Evaluation of Growth and Yield Attributes of Commonly Grown Potato *(Solanum Tuberosum*) Varieties at Kavre, Nepal

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Abstract- A varietal trial was conducted to evaluate growth and yield attributing characteristics of nine commonly grown potato varieties collected from central region of Nepal namely; Khumal Upahar, IPY -8, Khumal Seto-1, Jankdev, Khumal Ujjawol, Cardinal, Panauti Local, MS 42.3 and Khumal Bikash. The experiment was laid out on randomized complete block design (RCBD) with three replications. Parameters on, growth parameter such as plant height (cm), number of leaves per plant, number of main stem per hill, canopy diameter (cm) (at different days after planting) and yield parameters such as tuber weight per plant (g), tuber number per plant, tuber distribution by grading on number and weight was recorded. Collected data were analyzed using MS-Excel and R Studio. The plant height, number of main stem per hill and canopy diameter at different days after planting varied significantly up to harvest. At harvest, the tallest plant (57.25 cm) was recorded in Janakdev and shortest in (23.87) cardinal. The maximum number of leaves per plant (109.8) was observed in Janakdev and minimum (50.40) in cardinal. The highest (7.01) and lowest (4.13) number of main stem per hill was recorded in cardinal and Khumal upahar while maximum and minimum canopy was observed in Janakdev (60.96) and cardinal (40.42) respectively. All the yield attributing parameters was found significant at 5% level. The maximum tuber weight per plant (585g) was recorded in Jankdev however highest number of tuber (20.903) was produced by MS-42. Highest number of small size tuber (<25gm) was recorded from cardinal (69.234) while highest number of large size tuber (<50gm) was recorded in Janakdev (48.197). Tuber did not differ significantly among the varieties but numerically highest yield (33.40 t ha^{-1}) was obtained from variety Janakdev and lowest (14.2 t ha^{-1}) from cardinal.

Index Terms- Growth parameters, potato, R-studio, yield attributes, Yield

I. INTRODUCTION

Potato (*Solanum tuberosum* L) of the Solanaceae family is the world's number one non-cereal which feeds more than a billion people on daily basis (FAO 2013). It is third most important food crop in the world after rice and wheat in terms of consumption (FAO, 2011). Potato covers 1,99,971 ha area under cultivation with production of 28,05,582 mt. and productivity of 14.03 mt/ha in Nepal (ABPSD, 2016). It is the most potential food crops that could contribute to address global hunger problem by reducing poverty among smallholder farmers in developing countries (Timsina, Kafle, & Sapkota, 2011). It also serves as healthy replacement to most of the cereal crops and provides more calories, vitamins, and nutrients per area of land sown than other staple crops (Nunn & Qian, 2011). Potato tuber contains 70-80% water, 20.6% carbohydrate, 2.1% protein, 0.3% fat, 1.1% crude fiber and 0.9% 000000ash (Gemmechu, 2017).

National Potato Research Program (NPRP) under Nepal Agriculture Research Council (NARC) is working for the development, evaluation and conservation of different potato varieties and genotypes while the mandate of dissemination of improved production technologies is given to Potato Development program under Department of Agriculture in Nepal. Potato is the major vegetable crop of mid hills and terai and a stable food of high hills and mountain regions of Nepal (NPDP, 2007). It is primarily a temperate crop but can be cultivated from an altitude of 100 to 4000 masl in Nepal (FAO, 2013). The high value crop is preferred for short cropping cycle (3-4 months) and higher yields compared to cereal crops (K.C., 2016). One hectare of potatoes can yield two to four times the quantity of grain crops. Likewise, potatoes are up to seven times more efficient in using water than cereals (CIP). Potato is financially more remunerative than cereals from food security and can be recommended as a partial replacement of cereals (Anwar, Shabbir, Shahid, & Samreen, 2015). Potato is used mainly for three purposes, as table purpose (vegetable and number of recipes), as a seed tuber and as a processed food like chips, wafers, flakes, starch, granules, flour, potato biscuits, potato patties, puffs, wedges, pancakes, dehydrated mashed potatoes, canned potatoes.

In Nepal, potato occupies 5th position in the average area and 2nd position in productivity and 1st in productivity (ABPSD , 2016). Nepal is one of the top twenty country in terms of potato contribution in human diet, which is increasing due to the adoption of improved potato varieties which have direct impact on farmers income, household level food and nutrient security as well (Timsina, Kafle, & Sapkota, 2011).There are twelve released and registered varieties namely Kufri jyoti, Kufri Sindhuri, Desire, Janakdev, Khumal Seto-1, Khumal Rato-2, Khumal laxmi, IPY-8, Khumal Ujjawol, Khumal Upahar, TPS-1,TPS-2 and two recommended varieties as Cardinal and NPI-106 in Nepal. Khumal Bikash is newly released variety (2075). Improved varieties have high yield potential and choice of improved varieties is the most critical factors determining productivity (Gairhe, Gauchan, & Timilsina, 2017). According to Sapkota & Bajracharya, (2017) potato cultivation is popular among farmers due to its wider adaptability, high yield

potential and high demand that contribute about 6.57 and 2.17% in Agriculture Gross Domestic Product (AGDP) and Gross Domestic Product) GDP respectively.

Kavre district rank first in terms of productivity and production of potato in Nepal. Kavre district which is also super zone for potato production produces both in spring and winter season in 9,785 hectare area potato production was found to be 3,37404MT with average productivity of 19.2 MT/ha (Dr.Kalika psd upadhaya, 2074). There has always been a demand of high yielding varieties which are resistant to disease and insects and even grow well under drought and dry condition. Moreover, the production and productivity is also influenced by specific varieties and quality of planting materials. Therefore, this research was conducted at Kavre district with an aim to identify promising high yielding variety for the mid hills condition of Nepal.

II. MATERIALS AND METHODS

A field experiment was conducted at Panauti-5, Kavre, Nepal during the period from January 2019 to July 2019. The geographical situation of the experimental field is at latitude of 27º36'59.99''N and longitude of 85º32'59.66''E having subtropical climate. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. The selected field was firstly divided into three equal blocks and each block was further divided into twelve unit plots. The size of each unit plot was 17.64 m^2 (4.2 m × 2.8 m ×1.5 m). The total number of plot was twenty seven. All the blocks were separated by 1m buffer zone and each plot was separated by 0.5 m spacing between them. In this research nine commonly grown potato varieties viz. Khumal Upahar, IPY-8, Khumal Seto-1, Janakdev, Khumal Ujjawol, Cardinal, Panuti Local, MS 42 and Khumal Bikash were used. The experimental location was uniformly fertilized with 30mt ha^{-1} FYM and chemical fertilizers N, P_2O_5, and K_2O at 100:100:60 kg ha^{-1} respectively. The total FYM, P_2O_5, and K_2O and half of N were applied as basal dose. The rest of the urea was applied 45 days after planting (DAP). Single hand weeding were dine to check the weed infestation in the experimental field at 40 DAP. The field was irrigated twice at 20 DAP and 50 DAP using furrow method of irrigation. Late blight of potato was the most common disease during experimentation so one foliar spray of Diathene M 45 at 2ml lit^{-1} was applied at 50 DAP to control late blight. Earthing up of experimental field and halum pulling was done at 45 DAP and 115 DAP respectively. Data were recorded on growth parameters (at 45, 53, 61, 69 and 77 days after planting however number of stem per hill was recorded only thrice during entire research period (at 45, 53 and 61 days after transplanting). The recorded data were analyzed using MS-Excel and software package R-Studio.

III. RESULT AND DISCUSSION

Potato Plant Height

Effect of potatoes varieties on plant height during the early stages at 45DAP and 53 DAP was found non-significant (Table 1). However significant result was observed from 61days onwards till final harvesting. At 61 DAP Janakdev was recorded maximum height (18.75cm) and Khumal Seto -1(10.33cm) was recorded minimum height. At 69 DAP maximum height recorded on Janakdev (19.767cm) at par with IPY-8 (25.792cm) and minimum height recorded was Khumal Ujjawol (17.358cm) at par with Cardinal (17.917cm). At 77 DAP Janakdev (57.250cm) was recorded maximum which was at par with IPY-8 (54.733cm) and minimum height was recorded on Cardinal (23.875cm). At earlier stage of crop there was slow increment in plant height which may be due to low temperature. After 61 DAP, suitable temperature and proper irrigation led to higher plant height. These differences in plant height among the varieties may be caused by plant genetics and the quality of the plant material (Touria , Abul, Humayun, & Abu, 2017)

Table1: Average plant height (cm) of potato varieties at Kavre, 2019

Treatments	Plant Height (cm)				
	45 Days	53 Days	61 Days	69 Days	77 Days
Khumal Upahar	8.29	9.00	12.70^{cd}	19.41^{bcd}	45.29^{ab}
IPY-8	9.29	9.74	14.27^{C}	25.79^{a}	54.73^{a}
Khumal Seto-1	9.20	11.68	17.91^{ab}	24.60^{ab}	40.08^{b}
Janakdev	10.35	12.91	18.75^{a}	29.76^{a}	57.25^{a}
Khumal Ujjawol	7.96	9.39	10.33^{d}	17.35^{d}	45.12^{ab}
Cardinal	8.67	9.65	11.54^{cd}	17.91^{d}	23.87^{c}
Panauti local	9.12	9.91	14.62^{bc}	18.66^{cd}	38.12^{b}
MS 42.3	11.68	11.85	14.79^{bc}	24.00^{abc}	40.08^{b}
Khumal Bikash	9.49	10.74	12.95^{cd}	18.29^{cd}	45.12^{ab}
LSD	2.83^{NS}	3.13^{NS}	3.58^{**}	5.42^{**}	12^{**}
SEM(±)	0.94	1.04	1.19	1.8	4.01
CV%	17.5	19.1	14.5	14.4	16

Grand mean	9.34	10.5	14.5	21.8	43.3

Mean followed by common letter(s) within columns are non-significantly different based on DMRT P=0.05, **Significant at 0.01 P level, ***Significant at 0.001 SEM: Standard Error of Mean, CV: Coefficient of Variance

Number of Leaves per Potato Plant

The result of statistical analysis showed that the effect of different varieties on number of leaves during early stage at 45 DAP was found non-significant (Table 2). At 53 DAP maximum leaf number was recorded on Janakdev (34.927)which was at par with MS 42.3(33.428) and Khumal Seto-1(32.998).The minimum leaf number was recorded on Khumal Upahar(22.763) which was at par with Panauti Local(24.667) and Khumal Ujjawol(25.553).At 61 DAP maximum leaf number was recorded on MS 42.3(59.707) and minimum leaf number was recorded on Khumal Ujjawol(31.958) which was at par with Khumal Upahar (33.125) and Khumal Bikash(36.383). At 69 DAP maximum leaf recorded at MS 42.3(60.792) Which was at par with Janakdev (57.958) and minimum leaf number was recorded on Khumal Ujjawol (37.875) which was at par with Khumal Upahar (40.125).At 77 DAP Maximum leaf number was recorded at Janakdev (109.87) at par with MS 42.3(107.583) and minimum leaf number was recorded at cardinal (50.408).

Table 2: Average number of leaves of potato varieties at Kavre, 2019

Treatments	No of leaves				
	45 Days	53 Days	61 Days	69 Days	77 Days
Khumal Upahar	18.04	22.76^{b}	33.12^{d}	40.12^{c}	61.24^{bc}
IPY-8	26.52	32.70^{a}	50.87^{ab}	54.66^{ab}	70.63^{bc}
Khumal Seto -1	24.20	32.99^{a}	42.41^{bcd}	47.25^{bc}	64.18^{bc}
Jankdev	30.12	34.92^{a}	49.54^{abc}	57.95^{ab}	109.8^{a}
Khumal Ujjawol	16.99	23.55^{b}	31.95^{d}	39.87^{c}	67.12^{bc}
Cardinal	24.25	29.60^{ab}	39.70^{bcd}	42.83^{bc}	50.40^{c}
Panauti Local	24.25	24.66^{b}	38.16^{cd}	46.55^{bc}	78.41^{b}
MS 42.3	28.70	33.42^{a}	59.70^{a}	62.12^{a}	107.58^{a}
Khumal Bikash	24.68	29.20^{ab}	36.38^{d}	45.33^{bc}	62.15^{bc}
LSD	10.5^{NS}	6.9**	11.5**	9.49***	21.3***
SEM(±)	3.51	2.30	3.83	3.16	7.093
CV%	25.2	13.6	15.7	11.3	16.5
Grand mean	24.2	29.3	42.4	48.5	74.6

Mean followed by common letter(s) within columns are non-significantly different based on DMRT P=0.05, **Significant at 0.01 P level, ***Significant at 0.001 SEM: Standard Error of Mean, CV: Coefficient of Variance

Number of main stem per hill

The effect of different potato varieties on number of main stem per hill was significant among the treatment (Table 3) .At 45 DAP maximum stem number was recorded on MS 42.3(5.958) and minimum was recorded on Khumal Ujjawol (3.72). At 53 DAP maximum stem number was recorded on cardinal (7.017) whereas minimum on Khumal Upahar (4.136). Same data were recorded during 61 DAP.

Table 3: Average number of main stems per hill of potato varieties at Kavre, 2019

Treatments	Number of stem per hill		
	45 Days	53 Days	61 Days
Khumal Upahar	4.04^{bc}	4.13^{d}	4.13^{c}
IPY-8	4.50^{bc}	5.06^{bcd}	5.06^{bc}
Khumal Seto-1	5.18^{ab}	5.82^{abc}	5.82^{ab}
Janakdev	4.17^{bc}	4.99^{bcd}	4.99^{bc}
Khumal Ujjawol	3.72^{c}	4.24^{cd}	4.24^{c}

Cardinal	5.33[ab]	7.01[a]	7.01[a]
Panuti local	4.75[abc]	4.80[bcd]	4.80[bc]
MS 42.3	5.95[a]	6.02[ab]	6.07[ab]
Khumal Bikash	4.37[bc]	4.49[bcd]	4.49[bc]
LSD	1.19*	1.48*	1.48*
Grand mean	4.67	5.23	5.23
SEM(±)	0.39	0.49	0.49
CV %	14.7	16.3	13.3
Grand mean	4.67	5.23	5.23

Mean followed by common letter(s) within columns are non-significantly different based on DMRT P=0.05, **Significant at 0.01 P level, ***Significant at 0.001 SEM: Standard Error of Mean, CV: Coefficient of Variance

Canopy diameter

Effect of potato varieties on canopy diameter at different stages of growth is presented in Table 3. The result of statistical analysis showed that effect the effect of different varieties on canopy diameter at 45,53,61,69 and 77 DAP was found significant. At 45 DAP highest canopy was recorded on Janakdev (23.04cm) and minimum canopy diameter was recorded at Khumal Ujjawol (12.91cm). At 53 DAP maximum canopy was recorded on Jankdev (28.72cm) and minimum was recorded on Panauti Local (21.79cm). At 61 DAP maximum canopy diameter was recorded on MS 42.3 (36cm) and minimum was recorded at Khumal Ujjawol(25.89cm).At 69 DAP highest Janakdev (48.49cm) and minimum canopy diameter was recorded on cardinal (31.438cm) which was at par with Khumal Bikash(31.67cm) and Khumal Ujjawol(33.18cm). At 77 DAP maximum canopy was recorded on Janakdev (60.96cm) and minimum was recorded on cardinal (40.42cm).

Table 4: Average canopy diameter (cm) of different potato varieties at Kavre, 2019

Treatments	Canopy diameter (cm)				
	45 Days	53 Days	61 Days	69 Days	77 Days
Khumal Upahar	15.87[bc]	26.18[abcd]	30.75[bcde]	43.24[ab]	53.21[abc]
IPY-8	15.83[bc]	27.06[ab]	31.89[abcd]	42.67[ab]	52.88[abc]
Khumal Seto-1	17.95[abc]	25.68[abcd]	33.89[abc]	39.91[abc]	51.88[bc]
Janakdev	23.04[a]	28.72[a]	35.00[ab]	48.49[a]	60.96[a]
Khumal Ujjawol	12.91[c]	20.47[e]	25.83[e]	33.18[c]	45.64[cd]
Cardinal	15.55[bc]	22.97[cde]	28.35[de]	31.43[c]	40.42[d]
Panuti local	18.56[abc]	21.79[de]	29.47[cde]	37.10[bc]	48.95[bc]
MS	20.85[ab]	27.54[ab]	36.00[a]	43.60[ab]	55.40[ab]
Khumal Bikash	21.26[ab]	24.12[bcde]	29.20[cde]	33.16[c]	45.18[cd]
LSD	5.49*	4**	4.67**	8.39**	7.57**
SEM(±)	1.83	1.335	1.557	2.916	2.52
CV%	17.6	9.27	8.39	12.4	8.65
Grand mean	18	25	31.2	39.2	50.5

Mean followed by common letter(s) within columns are non-significantly different based on DMRT P=0.05, **Significant at 0.01 P level, ***Significant at 0.001 SEM: Standard Error of Mean, CV: Coefficient of Variance

Number and weight of tuber per plant

The effect of different potato varieties on number and weight of tuber per plant were significant (Table 5).The highest number of tuber per plant (20.903) was recorded from MS 42.3. Panauti Local showed the lowest number of tuber per plant (6.222) which was at par Khumal Upahar (8.457).The highest weight per plant (585g) was recorded from Janakdev and lowest weight per plant (237.33g) was recorded from Cardinal.

Table 5: Average number of tuber and weight of tuber per plant of potato varieties at Kavre, 2019

Treatments	Tuber number per plant	Tuber weight per plant(g)
Khumal Upahar	8.45^{e}	436.67^{d}
IPY-8	15.66	500.33^{c}
Khumal Seto-1	17.51^{bc}	532.33^{bc}
Janakdev	10.40^{de}	585^{a}
Khumal Ujjawol	18.32^{b}	480.66^{cd}
Cardinal	11.34^{d}	237.33^{f}
Panauti Local	6.22^{e}	313^{e}
MS 32	20.90^{a}	555^{ab}
Khumal Bikash	8.02^{fg}	302^{e}
LSD	2.07***	94***
SEM	0.69	16.70
CV	9.2	6.6
Grand Mean	13	438

Mean followed by common letter(s) within columns are non-significantly different based on DMRT P=0.05, **Significant at 0.01 P level, ***Significant at 0.001 SEM: Standard Error of Mean, CV: Coefficient of Variance

Number of tuber by grade basis (%)

The effect of different potato varieties on number by tuber grade is presented in table 9. There was significant effect of varieties on medium tuber and highly significant result was seen on small and large tuber class.Highest number of small size tuber (<25gm) was recorded from cardinal(69.234) and Janakdev (23.906) which was at par with Khumal Upahar(25.996) and Panauti Local (28.546). Highest number of medium size tuber (25-50gm) was recorded on Khumal Seto -1(37.191) and lowest was recorded on Cardinal (21.903). Highest number of large size tuber (<50gm) was recorded on Janakdev (48.197) which was at par with Khumal Upahar (45.104) and Panauti Local (43.756) and lowest number was recorded at MS 42.3 (9.144).

Table 5 : Percentage of number of tuber on grade basis of potato varieties at Kavre, 2019

Treatment	Tuber size distribution number %		
	Small (<25g)	Medium(25-50g)	Large(>50g)
Khumal Upahar	25.99^{e}	28.90^{b}	45.10^{a}
IPY- 8	50.07^{bcd}	28.86^{b}	21.05^{bc}
Khumal Seto-1	47.94^{cd}	37.19^{a}	14.86^{cd}
Janakdev	23.90^{e}	27.89^{bc}	48.19^{a}
Khumal Ujjawol	56.77^{bc}	28.41^{bc}	14.81^{cd}
Cardinal	69.23^{a}	21.90^{c}	8.85^{d}
Panuti local	28.54^{e}	27.69^{bc}	43.75^{a}
MS 42.3	59.63^{ab}	31.22^{ab}	9.14^{d}
Khumal Bikash	44.09^{d}	31.04^{ab}	24.86^{b}
SEM(±)	3.48	2.06	2.79
LSD	10.7***	6.18*	8.38***
CV%	13.4	12.1	19
Grand mean	45.1	29.4	25.5

Mean followed by common letter(s) within columns are non-significantly different based on DMRT P=0.05, **Significant at 0.01 P level, *** Significant at 0.001
SEM: Standard Error of Mean, CV: Coefficient of Variance

Weight of tuber per plant on tuber class

The effect of different potato varieties on weight of tuber were significant (Table 6). Highest weight of small size tuber (<25gm) was recorded from MS 42.3 (149.148g) and minimum weight was recorded from Khumal Bikash (30.481g). Highest weight of medium tuber was recorded from Khumal Seto-1 (233.33g) and lowest weight was recorded from Panuti (62.208) which was at par with Jankdev (114.028g) .Highest large tuber was recorded from Janakdev (428.75g) and lowest was recorded from Cardinal (65.972g).

Table 6 : Average weight of tuber per plant on grade basis potato varieties at Panauti, Kavre, 2019

Treatment	Tuber grade weight (g)		
	Small (<25g)	Medium (25-50g)	Large (>50g)
Khumal Upahar	30.48^{c}	112.33^{c}	293.75^{b}
IPY-8	97.37^{b}	176.66^{b}	226.38^{bc}
Khumal Seto-1	115.85^{ab}	233.33^{a}	175.27^{c}
Janakdev	41.88^{c}	114.02^{c}	428.75^{a}
Khumal Ujjawol	120.85^{ab}	179.30^{b}	180.55^{c}
Cardinal	87.92^{b}	83.11^{cd}	65.97^{d}
Panuti local	24.07^{c}	62.20^{d}	226.9^{bc}
MS	149.14^{a}	211.94^{ab}	192.77^{c}
Khumal Bikash	47^{c}	88.33^{cd}	166.52^{c}
SEM(±)	11.72	7.73	25.36
LSD	35.2***	40.2***	76***
CV%	25.6	16.6	20.2
Grand mean	79.4	140	217

Mean followed by common letter(s) within columns are non-significantly different based on DMRT P=0.05, **Significant at 0.01 P level, ***Significant at 0.001 SEM: Standard Error of Mean, CV: Coefficient of Variance

Tuber yield (t/ha)

The effect of different potato varieties on tuber yield (t/ha) was significant. The highest tuber yield (33.40 t/ha) was recorded from Janakdev which was statistically similar with MS 42.3 (31.70t/ha) and lowest yield was recorded on Cardinal (14.2t/ha).Tuber yield is influenced by many factors such as; environment and cultivars. The environmental factors including soil temperature, moisture, light intensity, nutrient supply and proper control of disease and pests affect the tuber yield (Struik & Wiersema, 1999).

Table 7 : Average yield (t/ha) of potato varieties at Kavre, 2019

Treatment	Yield (t/ha)
Khumal Upahar	24.95^{c}
IPY-8	28.59^{b}
Khumal Seto-1	30.42^{ab}
Janakdev	33.40^{a}
Khumal Ujjawol	27.46^{bc}
Cardinal	13.57^{e}
Panuti local	17.89^{d}
MS	31.70^{a}
Khumal Bikash	17.24^{d}
SEM(±)	0.95
LSD	2.86***
CV%	6.6
Grand mean	25

Mean followed by common letter(s) within columns are non-significantly different based on DMRT P=0.05, **Significant at 0.01 P level, ***Significant at 0.001 SEM: Standard Error of Mean, CV: Coefficient of Variance

I. CONCLUSION

From the findings of the study it can be concluded that among the commonly grown potato varieties in central region of Nepal some varieties have high yield potential such as Janakdev (33.40 mt ha^{-1}) and MS 42.3 (31.70 mt ha^{-1}). Moreover, these varieties are well adapted to the agro-ecology of this region. So, farmers can grow either of these variety for better yield of potato.

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