EVALUATION OF POTATO GENOTYPES FOR PLANT AND YIELD TRAITS AT DAILEKH DISTRICT, NEPAL

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ABSTRACT

Field experiments were conducted at on-farm condition of Dailekh during the spring season for two years (2019 and 2020) to study the plant and yield traits of potato genotypes, and to select high yielding and farmers' preferred genotype. Five promising potato genotypes (PRP226567.2, CIP395017.242, PRP136769.1, PRP276264.1 and CIP393617.1) were studied for their plant and yield traits and compared them with 'Kufri Jyoti', a popular check variety. Experiments were laid-out in randomized complete block design (RCBD) with four replications. Results showed that genotypes exhibited significant differences in all the plant and yield characters. CIP395017.242 gave the highest marketable (23.5 t/ha) and total tuber yield (25.9 t/ha). As compared to Kufri Jyoti, CIP395017.242 gave 12.4% higher marketable tuber yield. Farmer's preferences on plant and tuber of CIP395017.242 were also similar to Kufri Jyoti. Therefore, genotype CIP395017.242 can be recommended to grow at on-farm condition of Dailekh.

Keywords: Genotypes, Marketable, On-farm, Tuber, Yield traits

INTRODUCTION

Potato (*Solanum tuberosum* L.) is a tuberous crop of the Solanaceae family and it is the world's fourth-largest food crop after rice, wheat and maize. In Nepal, it ranks the first crop in total productivity (NPRP, 2019). It is a staple food crop in high hills but this is used as a major vegetable crop in mid hills and terai. Potato is considered as important crop for food and nutritional security at high hills and mountains. Potato is also rich in micronutrients and vitamins and one medium size potato boiled provides half adult daily requirements of vitamin C, iron and potassium (cipotato.org). Potato produces more energy and protein per unit area and unit of time than other food crops (Lutaladio and Castaldi, 2009).

Potato is cultivated in all agro-ecological regions of Nepal ranging from 100 to 4,400 m asl (Dhital and Khatri, 2004). It is cultivated 1, 93, 997 ha of arable land with total production 3,112, 947 tons and the productivity of 16.05 t/ha (MoALD, 2019). Mid hills of Nepal is a dominant region for potato production which occupies 44% of total area (NPRP, 2019). Despite Nepal has favorable agro-ecology for potato production, the national productivity is still low (MoALD, 2019). Lack of improved varieties, high seed demand during planting seasons, use of recycled seed tubers in high

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hill, and continuous growing of old and degenerated varieties are principal factors for limiting production at hills (Luitel et al., 2016).

National Potato Research Program (NPRP) has been developed and released eleven potato varieties so far since its establishment in 1991 (NPRP, 2019) but all the varieties cannot cope the growers' demand for their desired traits. With changing the needs of growers' and industry, there is a need to develop new variety. Cultivar development is a continuous process (Struik and Wiersema, 1999). Potato tuber yield is a complex polygenic trait (Killick, 1977) which is the product of interactions between various factors. Potato genotypes bred in the tropics and temperate regions may perform differently. The performance of potato varieties varies from place to place and none of the released varieties equally potential to perform throughout the country (Bradshaw, 2007). Cultivars of same species grown even in same environment have differences in the yield (Bairwa et al., 2018). On-farm trials are vital to speed up the variety development and enhancing the adoption of new varieties in farm communities (Assefa et al., 2005). The phenotypic characterization and evaluation of different crops in on-farm condition had been studied by several researchers (Bucheyeki and Mmbaga, 2013; Luitel et al., 2016 and Luitel et al., 2017). Dailekh, the second largest district of Karnali Province, represents the mid-western of Nepal and is also a potential area for potato production where many farmers use 'Cardinal' as improved variety for fresh production. Farmers are still used Lal Gulab, an Indian variety, and some other local varieties due to lack of access of well-adapted high yielding varieties. The varietal diversity is very low in this region (personal communication). Therefore, this study was carried out to evaluate different potato genotypes for their plant and yield characters, and to identify superior genotypes particularly at on-farm condition of Dailekh.

MATERIALS AND METHODS

The study was conducted at on-farm, Kalbhairab, Dullu Municipality-11 for two years (2019 and 2020). The mean annual rainfall ranged from 153 to 265 mm with rainy season extending from June to August (HRS, 2019). In the cropping season from Feb. to May, the average maximum temperature varied from 18.9 to 30.9˚C in 2019 whereas it varied from 20.1 to 27.9˚C in 2020. Average maximum and minimum temperature increased consistently from Feb. to May but rainfall was inconsistent in both years (Figure 1.)

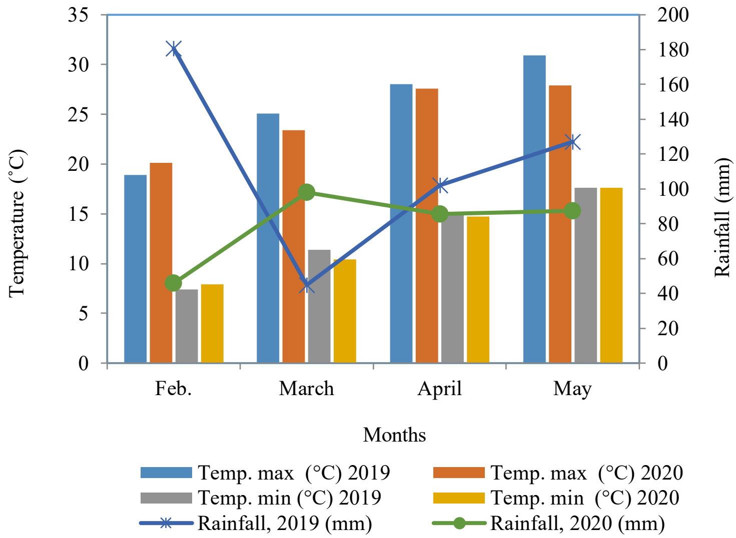

Figure 1. Temperature and rainfall in the cropping season of potato during 2019 and 2020 at Kalbhairab, Dailekh

Seed tubers of six potato genotypes (PRP226567.2, CIP395017.242, PRP136769.1, PRP276264.1, CIP393617.1 and Kufri Jyoti) were received from NPRP, Khumaltar. Out of six genotypes, CIP395017.242 and CIP393617.1 were bio-fortified and enriched with Zn and iron (Luitel et al., 2016). Experiments were arranged in a RCBD with four replications. 'Kufri Jyoti' is a popular variety in mid hills and it was used as check variety. The soil was tilled three times and compost (14.4 kg/plot) was applied a month before planting with a rate of 20 t/ha. Well-sprouted medium sized (30-50 g) tubers were planted on Feb. 14, 2019 and 2020 by hand in rows 60 cm apart and 25 cm between plants within rows. Four farmers were chosen at similar agro-climatic region where six genotypes were planted at each farmer's field and each farmer was considered as one replication. Four rows for each genotype were maintained with plot size 7.2 m^2. Each plot was fertilized with the rate of 100:100:60 kg/ha $NP_2O_5K_2O$ as recommended by NPRP (2019). Urea and DAP fertilizer were used as source of nitrogen and phosphorus, respectively. The entire rate of phosphorus, potash and half the rate of nitrogen was applied at the time of planting and the remaining half of nitrogen was applied 45 days after planting. Cultural practices such as earthening-up and weeding were carried out two times by hand during the growing period.

Observation on plant uniformity was recorded at 45 days after tuber emergence using 1 to 5 scale (1 = least uniform, 5 = most uniform and 2-4 in between). Ground cover was taken at about 60 days after emergence. Each plot was assessed for the percentage of ground cover by foliage converted to a 1-9 scale using following key; 1 = No emergence; 2 = Less than 20% ground cover, 3 = 29-35 % ground cover, 4 = 36-50 % ground cover, 5 = 51-65 % ground cover; 6 = 66-75 % ground cover; 7 = 76-90 % ground cover; 8 = 91-99 % ground cover and 9 = 100 % ground cover (Khatri and Luitel, 2014). 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 produce flowers. The number of stem per plant was recorded the stems that emerged independently above the soil as single stems at 50% flowering. Tubers were graded after harvesting; and tubers less than 25.0 g and diseased and insect infected was categorized as non-marketable whereas tubers size with greater than 25.0 g, and more than 50.0 g were categorized into marketable tuber. The marketable tuber yield was calculated using marketable tuber weight/plant (g) multiplied by planting density divided by area in hectare basis (De Haan et al., 2014.). Total tuber yield (t/ha) was calculated by adding the weight of all tubers (marketable and non-marketable tuber yields). In addition, plant and tuber characters such as maturity, shape, color, skin type and eye depth was recorded by visual observation of plant foliage and tubers as mentioned in Potato Field Book (Khatri and Luitel, 2014). ANOVA was performed using GenStat Release 10.3 DE Software (VSN International Ltd., UK) and phenotypic correlation of quantitative characters was analyzed by IBM SPSS Statistics (Version 20.0).

RESULTS AND DISCUSSION

PLANT TRAITS

The combined analysis showed that genotypes showed significant differences in plant uniformity, ground cover, plant height and stem number/plant (Table 1). The highest (5.0) plant uniformity was observed in PRP226567.2 and CIP395017.242. Year showed non-significant difference in plant uniformity but genotype and year interaction effect were significant. The variation in plant uniformity of the potato genotypes was reported by previous researchers (Luitel et al., 2016). CIP395017.242 produced the highest (80.0%) ground cover but it was statistical similar to CIP393617.1 (79.0%) and PRP226567.2 (77.0%) but the lowest (64.0%) ground cover was observed in PRP276264.1. Year and, genotype and year interaction showed highly significant differences in ground cover. Ground cover is also determined by the growing condition, planting time and tuber bulking behavior of genotypes. The tallest plant was measured in PRP276264.1 (67.0 cm) followed by CIP393617.1 (65.0 cm) but the shortest (51.0 cm) was measured in PRP136769. Differences in plant height among the genotypes may be caused by genetics of the plant as well as the quality of planting materials used (Eaton et al., 2017). CIP393617.1 produced more (6.0) number of stem/plant but it was statistically similar to PRP226567.2 (5.0) and CIP395017.242 (5.0) but the least (4.0) number of stem/plant was counted in PRP136769.1 and Kufri Jyoti. The variation in stem number/plant among the genotypes might be due to genetic traits (Nielson et al., 1989).

Table 1. Plant traits of potato genotypes evaluated at on-farm, Dailekh during 2019-2020.

Genotypes (G)	Uniformity (1-5 score)		Mean	Ground cover (%)		Mean	Plant height (cm)		Mean	Stem/plant (no.)		Mean
	2019	2020		2019	2020		2019	2020		2019	2020	
PRP226567.2	4.0	5.0	5.0	64.0	90.0	77.0	41.0	76.0	59.0	5.0	4.0	5.0
CIP395017.242	4.0	5.0	5.0	70.0	90.0	80.0	47.0	66.0	56.0	5.0	5.0	5.0
PRP1367	4.0	5.0	4.0	61.0	88.0	75.0	47.0	56.0	51.0	4.0	5.0	4.0

Genotypes (G)	Uniformity (1-5 score)		Mean	Ground cover (%)		Mean	Plant height (cm)		Mean	Stem/plant (no.)		Mean
	2019	2020		2019	2020		2019	2020		2019	2020	
69.1												
PRP276264.1	3.0	5.0	4.0	35.0	92.0	64.0	60.0	74.0	67.0	6.0	4.0	5.0
CIP393617.1	4.0	4.0	4.0	71.0	87.0	79.0	45.0	85.0	65.0	6.0	5.0	6.0
K. Jyoti (Ch)	4.0	5.0	4.0	55.0	92.0	74.0	49.0	61.3	55.0	3.0	5.0	4.0
Mean	3.83	4.75	4.39	59.4	90.1	74.7	48.1	69.6	58.13	4.84	4.91	4.88
Genotypes (G)			*			**			*			*
LSD (0.05)			0.541			8.98			14.50			1.12
Year (Y)			NS			**			**			NS
LSD (0.05)			0.33			5.19			8.40			0.64
G x Y			*			**			*			NS
LSD (0.05)			0.80			12.7			20.58			1.58
CV (%)			13.1			11.8			23.7			22.5

ns, *, ** non-significant or significant at 5% and 1%, respectively.

YIELD TRAITS

Genotypes revealed highly significant differences in non-marketable, marketable tuber number and total tuber number/plant (Table 2a). The highest (108.0) non-marketable tuber number/plot was produced in PRP136769.1 followed by CIP395017.242 (102.0) but the lowest (76.0) was in CIP393617.1. Year showed highly significant effect on non-marketable tuber/plot and, genotype and year interaction was also significant. Similarly, CIP395017.242 produced the maximum (214.0) marketable tuber number/plot followed by PRP136769.1 (211.0) but it was the lowest (148.0) in PRP276264.1. Year had non-significant effect on marketable tuber number/plot but interaction of genotype and year was highly significant. Total tuber number/plant was produced the highest (11.0) in CIP395017.242 and PRP136769.1 but the lowest (8.0) tuber number was produced in PRP276264.1, CIP393617.1 and Kufri Jyoti. Year showed significant effect on total tuber number/plant but genotype and year interaction showed highly significant. The significant variation in tuber number/plant might be due to genotypic factors. Lahlou et al. (2003) reported that tuber number was more affected by the bulking nature of genotypes. Seifu and Betewulign (2017) also reported a significant difference in total tubers number/plant among potato varieties.

Table 2a. Yield traits of potato genotypes evaluated at on-farm, Dailekh during 2019-2020.

Genotypes (G)	Non-marketable tuber/plot (no.)		Mean	Marketable tuber/plot (no.)		Mean	Total tuber/plant (no.)		Mean
	2019	2020		2019	2020		2019	2020	
PRP226567.2	136.0	58.0	97.0	237.0	171.0	204.0	9.0	9.0	9.0
CIP395017.242	116.0	88.5	102.0	183.0	245.0	214.0	8.0	15.0	11.0
PRP136769.1	146.0	71.0	108.0	223.0	198.0	211.0	10.0	13.0	11.0
PRP276264.1	81.0	76.0	79.0	107.0	190.0	148.0	5.0	11.0	8.0
CIP393617.1	108.0	75.0	76.0	198.0	121.0	159.0	8.0	7.0	8.0
K. Jyoti (Ch)	83.0	33.0	58.0	148.0	205.0	177.0	7.0	10.0	8.0
Mean	111.5	61.8	86.7	182.6	188.1	185.4	7.88	10.73	9.33
Genotypes (G)			**			**			**
LSD (0.05)			25.46			36.13			2.580
Year (Y)			**			NS			**
LSD (0.05)			14.7			20.86			1.49
G x Y			*			**			*
LSD (0.05)			36.01			51.09			3.65
CV (%)			28.9			19.2			23.7

ns, *, ** non-significant or significant at 5% and 1%, respectively.

Results of marketable tuber weight, marketable tuber yield and total tuber yields of potato genotypes are presented in Table 2b. Significant effect was found in marketable tuber weight among the genotypes. CIP395017.242 produced the highest (12.4 kg) marketable tuber weight followed by PRP136769.1 (11.8 kg) and PRP226567.2 (11.7 kg) and the lowest (8.9 kg) was observed in PRP276264.1. Marketable tuber yield produced the highest (23.5 t/ha) in CIP395017.242 and the lowest (17.0 t/ha) was in PRP276264.1.Variation in marketable tuber weight among the genotypes may be due to genetic make-up of the plants. Besides genotypes, management practices, seed quality and agro-ecological condition of the experimental site also affect the weight of tubers (Eaton et al., 2017). With respect to tuber yield, CIP395017.242 gave the highest (25.9 t/ha) but the lowest (19.1 t/ha) yield was recorded in PRP276264.1.Year showed highly significant on total tuber yield but interaction between genotype and year was significant. Genotypes showed significantly different in marketable tuber weight and yield at on-farm condition and this variation might be due to genotypic and similar results were reported by previous researchers (Hassanpanah et al., 2011; Luitel et al., 2017). High tuber yield might be due to better plant uniformity, ground cover and high number of tuber/plant (Patel et al., 2008; Luitel et al., 2017). Tuber yield variation in potato genotypes were reported by different researchers in Nepal (Luitel et al., 2017; Gainju et al., 2019).

Table 2b. Yield traits of potato genotypes evaluated at on-farm, Dailekh during 2019-2020.

Genotypes (G)	Marketable wt./plot (kg)		Mean	Marketable tuber yield (t/ha)		Mean	Total tuber yield (t/ha)		Mean
	2019	2020		2019	2020		2019	2020	
PRP226567.2	12.6	17.3	14.9	17.6	23.9	20.8	20.3	26.2	23.2
CIP395017.242	10.8	22.2	16.5	16.2	30.8	23.5	18.2	33.5	25.9
PRP136769.1	12.3	18.2	15.2	17.0	25.3	21.1	20.1	27.5	23.8

PRP276264.1	6.8	17.7	12.3	9.4	24.6	17.0	11.6	26.6	19.1
CIP393617.1	13.9	11.4	12.7	19.4	15.7	17.6	22.0	16.8	19.4
K. Jyoti (Ch)	8.1	21.9	15.1	11.3	30.5	20.9	13.3	31.4	22.3
Mean	10.79	18.11	14.4	14.9	25.2	20.07	17.6	27.0	22.3
Genotypes (G)			*			*			*
LSD (0.05)			1.1			5.13			2.16
Year (Y)			NS			**			**
LSD (0.05)			2.27			3.87			4.11
G xY			NS			*			*
LSD (0.05)			5.56			9.49			10.07
CV (%)			18.9			19.2			23.1

ns, *, ** non-significant or significant at 5% and 1%, respectively.

PHENOTYPIC CORRELATION

Plant uniformity showed strong positive association with ground cover, marketable tuber number, total tuber number/plant, marketable tuber weight, marketable tuber yield and total tuber yield (Table 3). Ground cover showed moderate correlation with plant height, marketable tuber number, total tuber number/plant, marketable tuber weight, marketable tuber yield and total tuber yield. Similarly, marketable tuber number exhibited positive correlation with total tuber number/plant, marketable tuber weight, marketable tuber yield and total tuber yield. Total tuber number/plant had positively correlated with marketable tuber weight, marketable tuber yield and total tuber yield. This result indicates that as the total number of tuber increases, tuber yield per plot also increases. So, selection of this trait is useful for potato variety improvement. Marketable tuber weight showed strong positive association with marketable yield and total tuber yield. The strong positive correlation between tuber weight and yield was also reported by Khayatnezhad et al. (2011). The positive correlation between tuber size and tuber yield was also reported by Yuan et al. (2016).

Table 3. Correlation coefficient of plant and yield traits of potato genotypes evaluated at on-farm, Dailekh during 2019-2020.

Variables	UNIF	GC	PHT	STPP	NMNO	MTN	TTPP	MTWT	MYLD	TYLD
UNIF	1.0	.87**	.15	.18	-.17	.50**	.50**	.68**	.64**	.63**
GC		1.0	.40**	.09	-.34*	.41**	.57**	.42**	.71**	.68**
PHT			1.0	.18	-.44**	-.30*	.07	-.13	.14	.10
STPP				1.0	0.02	.18	.03	.51**	.63**	.54*
NMNO					1.0	.26	.12	.16	-.19	-.09
MTN						1.0	.67**	.82**	.66**	.68**
TTPP							1.0	.82**	.84**	.87**
MTWT								1.0	.83**	.85**
MYLD									1.0	0.99**
TYLD										1.0

* and ** indicate significance at 5 and 1%, respectively. UNIF = Uniformity (1 to 5 scale), GC = Ground cover (%), PHT = Plant height (cm), STPP = Stem number/plant, NMNO = Non-marketable tuber/plot (no.), MTN = Marketable tuber/plot (no.) TTPP = Total tuber/plant (no.) MTWT = Marketable tuber weight/plot (kg), MYLD = Marketable tuber yield (t /ha), and TYLD = Total tuber yield (t/ ha)

MATURITY AND TUBER TRAITS

PRP226567.2, CIP395017.242, PRP136769.1 and Kufri Jyoti were medium (90-120 days) maturing types but PRP276264.1 and CIP393617.1 were late maturing (>120 days) genotypes (Table 4). Tuber shape varied from oblong, round, round flat to oval type. Out of six genotypes, PRP226567.2 and PRP276264.1 observed as light red and red tuber, respectively and remaining genotypes produced white tuber. Likewise, eye depth in tuber varied from shallow, medium to deep. Farmers' preferences in plants and tuber were not different considerably in the tested genotypes. Qualitative traits such as skin and flesh color, and eye depth are stable over the environments and therefore, tuber characters over the years did not change. In contrast, maturity class, tuber number and yield are influenced by environment (Struik and Wiersema, 1999). On the other hand, tuber shape, skin and flesh color, eye depth and general appearance are the distinctive quality parameters that influence consumer's choice (Pandey et al., 2000).

Table 4. Maturity and tuber traits of potato genotypes evaluated at on-farm, Dailekh during 2019-2020.

Genotypes	Maturity	Tuber shape	Tuber color	Eye depth	Farmers' preferences (1-5 score)	
					Plants	Tubers
PRP226567.2	Medium	Oblong	Light Red	Shallow	5	4
CIP395017.242	Medium	Round	White	Medium	5	4
PRP136769.1	Medium	Round flat	White	Shallow	4	4
PRP276264.1	Late	Round	Red	Deep	5	4
CIP393617.1	Late	Round flat	White	Shallow	3	4
K. Jyoti (Ch)	Medium	Oval	White	Shallow	4	4

Maturity; Early = < 90 days, Medium = 90-120 days, and Late = >120 days (Khatri and Luitel, 2014).
Farmers preference, 1-5; 1 = Very poor, 5 = Very good (Luitel et al., 2016).

CONCLUSION

Genotypes revealed the significant variation in all the plant and yield traits. CIP395017.242 produced the highest (23.5 t/ha) marketable tuber yield and it imparted 12.4% yield advantage over check variety Kufri Jyoti. Plant uniformity, ground cover, marketable tuber number/plot, total tuber number/plant and marketable tuber weight/plot recorded high positive and significant correlation with tuber yield suggesting their potential use in potato improvement. Since CIP395017.242 is a medium maturing type, white skin with medium eye depth in tuber, farmers preferred similar to Kufri Jyoti. CIP395017.242 is also zinc and iron enriched genotype and therefore, cultivation of this clone would help to contribute food nutrition of the people of Karnali Province.

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