotypes at 30 DAP and 45 DAP at HRS, Rajikot, Jumla during 2019 and 2020

SN	Treatments	Emergence % at 30 DAP			Emergence % at 45DAP		
		2019	2020	Average	2019	2020	Average
1	CIP 303381.106	90.97 abc	77.08 bc	84.03 ab	97.22 abc	95.83 ab	96.53 a
2	CIP 393371.164	88.89 abc	65.28 e	77.08 c	93.75 abcde	84.03 d	88.89 d
3	CIP 394600.52	84.72 cd	70.83 bcde	77.78 c	91.67 acde	88.89 abcd	90.28 cd
4	CIP 393371.159	88.19 abc	75.69 bc	81.94 abc	92.36 abcde	90.97 abcd	91.67 bcd
5	CIP 392797.22	97.22 a	65.97 de	81.6 abc	97.92 a	87.5 cd	92.71 abcd
6	CIP 392025.7	86.11 bcd	74.31 bcd	80.21 bc	96.53 abcd	91.67 abcd	94.1 abc
7	PRP 016567.6	93.06 abc	78.47 ab	85.76 a	97.92 a	93.75 abc	95.83 ab
8	PRP 296667.2	86.81 bcd	68.75 cde	77.78 c	90.28 e	86.81 cd	88.54 d
9	PRP 146871.20	94.43 ab	78.47 ab	86.45 a	96.53 abcd	96.53 a	96.53 a
10	Desiree	79.17 d	85.42 a	82.29 abc	95.14 abcde	96.53 a	95.83 ab
11	Jumli Local	38.89 e	72.22 bcde	55.56 d	90.97 de	88.19 bcd	89.58 d
	Mean	84.41	73.86	79.13	94.57	90.97	92.77
	F test	**	**	**	*	*	**
	CV (%)	6.6	7.4	4.3	4	5.5	2.9
	LSD (0.05)	8.09	7.9	4.88	5.45	7.27	3.86

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

3.2 Plant Height

Highly significant difference was observed in plant height. The tallest plants (50.77 cm) were measured in PRP 016567.6 followed by CIP 393371.159 (45.6 cm), PRP 296667.2 (42.1 cm), CIP 392797.22 (40.4 cm) whereas the dwarfest (23.07 cm) in CIP 303381.106 (Table 2). Significant variation among potato genotypes in plant height may be due to reserve food material for the early growth of seed tubers and genetic characters [22]. Similar type of significant variation in plant height among the tested potato genotypes was also recorded by other researchers [23].

3.3. Number of main stem per hill

Similarly, number of main stem differed significantly among the potato genotypes tested. The highest number of main stems (5.6) were counted in CIP 392797.22 followed by PRP 146871.20 (5.5), PRP 296667.2 (5.12) whereas the lowest (2.68) in CIP 393371.159. (Table 2). The variation in stem number among the genotypes might be due to genetic traits [24]. Similar type of variation among different potato genotypes have been reported by some researchers [25].

Table 2: Plant height and number of main stems of potato genotypes at HRS, Rajikot, Jumla during 2019 and 2020

SN	Treatments	Plant height (cm)			No. of main stem		
		2019	2020	Average	2019	2020	Average
1	CIP 303381.106	16.8 e	29.35 e	23.07 e	2.4 e	4.3 c	3.35 def
2	CIP 393371.164	29.3 bcd	47.8 bc	38.55 c	2.65 de	3.65 cd	3.15 ef
3	CIP 394600.52	24.65 de	39.45 d	32.05 d	3.35 cde	3.65 cd	3.5 de
4	CIP 393371.159	37.55 ab	53.65 ab	45.6 b	2.7 de	2.65 d	2.68 f
5	CIP 392797.22	28.45 cd	52.35 ab	40.4 bc	4.75 a	6.45 b	5.6 a
6	CIP 392025.7	18.4 e	43 cd	30.7 d	3.2 cde	5.85 b	4.52 bc
7	PRP 016567.6	42.05 a	59.5 a	50.77 a	3.8 bc	4.05 cd	3.92 cd
8	PRP 296667.2	34.5 abc	49.7 bc	42.1 bc	4.55 ab	5.7 b	5.12 ab
9	PRP 146871.20	18.4 e	28.45 e	23.42 e	3.3 cde	7.8 a	5.55 a
10	Desiree	20.75 de	39.85 d	30.3 d	3 cde	3.3 cd	3.15 ef
11	Jumli Local	16.65 e	47.3 bc	31.97 d	3.55 cd	2.75 d	3.15 ef
	Mean	26.14	44.58	35.36	3.39	4.56	3.98
	F test	**	**	**	**	**	**
	CV (%)	21.4	10.6	9.9	16.4	17.1	12
	LSD (0.05)	8.09	6.84	5.04	0.8	1.1	0.69

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

Maximum ground coverage (73.75%) was recorded in CIP 392797.22 followed by PRP 016567.6 and CIP 394600.52 (61.25%), CIP 393371.159 (60%) whereas the lowest (40) in PRP 296667.2 and Jumli Local (Table 3). The variation in ground coverage percentage in different genotypes of potato might be due to varietal characters [26].

3.5 Uniformity (1-5 scale)

Highly uniform (5) plants were observed in CIP 392797.22 followed CIP 394600.52 (4.75), CIP 392025.7 (4.62), PRP 016567.6 (4.5) whereas the lowest (2.75) in Jumli Local (Table 3). The result showed highly significant differences among potato genotypes which indicated the presence of genetic variation. The variation in plant uniformity of the potato genotypes was reported by previous researchers too [27]. Similarly highly significant variation among the potato genotypes was reported by some researchers too [28].

Table 3: Ground cover (%) and uniformity (1-5 scale) of potato genotypes at HRS, Rajikot, Jumla during 2019 and 2020

SN	Treatments	Ground coverage (%)			Uniformity (1-5 scale)		
		2019	2020	Average	2019	2020	Average
1	CIP 303381.106	52.5 c	35 d	43.75 cd	4 cd	3.25 cde	3.62 de
2	CIP 393371.164	60 b	55 bc	57.5 b	4.25 bc	4.5 ab	4.38 bc
3	CIP 394600.52	62.5 b	60 b	61.25 b	4.75 ab	4.75 a	4.75 ab
4	CIP 393371.159	60 b	60 b	60 b	4.25 bc	4.5 ab	4.38 bc
5	CIP 392797.22	70 a	77.5 a	73.75 a	5 a	5 a	5 a
6	CIP 392025.7	57.5 bc	60 b	58.75 b	4.5 abc	4.75 a	4.62 ab
7	PRP 016567.6	72.5 a	67.5 ab	70 a	4.25 bc	4.75 a	4.5 b
8	PRP 296667.2	40 de	40 d	40 d	3 e	2.75 de	2.88 f
9	PRP 146871.20	45 d	37.5 d	41.25 d	3.5 de	3.5 cd	3.5 e
10	Desiree	57.5 bc	40 d	48.75 c	4.25 bc	3.75 bc	4 cd
11	Jumli Local	35 e	45 cd	40 d	3 e	2.5 e	2.75 f
	Mean	55.68	52.5	54.09	4.07	4	4.03
	F test	**	**	**	**	**	**
	CV (%)	6.9	15.8	7.7	10	12.9	7.6
	LSD (0.05)	5.54	11.95	6.01	0.59	0.74	0.44

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

Major insect pests observed during the crop growing season were Blister beetle and Leaf minor. Insect damage percentage was maximum (16.75%) in genotype CIP 393371.159 followed by CIP 393371.164 (11.62%), Desiree (11.5%), CIP 392025.7 (10.88%) whereas minimum in genotype CIP 392797.22 (%). Similarly, occurrence of late blight was maximum (5.25) followed by Desiree (5), Jumli Local (4.88) whereas minimum (1.38) in genotype CIP 393371.159. (Table 4). Similar type of insect pests and their damage pattern as well as variation in occurrence of late blight in different potato genotypes have been reported [25].

Table 4: Insect damage (%) and late blight scoring (1-9 scale) of potato genotypes at HRS, Rajikot, Jumla during 2019 and 2020

SN	Treatments	Insect damage (%)			Late blight reading (1-9 scale)		
		2019	2020	Average	2019	2020	Average
1	CIP 303381.106	12.5 cd	3.75 bc	8.12 bc	6.5a	4 ab	5.25 a
2	CIP 393371.164	21.25 b	2 e	11.62 b	4cd	1.75 d	2.88 d
3	CIP 394600.52	18.75 bc	2.5 de	10.62 bc	3def	3 bc	3 cd
4	CIP 393371.159	31.25 a	2.25 de	16.75 a	1h	1.75 d	1.38 e
5	CIP 392797.22	32.5 a	3 d	17.75 a	2fgh	1.75 d	1.88 e
6	CIP 392025.7	18.75 bc	3 cd	10.88 bc	5bc	2.25 cd	3.62 bc
7	PRP 016567.6	18.75 bc	2 e	10.38 bc	1.5gh	2 cd	1.75 e
8	PRP 296667.2	16.25 bcd	2 e	9.12 bc	3.5de	2.25 cd	2.88 d
9	PRP 146871.20	17.5 bcd	3 cd	10.25 bc	5bc	3 bc	4 b
10	Desiree	10.75 bc	4.25 ab	11.5 bc	5.5ab	4.5 a	5 a
11	Jumli Local	11.25 d	4.75 a	8 c	5bc	4.75 a	4.88 a
	Mean	19.77	2.96	11.36	3.71	2.82	3.32
	F test	**	**	**	**	**	**
	CV (%)	21.8	17.4	19	20.7	24.7	13.5
	LSD (0.05)	6.23	0.74	3.12	1.1	1.01	0.65

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

Most of tested potato genotypes were late in maturity whereas CIP 303381.106, CIP 392025.7, PRP 146871.20 and Desiree were early and CIP 393371.164 & CIP 394600.52 were medium in maturity. Highly significant difference was recorded in tuber number per hectare among the potato genotypes tested. Maximum number (459954) in CIP 392025.7 followed by Jumli Local (448380), CIP 392797.22 (419676) whereas minimum number (236574) in genotype CIP 393371.164 (Table 5). The number and size of potato tubers are economically important characters for marketing, human consumption and seeds for planting [29]. Significant variations in the numbers of tubers among the genotypes could be related to the genotypic effect. Statistically highly significant variation in tuber number among the tested potato genotypes was also reported by some researchers [30,31].

3.8 Tuber Yield and other characteristics

Similarly, tuber yield of different potato genotypes was also found highly significant among each other. Maximum tuber yield (20.9 t/ha) was recorded in genotype CIP 392797.22 followed by CIP 392025.7 (14.28 t/ha) whereas the lowest (5.82 t/ha) in PRP 296667.2 (Table 5). Tuber characteristics (tuber shape and tuber color) differed among potato genotypes. CIP 303381.106, CIP 393371.164, CIP 393371.159, PRP 016567.6, PRP 296667.2 and PRP 146871.20 were round; CIP 392025.7, Desiree and Jumli Local were long, whereas CIP 394600.52 and CIP 392797.22 were oblong in shape. CIP 303381.106, CIP 393371.164, CIP 394600.52, CIP 393371.159, CIP 392025.7, PRP 296667.2, PRP 146871.20 and Jumli Local were white, PRP 016567.6 was light red, CIP 392797.22 and Desiree were red in tuber color.

Significant variation in tuber yield among the potato genotypes might be the genotypic effect. Tuber weight is an important yield component of potato that contributes to total tuber yield [32,33]. Besides genotypes, management practices, seed quality and agro-ecological condition of the experimental site also affect the weight of tubers [34].

Potato varieties significantly influenced the yield of tuber per plant [35]. Significant variatioin of potato varieties in tuber yield was also reported by many scholars [36]. Similar result of differential performance of total tuber yield (t/ha) of potato was reported [37,38,39,40].

Table 5: Number of tubers per hectare and tuber yield (t/ha) of potato genotypes at HRS, Rajikot, Jumla during 2019 and 2020

SN	Treatments	Tuber number per ha			Tuber yield (t/ha)		
		2019	2020	Average	2019	2020	Average
1	CIP 303381.106	319444 cde	290278 c	304861 def	10.46 cd	10.05 bc	10.26 c
2	CIP 393371.164	225463 e	247685 c	236574 f	12.81bc	12.63 b	12.72 bc
3	CIP 394600.52	440278 abc	330093 bc	385185 abcd	15.0 4b	8.06 cd	11.55 bc
4	CIP 393371.159	407407 abcd	235185 c	321296 cdef	13.89 bc	11.09 bc	12.49 bc
5	CIP 392797.22	492593 ab	346759 bc	419676 abc	24.7 a	17.1 a	20.9 a
6	CIP 392025.7	443056 abc	476852 a	459954 a	15.65 b	12.9 b	14.28 b
7	PRP 016567.6	355093 bcde	310185 bc	332639 cdef	13.33 bc	11.33 bc	12.33 bc
8	PRP 296667.2	287963 de	296759 c	292361 def	6.41 e	5.22 d	5.82 d
9	PRP 146871.20	278704 de	425000 ab	351852 bcde	9.19 de	11.25 bc	10.22 c
10	Desiree	278704 de	246759 c	262731 ef	14.16 b	10.31 bc	12.23 bc
11	Jumli Local	533796 a	362963 abc	448380 ab	6.37 e	5.72 d	6.04 d
	Mean	369318	324411	346864	12.91	10.52	11.71
	F test	**	**	**	**	**	**
	CV (%)	26.5	24	19	17.6	22.6	16.2
	LSD (0.05)	141067.5	112484.3	95098	3.28	3.43	2.75

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

4. CONCLUSION

The research results of both years showed that significant differences for total yield and yield attributing characters. The study showed that among the tested genotypes CIP 392797.22 produced maximum tuber yield (20.9 t/ha) based on compost only. Till date red colored recommended variety in Jumla is Desiree. This may be additional one more variety with red skin color for Jumla and locations with similar climatic conditions. Maximum yield can be obtained with the use of chemical fertilizer in addition to organic one from this genotype. Therefore the large scale cultivation of this genotype will help to increase the food availability as well as income generation for commercial farmers in the conditions of Jumla.

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