Effect of Seed Tuber Size on Growth and Yield of Potato (*Solanum Tuberosum* L.) Variety Desiree in Dadeldhura[1]

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Abstract

A field study was carried out on potato (*Solanum tuberosum* L.) variety Desiree to determine the effect of seed tuber size on growth and yield performance in Dadeldhura district in 2023. The experiment was carried out in randomized complete block design (RCBD) using four replications and five treatments. Treatments used were different weighed seed tubers viz.T_1:(11-20g),T_2:(21-30g), T_3:(31-40g), T_4:(41-50g), and T_5:(51-60g) . The results showed significant effect of the size of seed tubers on the growth and yield of potato. The treatment 51-60g seed tuber proved to be superior in terms of plant height, number of leaves/plant and tuber weight/hill followed by the treatment 31-40g seed tuber. Similarly, at harvest, 31-40g seed tubers yielded maximum number of tubers/hill, number of tuber/m^2, total yield, total marketable yield, and average number of stem/hill followed by the treatments 51-60g and 21-30g seed tubers respectively. On the basis of potato tuber grading 21-30g seed tuber yielded bigger sized potato tubers followed by 31-40g and 51-60g respectively. The treatment 31-40g proved to be the best among all the treatments in yielding maximum total yield, total marketable yield and less number of unmarketable tubers. Similarly, the benefit cost ratio obtained from 31-40g seed tuber is significantly higher (3.82) than all other treatments. Hence, 31-40g seed tuber is suggested to farmers for profitable production of potato.

***Keywords**:* Growth, Potato, Seed tuber, Tuber size, Yield

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Introduction

Potato (*Solanum tuberosum* L.) is one of the most important food crop after rice in terms of production (Ministry of Agriculture and Livestock Development (MoALD, 2023), and a high potential food security crop in Nepal (National Planning Commission NPC, 2019). Potato contains 75-80% water, 16-20% carbohydrate, 2.5-3% crude protein, good source of vitamins B1, B3, B6, minerals P, K, Mg and moderate source of Fe and Cu (Tolessa, 2018). It is source of both food and income in the growing countries of the world due to its high nutritional value, production per unit area, adaptability to different climates, crop rotation benefits and short growing period as compared to other crops. Cultivated in 2,89,839 ha land with a total production of 4,153,157 metric tons, potato contributes 6.30% in Agricultural GDP after rice (13.60%), vegetable (13.43%) and maize (7.60%) in Nepal. Among the different provinces growing potato in Nepal, Bagmati Province ranks 1st in terms of productivity (19.94 mt/ha) while Sudurpaschim Province (15.87 mt/ha) ranks the last. Prime Minister Agriculture Modernization Project (PMAMP) 2073-2082 B.S. has declared two districts (Kavre and Dadeldhura) as the 'Potato Super Zone' of Nepal. Productivity of potato is greater in Kavre (21.86t/ha) than that of Dadeldhura (17.56t/ha) (Ministry of Agriculture and Livestock Development MoALD, 2023).

The reasons behind low productivity of potato are insufficient supply of inputs during planting season, low quality of seed tubers, planting depth, disease pest incidence, over use of chemical fertilizer and lack of storage facilities. Farmers prefer larger sized tubers for consumption rather than using them as seed materials. The use of small sized seed tubers is common in Nepalese context due to the higher cost associated with appropriate sized seed tubers at the time of planting. Farmers are unaware about the impact of using different sized seed tubers on the yield of potatoes. Planting large sized potato tubers showed high physiological growth and yield due to early emergence and establishment of plant stand (Masarirambi et al., 2012), production of greater number of sprouts per seed tuber leading to higher number of stems per hill, as compared to small sized seed tubers. Early canopy cover ensures proper solar radiation at early growth stage leading to total dry matter production (Mackerron and Waister, 1985). Also, planting appropriate size of tubers play significant role in increasing production per unit area and saves the cost of potato seed tuber (Hirpa et al., 2010). So, it is essential to find the cost effective ways for improving the productivity of potato that will ultimately benefit the

potato growers. Thus, this study has assessed the use of different sized seed tubers on growth and yield of potato.

Materials and Methods

Description of experimental site

The research was conducted in farmer's field at Dotighatal-03, Amarghadhi Municipality, Dadeldhura district, Sudurpaschim Province during the month of February-June, 2023. The district research located in humid sub-tropical region is located at an elevation of 1553 masl on the latitude of 29°16'59.8"Nand longitude of 80°34'08.1"E. The site had sandy loam soil with pH of 5.2 and 3.53% organic matter as shown in Table 1. Nitrogen content of the soil was found to be 0.18% (medium), whereas the phosphorous and potassium content in the soil was higher with the amount 95.97 kg/ha and 404.4 kg/ha respectively, as per the soil test report.

Table 1

Physio-chemical properties of soil at experimental site

Description	Test result	Analysis	Base value
pH	5.2	Acidic	<6.5 acidic, 6.5-7.5 neutral, >7.5 basic
Organic matter (%)	3.53	Medium	<2.5 low, 2.5-5 medium, >5 high
Nitrogen %	0.18	Medium	<0.10 low, 0.11-0.20 medium, > 0.20 high
Phosphorous (kg/ha)	95.97	High	<31 low, 32-55 medium, >55 high
Potash (kg/ha)	404.4	High	<110 low, 111-280 medium, >280 high
Soil texture	Sandy loam	Sandy loam	

The site received a total precipitation of 259mm with the highest precipitation of 19.57mm on 21st March, during the growing period. The temperature ranged from 31.8^{0}C to 19.6^{0}C with an average of 27.2^{0}C during the experimental period. The highest temperature was observed during the month of June whereas the lowest temperature was recorded during the month of February. Likewise, relative humidity ranged from 34% (March) to 50% (June) with an average of 37.8% during the crop standing period (NASA, 2023).

Experimental details

The experiment was laid out in Randomized Complete Block Design (RCBD) with four replications and five treatments comprising different size of seed tubers viz.

T_1:11-20g, T_2: 21-30g, T_3: 31-40g, T_4: 41-50g and T_5: 51-60g as shown in Table 2. There were altogether 20 plots (3m x1.25m) made 0.5 m apart in each replication. Plant space was maintained at 60cm x25cm, maintaining 25 plants per plot. The distance between each replication was 1m.

Table 2

Treatment details

Treatment	Details of treatment	Seed rate(kg/ha)
T_1	11-20 g seed tuber	1000
T_2	21-30 g seed tuber	1667
T_3	31-40 g seed tuber	2332
T_4	41-50 g seed tuber	3000
T_5	51-60 g seed tuber	3660

Agronomic practices

Desiree, red skinned yellow fleshed, irregular slender potato having many shallow eyes with short to medium duration variety (90-120 DAP) was used in the study. This variety is mostly preferred by the farmers of Dadeldhura district due to its creamy texture for using it in wide range of dishes, good storability as well as availability besides being resistance to diseases. The main field was ploughed twice before application of organic manure. Farmyard manure was applied at 10 tons/ha whereas chemical fertilizer was applied at 100:100:60 kg NPK/ha as per the recommendation by government of Nepal on the day of planting. Seed tubers were planted at a depth of 15cm in the ridges made 60cm apart on 24th February, 2023. The distance between each seed tuber was 25cm in each row/ridge. The crop was grown under rainfed condition, as done by majority of farmers in the location. Weeds were removed manually at 45 days and 75 days of planting. Earthing up was done on the same day of weed removal. For controlling late blight, Mancozeb 70%WP at 2.5g/liter water was applied three times at an interval of 7 days after 60 days of planting. Similarly, cypermethrin 25% EC was applied @2.5-3ml/lit of water to control infestation of pest (Ebrahim et al., 2018).Potato was harvested manually on 13th June (108 days after planting), when stem and leaves turned brown and tubers under the ground matured (Luitel et al., 2022). Different yield attributes were recorded from sample plants as well as from each treatment.

Data collection and observation

For recording various growth parameters of potatoes, five random plants were selected from each plot. The data like plant height, number of stem per hill and number of leaves per plant were recorded at 60, 75 and 90 days after planting (Zelalem et al., 2009) as described below:

Days to sprouting

It was recorded by counting the number of days from the days of planting to the days at which about 50% of planting materials in each plot sprouted.

Plant height (cm)

Plant height was measured from randomly selected five plant per plot from the soil surface to the top most growth point of the above ground parts.

Number stem/hill

The average number of main stem produced per hill was recorded by counting the main stem which came out from each seed tuber at different growing stages.

Number of leaves/plant

The average number of leaves per planting material was recorded by counting number of leaves at various growth stages.

Yield parameter

The data on number of tubers per hill, tuber yield hill^{-1}, number of unmarketable tubers, total tuber yield, total marketable and unmarketable tuber yield were recorded at the time of harvest from the field. Unmarketable tuber included the entire diseased, rotten, insect attacked and deformed tuber. Marketable tubers were obtained by subtracting unmarketable tuber from the total tuber yield from each plot. The average of all these parameters were taken and used for statistical analysis.

Quality parameter

Tuber of sample plants were graded according to the size of tuber where all the tuber having<25mm were considered as small sized and 25-50mm as large sized. Tuber in each grade were counted and weighted.

Statistical analysis

The collected data were systematically arranged and entered in MS Excel. Analysis of variance Table was prepared and the means of treatments were compared by least significant difference (LSD) at 5% level of significance, using the software, R studio.

Economic analysis

For analyzing the profitability among the treatments i.e. the size of seed tuber, the cost of cultivation was calculated on the basis of local charges for different agro inputs viz. labor, fertilizer, tubers, pesticides and other necessary materials. Economic yield was converted into gross returns (NRS. ha^{-1}) on the basis of local market price and net return was calculated from gross return and total expenditure. The benefit cost ratio was then calculated.

Results and Discussion

The influence of seed tuber sizes on growth, yield and quality parameters of potato are discussed below.

Sprouting

Significant differences among different sizes of potato seed tuber were observed in sprouting at recorded at 45 days after planting (DAP). Numerically the highest sprouting rate was recorded in 31-40g tuber, which was statistically at par with the treatments 21-30g and 51-60g seed tuber. However, the treatment 41-50g was late to sprout as compared to others. The lowest sprouting rate was found in 11-20g seed tuber

Table 3

Sprouting data of potato as influenced by different sizes of seed tubers

Treatments	45 DAP
11-20g seed tuber	21.25^{b}
21-30g seed tuber	23.00^{a}
31-40g seed tuber	24.00^{a}
41-50g seed tuber	22.75^{ab}
51-60g seed tuber	23.00^{a}
SEm	0.53
$LSD_{0.05}$	1.63
F test	*
CV (%)	4.63
Grand Mean	22.9

Number of stem/hill

The number of stem/hill was significantly affected by the size of seed tuber across all the growth stages as shown in Table 4. The number of stem per hill ranged from 3.82 to 4.16 at 90 DAPS. Maximum number of stem/hill was observed in 31-40g tuber which

was numerically superior among all the treatments. Statistically, all the seed tuber size yielded statistically similar number of stem/hill except for the tuber size 11-20g, which showed minimum number of stem/hill with the value 3.82. In line with our findings, Regasa et al. (2022) also reported an increase in the number of stem/hill with increase in seed tuber size. (Sadik et al., 2018).

Table 4

Number of stem/hill of potato as influenced by different size of seed tubers

Treatments	Number of stem/hill		
	60 DAP	75 DAP	90 DAP
11-20g seed tuber	3.68[b]	3.82[b]	3.82[b]
21-30g seed tuber	4.02[a]	4.11[a]	4.11[a]
31-40g seed tuber	4.12[a]	4.16[a]	4.16[a]
41-50g seed tuber	4.06[a]	4.12[a]	4.12[a]
51-60g seed tuber	4.08[a]	4.13[a]	4.13[a]
SEm	0.08	0.07	0.07
$LSD_{0.05}$	0.25	0.21	0.21
F test	*	*	*
CV (%)	4.10	3.43	3.43
Grand Mean	3.99	4.07	4.07

Number of leaves/plant

Significant differences in the number of leaves/plant was found among the different size of seed tube at 75 and 90 DAP whereas non-significant difference in leaf number was observed at early growth stage i.e., 60 DAP. Statistically highest number of leaves per plant was observed in 41-50g tuber followed by 31-40g and 51-60g respectively. The other treatments 11-20g and 21-30g were statistically at par with 51-60g in yielding number of leaves per plant recorded at 90 DAP. Significantly lowest number of leaves/plant was observed in 11-

Table 5

Number of leaves/plant of potato as influenced by different sizes of seed tubers

Treatments	Number of leaves/plant		
	60 DAP	75 DAP	90 DAP

11-20g seed tuber	34.09	47.56^{c}	69.57^{b}
21-30g seed tuber	34.97	49.53^{bc}	69.88^{b}
31-40g seed tuber	38.01	50.83^{ab}	72.08^{ab}
41-50g seed tuber	36.55	49.72^{abc}	73.74^{a}
51-60g seed tuber	36.34	52.53^{a}	70.95^{b}
SEm	1.07	0.92	0.81
$LSD_{0.05}$	3.30	2.86	2.51
F test	ns	*	*
CV (%)	5.96	3.71	2.28
Grand Mean	35.99	50.03	71.24

20g seed tuber at all the growth stages, which might be due to lesser number of stems per hill. The Lowest number of leaves were also observed in small sized seed tubers as compared to larger sized seed tuber in a study (Aulakh and Kumar, 2022).

Plant height

Plant height was greatly affected by different sizes of potato seed tuber as observed in Table 6. The plant height showed non-significant effect among the treatments at 60DAP and 90DAPwhereas highly significant at 75DAP. The result showed an increase in plant height

Table 6

Plant height of potato as influenced by different sizes of seed tubers

Treatments	Plant height (cm)		
	60 DAP	75 DAP	90 DAP
11-20g seed tuber	23.94^{b}	37.37^{c}	48.09
21-30g seed tuber	24.86^{ab}	38.45^{bc}	48.97
31-40g seed tuber	25.70^{a}	39.74^{ab}	52.01
41-50g seed tuber	25.66^{a}	39.62^{ab}	50.55
51-60g seed tuber	26.01^{a}	40.04^{a}	50.34
SEm	0.53	0.57	1.07
$LSD_{0.05}$	1.63	1.77	3.30
F test	.	*	ns
CV (%)	4.21	2.94	4.29
Grand Mean	25.23	39.15	49.99

with increase in seed tuber size at early growth stages, with the smallest height recorded in treatment 11-20 g. Significantly highest plant height was observed in 51-60g (40.04cm) followed by 31-40g which was statistically at par with 41-50g seed tuber. At 90DAP, the highest plant height was observed in 41-50g seed tuber followed by 51-60g seed tuber, though non- significant. With increase in seed tuber size, height of plant significantly increased as reported by Regasa et al., (2022) in 66-80g seed tuber and Masarirambi et al., (2012).

Number of tuber per hill

The result revealed significant effect of different sized tubers on average number of tubers per hill at 5% level of significance. The average number of tuber/hill was found to be 10.7 with the highest (13.70) in the treatment 31-40g seed tuber whereas the lowest was recorded in the treatment 11-20g (8.05). Statistically, 21-30g, 31-40g were at par in yielding the number of tubers per hill with the value more than 13.45. However, 41-50g seed tuber produced higher number of tubers than 51-60g and 11-20g seed tuber, though are statistically similar.

Table 7

Number and weight of total tubers and unmarketable tubers

Treatments	Number of tuber/hill	Number of unmarketable tuber/m^2	Unmarketable tuber weight /m^2($g/m^{2)}$	Tuber weight(g)/hill
11-20g seed tuber	8.05^{b}	2.71	18.00	266.75^{b}
21-30g seed tuber	13.45^{a}	3.15	19.50	458.00^{a}
31-40g seed tuber	13.70^{a}	3.06	17.87	493.25^{a}
41-50g seed tuber	9.65^{ab}	2.43	12.83	405.50^{a}
51-60g seed tuber	8.65^{b}	2.31	12.29	499.50^{a}
SEm	1.46	0.50	2.34	43.50
$LSD_{0.05}$	4.50	1.54	7.21	134.06
F test	*	ns	ns	*
CV (%)	27.33	36.66	29.09	20.49
Grand Mean	10.7	2.73	16.09	424.6

Tuber weight per hill

Statistically, the treatment 51-60 g seed tuber was superior in yielding tuber weight per hill (499.50g) as compared to all other treatments. All other treatments were

statistically at par in yielding tuber weight per hill except the treatment 11-20g seed tuber. The lowest tuber weight/hill was recorded in the smallest tuber size used in the experiment with the value 266.75g. In line with our research, the highest yield was obtained through large sized tuber followed by medium sized seed tuber (Ozkaynak, 2021).

Unmarketable tuber number

No significant effect of tuber size was observed for unmarketable tuber number per square meter. Average number of unmarketable tuber ranged from 2.3 to 3.15 with the highest from 21-30g seed tuber and lowest obtained from the large sized seed tuber 51-60g.

Unmarketable tuber weight

The highest weight of unmarketable tuber was observed in 21-30g tuber (19.5g/m^2) followed by 11-20g seed tuber (18g/m^2), though non-significant. Similarly, the lowest weight of unmarketable tuber/m^2 was observed in 51-60g tuber (12.29g/m^2). The result revealed that the number and size of unmarketable tuber was much lower in the bigger sized seed tuber as compared to middle sized seed tuber as observed in Table7.

Tuber yield (t/ha)

The treatments had statistically greater influence on the total tuber yield at 1% level of significance. Significantly highest tuber yield was recorded in 31-40g tuber (33.37 t/ha) followed by 51-60g tuber (32.14 t/ha) which was statistically at par with all other treatments except 11-20g seed tuber, which provided the lowest tuber yield (18.96 t/ha).

Table 8

Total yield of tuber (t/ha) of potato (marketable yield and unmarketable yield)

Treatments	Tuber yield		
	Total tuber yield (t/ha)	Total unmarketable tuber yield (t/ha)	Total marketable tuber yield (t/ha)
11-20g seed tuber	18.96[b]	0.18	18.78[b]
21-30g seed tuber	29.70[a]	0.19	29.51[a]
31-40g seed tuber	33.37[a]	0.17	33.19[a]
41-50g seed tuber	27.73[a]	0.12	27.60[a]

51-60g seed tuber	32.14[a]	0.12	32.01[a]
SEm	2.22	0.02	2.24
$LSD_{0.05}$	6.86	0.07	6.91
F test	**	ns	**
CV (%)	15.70	29.09	15.89
Grand Mean	28.38	0.16	28.22

Marketable tuber yield (t/ha)

Statistically variations in the marketable tuber yield/ha was obtained among different treatments compared in this study. The average weight of marketable tuber per ha was recorded to be 28.22 tons with the highest obtained from 31-40g seed tuber amounting 33.19 t/ha. Similarly, statistically lowest yield was obtained from 11-20g as compared to other treatments. But in terms of unmarketable tuber yield, no significant difference was observed among the size of seed tubers. As reported in a study, small sized tuber decreased the tuber yield whereas medium sized tuber >30-40g seed tuber increased the yield of potato (Kumar, et al., 2009) but in contrary to the findings of this study, Regasa, et al., (2022) reported the highest tuber yield in large sized tuber.

Table 9

Grading of potato as influenced by different sizes of seed tubers

Treatments	Small sized (<25mm) Diameter	Large sized (25-50mm) diameter
11-20g seed tuber	2.85	3.48[b]
21-30g seed tuber	3.55	6.62[a]
31-40g seed tuber	3.86	6.62[a]
41-50g seed tuber	2.64	5.95[a]
51-60g seed tuber	2.16	6.29[a]
SEm	0.69	0.46
$LSD_{0.05}$	2.13	1.44
F test	ns	**
CV (%)	45.90	16.20
Grand Mean	3.01	5.79

Size of potato tubers

Significant effect of different sized seed tubers was observed in the size of harvested tubers as shown in Table 9. Large sized potato seed tubers produced significantly larger potatoes (25-50mm) as compared to smallest size seed tuber i.e. 11-20g. The average number of seed tuber was found to be 5.79 where significantly higher number of large sized potato was observed in the treatment 21-30g and 31-40g followed by 51-60g seed tubers. Despite the differences in numerical value among the treatments, all the treatments were statistically at par in generating larger sized tubers while harvesting except the treatment 11-20g seed tuber. Bussan et al., (2007) reported that bigger sized tubers can be obtained from larger size seed tubers, which is in line with the findings of this research.

Economic analysis

The cost of production was calculated for one hectare from the cost involved in the experimental plots. Production cost included general cost of cultivation and treatment wise variable cost (Bajrachrya and Sapkota, 2017). The average cost was about NRs.391563. Among all the treatment, the highest production cost (NRs. 464472) occurred in 51-60g seed tuber followed by 41-50g (NRs. 428814) as shown in Table 10.

Table 10

Economics analysis of different treatments

Treatments	Totalcostof production (NRs./ha)	Grossreturn (NRs./ha)	B:C ratio
11-20g seed tuber	3,14,814.1	8,38,350	2.66
21-30g seed tuber	3,56,508	13,36,905	3.75
31-40g seed tuber	3,93,208	15,02,055	3.82
41-50g seed tuber	4,28,814	12,47,850	2.91
51-60g seed tuber	4,64,472	14,46,367	3.11

Similarly, the average gross return in the experiment was NRs. 1274305. But the gross return was found to be the highest amounting NRs. 1502055 in 31-40 followed by 51-60g (NRs.1446367).In terms of yielding benefit cost ratio, the highest value of 3.82 was observed in 31-40g which was nearly equal to 21-30g (3.75). The result revealed that use of potato seed tuber ranging from 21-40g proved to be the most profitable among other sizes of seed tubers used in the study.

Conclusion

Size of seed tuber affected both the growth and yield of potato significantly. Larger sized planting material i.e. seed tuber performed better in terms of growth and yield parameters as compared to smaller ones. The highest number of tuber/hill, number of tuber/m^2, total marketable yield and total yield (t/ha) was noticed in 31-40g seed tuber and higher weight of tuber/hill was noticed in 51-60g seed tuber, whereas the lowest value for all these parameters was observed in 11-20g seed tuber. Similarly, weight of total unmarketable tuber was found to be the highest in 21-30g seed tuber whereas the greater value of larger sized (25-50mm) harvested tubers was obtained from 31-40g resulting in higher benefit cost ratio (3.82). Thus, it could be concluded that the size of seed tuber ranging from 21-40gare most profitable among all other sizes, under the rainfed condition in Dadeldhura. It is recommended to conduct further research considering different varieties at different locations under irrigated condition for wider applicability of the findings of this research.

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