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Research Article

Different Planting System of Potato and its Performance in High Hills of Nepal

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ABSTRACT

Field research was conducted on Phidim-8, Ithung, Panchthar district of Nepal during February 2022 to July 2022 to evaluate the performance of potato in different planting system in high hills of Nepal. Five different treatments *viz.*, drilling, bund, line planting, behind the plough and random planting was selected and replicated for four times. The experiment was laid out in single factorial randomized complete block design. Crop growth parameter namely plant height and stem diameter at 55 Days After Planting (DAP) were not significantly influenced but later on it was highly significant and maximum plant height was seen on bund at 70 and 85 DAP which was 14.3 cm and 35.5 cm. Similarly, thickest stem diameter was recorded in bund planting at 70 DAP was 0.85 cm and on 85 DAP was 1.18 cm. Average number of potato tubers per plant, average number of tuber above 50 gm and average yield of tuber per plot was also seen higher in bund including productivity *i.e.*, was 11.10, 4.95, 9.15 kg and 36.33 mt/ha respectively.

Keywords: Bund; Drilling; Planting system; Random planting

INTRODUCTION

Potato is native crop to the Andes mountains of South America *i.e.*, Peru and Chile as well as the Alpine zone with an elevation of 3000 m-4000 m in Mexico. It may have been adopted before 10,000 years by the native people of this region. Potatoes from Andes are of all colors and sizes. Earliest archeologically verified potato tuber has been found on coastal site of central Peru, dating to 2500 BC.

Potato (*Solanum tuberosum*) from night shade family Solanaceae is a starchy tuber of plant. It is widely cultivated in Nepal from 100 m mean sea level of southern Terai to the Northern mountains as high as 4000 masl. After rice and maize, potato is taken as third most important crop in terms of human consumption. In Nepal, it is the fourth most important crop after rice, maize and wheat. A billion of people worldwide consume potato in daily basis and is grown in over 125 countries [1]. In terms of potato contribution in human diet, Nepal is one of the top twenty country. The adoption of improved varieties of potato is increasing and have direct impact on farmer's income, nutrient security and household level food as well. In high hills of Nepal, potato is considered as an important vegetable crop in every kitchen garden and also cash crop for smallholder farmers. Potato is composed of 80% water, 18% starch and 2% protein in average. It is easily available and one of the cheapest sources of carbohydrates. Nutrients available in potato includes carbohydrates, vitamin C and different form of vitamin B, proteins and minerals because of these all availability it is considered as excellent source of nutrients. Potato tubers are high in compounds including β-carotene, ascorbate, cysteine-rich polypeptides and organic acids, that promote mineral bioavailability. Furthermore, potato can decrease mineral bioavailability as it is low in anti-nutrients such as oxalates and phytates.

It is considered as second staple food crop now after rice and grown as a cash crop in Nepal. Since 1990 per capita consumption has almost doubled to 51 kg a year. It is grown in 188,098 ha with 16.64 mt/ha productivity and 3,131,830 mt production in Nepal.

Potato is highly suggested as food security crop by food and agriculture organization of united nation as world population is on growing phase with food security problems [2].

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MATERIALS AND METHODS

Research site

The research titled 'different planting system of potato and it's performance in high hills of Nepal' was carried on Phidim municipality-8 Ithung, Panchthar district during 2022 under rainfed condition. Site was located at an altitude 2400 masl, 27°4'20" N latitude and 87°48'50" E longitude.

Climate condition during the study

The climate of experimental site was temperate, characterized by the winter season from November to February, the morning and nights are quite chilly there throughout the year. Snowfalls occurred during January and February as temperature remains very low during these months. The study was conducted during February 11 to July 10.

Tuber selection

Potato tuber stored at local level was used. It was cleaned and extra out growth was separated. Tuber with similar size were kept aside for sowing from the given tuber. Healthy and disease-free tubers were only planted.

Tuber treatment

Tubers were treated with fungicide carbandazime. 10 gm of carbendazim was mixed in 20 l of water and tubers were dipped in it for 5 mins and shade dried for 1 hour. It was done to protect the tuber from soil borne diseases [3].

Experimental design

The field experiment was laid out on RCBD with five treatments and four replications in 210 m^2 (15 m × 14 m) land area (15 m × 14 m) at Phidim municipality-8, Ithung, Panchthar district. Each replication consists of five treatments (drilling, bund, line planting, planting behind the plough and random planting) were placed through randomization. Area of each plot was (3 × 2) m^2. The local variety of potato bitte was taken for the experimental study of research project. The potato variety bitte (local variety) was sown on February 9, 2022. Crop geometry (60 × 25) cm was maintained in three treatments *i.e.,* drilling, bund and line sowing. Five rows were made in one plot and 7 plants per row were planted. No particular spacing was done on random planting and planting behind the plough as it was done in the way as local farmers were doing. The distance between two treatments and replication was 1 m.

Soil was made free of weed roots and harrowed completely. Ploughing was done two times, along with the harrowing, to reach soil to suitable condition for farming: Soft, well-aerated and well-drained. FYM was incorporated the field before one week of planting and the recommended dose of fertilizers in potato was used [4].

Tagging

Tagging of plot was done on the same day of planting to make observation and inspection easier. Five plants from each plot were selected randomly and tied with red ribbons so that they would be easily identified for recording physical parameters.

Weeding

The potato plant develops canopy on about 4 to 6 weeks about planting normally. Weed must be controlled by this time to take competitive advantage for crop.

After planting of potato, observation was done on regular interval. First hand weeding was done at 60 days of planting. Similarly, second hand weeding was done on 100 days after planting. Field was cleaned and data was also recorded on regular time interval.

Earthing up

Proper earthing up in potato promotes the length of underground stems which bear potatoes. The main objective of earthing up is to keep soil loose, destroy weed and to cover up the tuber properly. Earthing up was done at 80 days after planting.

Harvesting

As, Ithung, Panchthar lies in temperate zone, crop took longer time for its germination, growth and development of potato. Potato was harvested after 5 months of planting manually. Generally, potato is lifted up with the long handle kodalo, spading fork or a potato hook. Large potato harvesters are used for harvesting potato commercially which lift up the plant with surrounding soil.

RESULTS AND DISCUSSION

Plant height (cm)

At 55 days after planting treatments did not show significant variation in plant height. All plants were similar in their initial height. Plants were 6.24 cm tall on an average.

While at 70 days' plant height was significantly variable among the different planting systems. Plants raised through bund were the tallest *i.e.,* 14.3 cm followed by line sowing and least height was seen on drilling which was 9.32 cm. The average plant height was 11.62 cm.

Similarly, at 85 days of planting plant height showed significant variation among different planting systems. It was maximum on bund *i.e.,* 35.65 cm followed by line sowing 34.60 cm and behind the plough 33.15 cm. Least plant height was observed on drilling which was 23.85 cm.

Also found potato tuber on ridges reached highest plant height 53.4 cm and potato tubers planted on traditional method was lowest. This might be due to the earthing up and loose soil surface which enhances the plant to attain maximum height in

bund and ridges. While on drilling it might be covered with compact layer of soil and plant emergence is slow and could not reach the maximum height (Table 1) [5].

Table 1: Average plant height of potato in different planting system.

Treatment	Plant height		
	55 DAS	70 DAS	85 DAS
Drilling	4.98 ± 0.26^{b}	9.325 ± 0.55^{c}	23.85 ± 0.07^{b}
Bund	7.30 ± 0.74^{a}	14.3 ± 0.44^{a}	35.65 ± 0.02^{a}
Line planting	6.88 ± 0.84^{ab}	12.27 ± 0.54^{b}	34.60 ± 0.03^{a}
Behind the plough	5.93 ± 0.80^{ab}	11.37 ± 1.04^{bc}	33.15 ± 0.06^{a}
Random planting	6.16 ± 0.0.72^{ab}	10.85 ± 0.46^{bc}	24.85 ± 0.03^{b}
F value	0.15 NS	0.001	0.01
LSD	1.94	1.97**	7.78*
CV%	20.23	11.04	16.6
Mean	6.24	11.62	30.42

Note: *Significant at 5% level of significance, **significant at 1% level of significance, NS (Non-Significant), (LSD) Least Significance Difference, (CV) Coefficient of Variation

Stem diameter (cm)

At 55 DAP, different planting systems of potato did not show any significant variation in stem diameter of plant. Stem diameter was 0.55 cm on average.

While at 70 DAP stem diameter was significantly variable among different planting systems. Plant raised on bund showed thickest stem diameter *i.e.*, 0.85 cm followed by line sowing *i.e.*, 0.73 cm.

Similarly, at 85 DAP stem diameter was maximum on bund *i.e.*, 1.18 cm. The lowest stem diameter was recorded on drilling techniques which was 0.91 cm (Table 2).

Table 2: Average stem diameter of potato in different planting system.

Treatment	Stem diameter		
	55 DAS	70 DAS	85 DAS
Drilling	0.47 ± 0.03^{b}	0.61 ± 0.01^{b}	0.91 ± 0.07^{b}
Bund	0.65 ± 0.01^{a}	0.85 ± 0.01^{a}	1.18 ± 0.02^{a}
Line sowing	0.57 ± 0.04^{ab}	0.73 ± 0.05^{ab}	1.14 ± 0.03^{a}
Behind the plough	0.59 ± 0.03^{ab}	0.69 ± 0.09^{b}	1.16 ± 0.06^{a}
Random planting	0.51 ± 0.04^{b}	0.70 ± 0.02^{b}	1.09 ± 0.03^{a}
LSD	0.12 NS	0.14*	0.16*
CV%	14.31	12.85	9.91
Mean	0.55	0.71	1.09

Note: *Significant at 5% level of significance, **significant at 1% level of significance, NS (Non-Significant), (LSD) Least Significance Difference, (CV) Coefficient of Variation

Average number of stem per plant

The Table 3 showed highly significant variation on average number of main stems in different planting system. Plant raised on bund had maximum number of stems which was 4.00 which was followed by line planting and random planting [6]. The least number of stems was recorded on drilling which was 3.25.

Average number of tubers in bund was more, this might be aeration, preserved soil moisture in field by making hills.

Table 3: Average number of stems in different planting system.

Treatment	Average number of main stems
Drilling	3.25 ± 0.05^{c}
Bund	4.00 ± 0.14^{a}
Line sowing	3.70 ± 0.1^{b}
Behind the plough	3.35 ± 0.05^{c}
Random planting	3.45 ± 0.12^{bc}
LSD	0.29^{***}
CV%	5.41
Mean	3.55

Note: *Significant at 5% level of significance, **significant at 1% level of significance, NS (Non-Significant), (LSD) Least Significance Difference, (CV) Coefficient of Variation

Average number of tuber per plant

The below (Table 4) showed that average number of tubers per plant were significantly different at different planting system. The average number of potatoes was more in bund which was 11.10 followed by behind the plough and least number of tubers were counted in random planting it was 6.65.

Muhammad Qasim also reported that average number of potato tuber was significantly different which was 10.1 when potato is planted on wide beds and covered by soil from one side whereas lowest number of tubers *i.e.*, 5.8 was found on haphazardly planting techniques which was local farmer's techniques. More aeration and adequate amount of water is present in bund planting [7].

Entz findings while working on seed type and effect of row spacing on yield of potato crop was also similar.

Table 4: Average number of tubers in different planting system.

Treatment	Average number of tubers per plant
Drilling	8.40 ± 0.25^{c}
Bund	11.10 ± 0.46^{a}
Line planting	10.30 ± 0.42^{b}
Behind the plough	9.55 ± 0.26^{ab}
Random planting	6.65 ± 0.27^{c}
LSD	1.11^{***}
CV%	7.83

Grand mean	9.2

Note: *Significant at 5% level of significance, **significant at 1% level of significance, NS (Non-Significant), (LSD) Least Significance Difference, (CV) Coefficient of Variation

Average number of tuber below 20 gm

The Table 5 showed that the average number of tubers below 20 gm were significantly variable to different planting system. Highest number of tubers below 20 gm was recorded on line sowing which was 5.17 followed by planting behind the plough. The lowest number of tubers below 20 gm was counted on drilling *i.e.*, 2.32.

Average number of tubers below 20 gm was seen more in line sowing this might be due to thin layer of soil which doesn't provide proper soil nutrient and moisture loss might be more in thin layer of soil surface than in other techniques because of which tuber could not get sufficient amount of water to grow.

Table 5: Average number of tubers below 20 gm.

Treatment	Average number of tubers below 20 gm
Drilling	2.32 ± 1.41^{d}
Bund	3.60 ± 0.44^{c}
Line planting	5.17 ± 0.87^{a}
Behind the plough	4.20 ± 1.73^{b}
Random planting	2.65 ± 0.54^{d}
LSD	0.533^{***}
CV%	9.64
Mean	3.59

Note: *Significant at 5% level of significance, **significant at 1% level of significance, NS (Non-Significant), (LSD) Least Significance Difference, (CV) Coefficient of Variation

Average number of tubers weighing 20 gm-50 gm.

The data in Table 6 showed that average number of potato tuber weighing from 20 gm-50 gm was highly significant among different planting system. Highest number was seen on bund which was 4.25 followed by planting behind the plough [8]. Least number of tubers of weight 20 gm-50 gm was recorded in drilling which was 1.30.

Table 6: Average number of tubers weighing 20 gm-50 gm.

Treatment	Average number of tuber 20 gm-50 gm
Drilling	1.30 ± 0.44^{d}
Bund	4.25 ± 0.22^{a}
Line sowing on flat land	2.85 ± 0.17^{bc}
Planting behind the plough	2.90 ± 0.12^{b}
Random planting	2.25 ± 0.09^{c}
LSD	0.63^{***}
CV%	15.25
Grand mean	2.71

Note: *Significant at 5% level of significance, **significant at 1% level of significance, NS (Non-Significant), (LSD) Least Significance Difference, (CV) Coefficient of Variation

Average number of tubers above 50 gm

The Table 7 showed that the total number of tubers weighing above 50 gm was highly significant among different planting system. The highest number of tubers above 50 gm were recorded on bund which was 4.95 followed by line sowing *i.e.*, 3.75, behind the plough *i.e.*, 2.65 and random planting *i.e.*, 1.75. The lowest number of tubers weighing above 50 gm was observed on drilling which is 1.35.

This might be due to earthing up in bund planting is very easy and tuber are covered up properly so that they enlarge to the maximum size as soil is loose and friable. The wider spacing and hills made here also enhances tuber to be bigger in size.

Table 7: Average number of tubers above 50 gm.

Treatment	Weight of tuber above 50 gm
Drilling	1.35 ± 0.38^{d}
Bund	4.95 ± 0.22^{a}
Line sowing on flat land	3.75 ± 0.17^{b}
Planting behind the plough	2.65 ± 0.09^{c}
Random planting	1.75 ± 0.09^{d}
LSD	0.70^{***}
CV%	15.93
Mean	2.89

Note: *Significant at 5% level of significance, **significant at 1% level of significance, NS (Non-Significant), (LSD) Least Significance Difference, (CV) Coefficient of Variation

Average yield of tuber per plant

The Table 8 showed highly significant variation on average yield of tuber per plant among different planting system. Average yield of tuber per plant was recorded highest on bund which was 545 gm followed by line planting whereas least weight was observed on drilling system, it was 256.0 gm.

Table 8: Average yield of tuber per plant.

Treatment	Average yield of tuber per plant
Drilling	256.0 ± 55.5^{d}
Bund	545.0 ± 66.62^{a}
Line sowing on flat land	399.0 ± 30.24^{b}
Planting behind the plough	375.5 ± 31.38^{bc}
Random planting	291.0 ± 48.77^{cd}
LSD	97.98^{***}
CV%	17.03
Mean	373.3

Note: *Significant at 5% level of significance, **significant at 1% level of significance, NS (Non-Significant), (LSD) Least Significance Difference, (CV) Coefficient of Variation

Average yield of tuber per plot (kg)

The data presented on Table 9 about average yield of tuber per plot showed highly significant variation among different planting system. Average yield of tuber per plot was recorded more in bund *i.e.*, 9.15 kg followed by line planting. Lowest average yield of tuber per plot was weighted on drilling which was 3.5 kg.

Table 9: Average yield of tuber per plot.

Treatment	Average yield of tuber per plant
Drilling	256.0 ± 55.5^{d}
Bund	545.0 ± 66.62^{a}
Line sowing on flat land	399.0 ± 30.24^{b}
Planting behind the plough	375.5 ± 31.38^{bc}
Random planting	291.0 ± 48.77^{cd}
LSD	97.98^{***}
CV%	17.03
Mean	373.3

Note: *Significant at 5% level of significance, **significant at 1% level of significance, NS (Non-Significant), (LSD) Least Significance Difference, (CV) Coefficient of Variation

Productivity of potato in metric ton per hectare

The analyzed Table 10 below showed that total productivity of potato was highly significant to different planting system. It was observed that productivity of potato was highest on bund which was 36.33 mt/ha followed by line sowing 26.60 mt/ha. The lowest productivity was observed in drill which was 19.40 mt/ha.

Productivity of potato was in more in bund this might be due to good emergence, a greater number of stems per plant, wider planting distance and earthing up [9]. Due to wider planting space and bund made on land, plant was exposed to sunlight and spread well on the ground. It increases photosynthesis was increased thus increases starch accumulation and led to higher yield. Similarly, earthing up loose soil sufficiently for aeration and adequate drainage. Aeration of soil has great effect on tuber setting and development. Potato tubers planted haphazardly *i.e.*, random planting showed poor result because of less emergence and narrow spacing. The findings of other studies worldwide are in agreements with these results [10].

Table 10: Productivity of potato (mt/ha).

Treatment	Productivity of potato (mt/ha)
Drilling	17.06 ± 0.14^{d}
Bund	36.33 ± 0.26^{a}
Line sowing	26.60 ± 0.50^{b}
Behind the plough	25.03 ± 0.12^{bc}
Random planting	19.40 ± 1.20^{cd}
LSD	6.53^{***}
CV%	17.03

Mean	24.88

Note: *Significant at 5% level of significance, **significant at 1% level of significance, NS (Non-Significant), (LSD) Least Significance Difference, (CV) Coefficient of Variation

CONCLUSION

Different planting system of potato and its performance in high hill of Nepal showed significant variation. Improved planting system increase the yield of potato and its overall whereas in tradition methods productivity was comparatively lower. It can be concluded that among different planting system of potato in high hill of Nepal, planting potato in bund showed significant variation on growth, development and yield of potato. So, planting potato in bund is best for cultivating potato in high hill of Nepal. In this way, improved cultivation practice increases the productivity of potato.

RECOMMENDATIONS

Hence, for enhancing commercial cultivation of potato with better growth and yield, potato should be grown on bunds and cultural operations like weeding and earthing up should be necessarily done to enhance the tuber quality. As in all planting system cost of cultivation is same it is just about the time requirements to plant in different planting system differs. In bund system weeding and earthing up is easier than in other system because of height raised, weed could not spread in the surface as in planting behind the plough and line planting. In random planting these intercultural operations are difficult to perform as potato are planted haphazardly.

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