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Performance of Plant Spacing Using Cut Seed Tubers of Different Varieties on Growth Parameters, Yield Attributes and Yield

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This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Aim: Potato is one of the most prominent crops to eliminate hunger and poverty at the global level. It is one of the world's most widely consumed and important food crops, providing a significant portion of the world's dietary energy and nutrients.
Methodology: The study was carried out at the research farm of Vegetable Science, Chaudhary Charan Singh Haryana Agricultural University- Hisar, India during the rabi season of the year 2021-22. The field experiment was conducted in a split-plot design with three potato varieties (Kufri Neelkanth, Kufri Bahar and Kufri Lima) and four different spacing (60×10 cm, 60×15 cm, 60×20 cm with cut tuber and 60×20 cm with whole tuber).
Results: Among different spacings and varieties, spacing 60×20 cm with whole tuber and Kufri Neelkanth was found best for plant height at 60, 75 and 90 days after planting, number of leaves/hill,

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leaves weight/hill (g), stem weight/hill (g), weight of fresh foliage (kg/m^2) and and total tuber yield (q/ha), biological yield (q/ha), respectively. Whereas, Kufri Bahar was found maximum for the number of stems/hill (7.22) and Kufri Lima for total marketable tuber yield (374.4 q/ha).
Conclusion: The present study opens up new doors to the farmers and researchers for sustainable production of potatoes. The findings can be useful for farmers and researchers in developing effective strategies for improving the production of potato, which can have significant economic and nutritional benefits.

Keywords: Yield attributes; tubers; plant spacing; potato varieties; tuber yield; yield components.

1. INTRODUCTION

Potato is one of the most prominent crops to eliminate hunger and poverty at the global level. However, the crop possesses huge potential concerning yield and nutrition and enhancement of potato production is a major concern due to the increasing global population. Devoid of genetics, various agronomic practices in potato production affect its yield to a greater extent. It has originated in the Andes of Peru and Bolivia in South America, where it is found growing wild with the widest diversity of forms, *i.e.* tuber size, shape, colour and taste. It also known as white or Irish potato, is an annual herbaceous plant and the edible part is the underground modified stem.

Among the different states of India, Uttar Pradesh ranks first in terms of both area and production of potatoes. It is also one of the most important crops of Haryana, having an area of 34.7 thousand hectares with production and productivity of 897.9 thousand million tonnes and 26.0 t/ha, respectively [1].

Potato plant growth and yield are also determined by the genetic potential of a variety and different varieties may have varying plant spacing requirements [2]. Arsenault and Christie [3] showed that tuber yield might be related to the number of main stems regardless of seed size, considerable data have been collected that support the use of stems as the unit of density in the potato crop. Plant spacing and tuber size are very important for the seed production of potatoes due to their effects on plant development and the yield of the crop. Closer spacing resulted in a higher number of tubers with smaller tubers size. Planting larger-size mini-tubers had a beneficial impact on all growth and yield parameters [4]. Plant geometry has a significant impact on potato plant height, stems and leaf production. Plant spacing issues can result in a plant population that is either too thin or too dense, lowering potato tuber yield [2].

Cutting seed tuber has been adopted because of the lack of adequate availability of whole seed tuber and also by reducing the seed cost. However, cut surfaces may be susceptible to attack by soil-borne fungi, particularly during cool and wet conditions. Whole seed tubers of potatoes have been reported to have some performance advantages over seed pieces produced by cutting whole tubers, even if the cut seed is treated with a fungicide [5]. Small and medium-sized seed tubers are preferred by farmers engaged in small-scale cultivation to reduce seed costs under Bangladesh conditions [6].

The use of cut seed pieces and maintaining a higher planting density per unit area were also different options for lowering the cost of seed input in such cultivars. Considering the above facts, the present investigation has been carried out to study the “Performance of plant spacing using cut seed tubers of different varieties on growth parameters, yield attributes and yield”.

2. MATERIALS AND METHODS

The present study was carried out at Vegetable Research Farm, Chaudhary Charan Singh Haryana Agricultural University, Hisar. The experimental site is situated at 29°10"N latitude and 75°46"E longitude with 215.2 m above mean sea level in the northwest part of India. The treatments comprising of three potato varieties; (V_1):- Kufri Neelkanth, (V_2):- Kufri Bahar and (V_3):- Kufri Lima (V_3) and four different spacing; (S_1):- 60×10 cm with cut tuber, (S_2):- 60×15 cm with cut tuber, (S_3):- 60×20 cm with cut tuber and (S_4):- 60×20 cm with whole tuber were laid out in a randomized block design (factorial) with three replications keeping gross plot size 4.8 x 3.6 m^2 net plot size 3.6 x 3.0 m^2.

Tubers of 2.5-3.0 cm diameter disease-free certified seed tubers were used and the recommended package of practices for potato

FYM @ 20 tonne/ha + 150: 100: 120 kg/ha was used. At the last ploughing, the whole quantity of FYM @ 20 tonnes per hectare was incorporated into the soil. In addition to this half the quantity of nitrogen and full phosphorus and potassium were applied in rows about 4-5 cm away from seed tubers and the remaining quantity of nitrogen was top dressed in furrow at the time of earthing up. The tubers were planted on the surface of plots at different spacing and covered with soil to make the ridges. Irrigations were applied by tube well at fortnightly intervals. Earthing up was done 30 days after planting of tubers with the help of Kudal. At the same time, a remaining dose of nitrogen was also applied. The crop was dehaulmed after 110 days of planting and after 10 days of dehaulming to allow tuber hardening (curing). The foliage weight and total tuber yield of the individual plot were noted separately at the time of harvesting. Later the values were converted into quintal per hectare and summed up to work out the biological yield per hectare (q). The data recorded during the study for various parameters was statistically analyzed with the help of OPSTAT available at CCS HAU, Hisar, website.

The plant emergence at different plant spacing using cut or whole tubers was recorded in the range of 90.8 to 95.4 % at 30 DAP (as shown in Table 1). The maximum plant emergence was observed with 60×20 cm spacing using whole tuber for planting and comparatively lower with cut tuber planting. This might be due to the reason that cutting the tuber into small pieces resulted in the cut seed piece decay and consequently, a low plant population as reported by Khalafalla [7]and Kushwah and Grewal [8]. Among the varieties, maximum plant emergence was observed in Kufri Lima which was at par with Kufri Neelkanth may be due to the inherent capacity of the variety as well as the more buds available in these two varieties. The interaction between plant spacing and varieties was found non-significant for plant emergence. This may be because all varieties respond equally to different spacings. The present results follow the findings of Khalafalla [7] and Kushwah and Grewal [8] in potatoes.

The data on plant height (Table 1) revealed that it varied significantly with different plant spacings and varieties. The plant height was recorded in the range of 56.6 to 64.6, 60.0 to 67.8 and 61.4 to 68.4 cm, respectively at 60, 75 and 90 DAP. Among cut tubers, the maximum plant height was recorded with closer spacing viz. 60×10 cm, while the highest was recorded with 60×20 cm spacing using whole tuber. At closer spacing, competition for light between plants probably increased which resulted in the tallest plants at closer spacing [9]. Among the cut tuber and whole tuber, the maximum height was recorded in the whole tuber planted at 60×20 cm spacing. It may be due to increased availability of stored food and a greater number of eyes per tuber. The maximum plant height was recorded in Kufri Neelkanth, followed by Kufri Lima and Kufri Bahar at 60, 75 and 90 DAP. The variation in plant height may be due to the varietal difference which could be associated with canopy structure. The canopy structure will favour the photosynthetic rate and result in a higher growth rate and better stem growth. Similar findings were observed by Robert et al. [10]. The interaction effect between different plant spacings and potato varieties was found non-significant for plant height. This may be due to that all varieties respond equally to different spacings and the same has been reported by Birhanu et al. [11].

3.1 Growth Parameters

The number of stems and leaves *viz.* 4.76 and 44.47, respectively were recorded maximum with a spacing of 60×20 cm planted with a whole tuber, while the minimum was observed with the spacing of 60×10 cm for cut tuber planting as shown in Table 3. The same trend was also recorded for stem and leaf weight *i.e.* maximum stem and leaf weight was 238.8 and 87.1 g, respectively with spacing of 60×20 cm for whole tuber planting (Table 3). The wider spacing with whole tuber planting gives a higher number and weight of stems and leaves per hill because of the availability of more space and nutrients as well as more eyes on the whole tuber. The present results are following the findings of Zamil *et al*. [12].

Among varieties, a significantly higher number of leaves *viz*. 42.33 and stems *viz*. 4.73 were recorded in Kufri Neelkanth, whereas, the lowest number of leaves was recorded in Kufri Bahar (37.12). The number of leaves and stems per hill in the Kufri Neelkanth variety of potato may be due to higher plant height and better growth of this variety. However, the lowest number of stems was recorded in Kufri Lima (3.80) because of less number of eyes on the tuber, which may

3. RESULTS AND DISCUSSION

Table 1. Effect of plant spacing using cut seed tuber of different potato varieties

Plant spacing	Plant emergence at 30 DAP	Plant height at 60 DAP	Plant height at 75 DAP	Plant height at 90 DAP
S_1	90.8	61.1	65.0	65.8
S_2	92.2	60.3	63.3	63.7
S_3	92.8	56.6	60.0	61.4
S_4	95.4	64.6	67.8	68.4
SEm ±	1.1	1.5	1.5	1.3
CD at 5%	2.3	3.1	3.1	2.7
Varieties				
V_1	93.7	63.0	66.1	67.0
V_2	90.7	58.7	62.1	62.4
V_3	94.1	60.2	63.8	65.0
SEm ±	1.0	1.3	1.3	1.1
CD at 5%	2.0	2.7	2.7	2.7

Table 2. Effect of plant spacing using cut seed tuber of different potato varieties on growth parameters

Plant spacing	Number of stems/hill	Number of leaves/hill	Leaves weight/hill (g)	Stem weight/hill (g)	weight of fresh foliage (kg/m^2)
S_1	4.00	35.5	164.9	66.6	1.95
S_2	4.07	38.1	192.0	73.0	1.92
S_3	4.18	40.1	221.5	80.2	1.73
S_4	4.76	44.5	238.8	87.1	2.07
SEm ±	0.27	1.75	6.5	3.5	0.08
CD at 5%	0.56	3.65	13.5	6.3	0.17
Varieties					
V_1	4.73	42.3	212.6	82.0	2.05
V_2	7.22	37.1	189.5	70.8	1.76
V_3	3.80	39.2	210.9	77.3	1.94
SEm ±	0.23	1.52	5.6	3.0	0.05
CD at 5%	0.49	3.17	11.7	6.4	0.14

also be the genetic makeup of this variety. The stem and leaf weight was observed as maximum in the case of Kufri Neelkanth, while Kufri Bahar showed minimum. The difference among varieties for stem and leaf weight might be due to the genetic makeup of the varieties and also because of a higher number of leaves hill. Similar findings have been reported by Kumar *et al*. [13].

The weight of fresh foliage was recorded as maximum (2.07 kg/m^2) with 60×20 cm spacing using whole tuber for planting (as shown in Table 3). In the case of cut tuber planting, the maximum weight of fresh foliage (1.95 kg/m^2) was recorded with 60×10 cm spacing and the lowest (1.73 kg/m^2) with 60×20 cm spacing using cut tuber for planting. The maximum foliage weight per m^2 area under 60×10 cm spacing may be due to more plant population per unit area under this spacing. Among different varieties, the maximum weight of fresh foliage was recorded in the case of Kufri Neelkanth (2.05 kg/m^2), followed by Kufri Lima (1.94 kg/m^2) and the minimum was in Kufri Bahar (1.76 kg/m^2). The better adaptation and better stem and leaf growth weight might be attributed to higher fresh foliage weight in Kufri Neelkanth and Kufri Lima as compared to Kufri Bahar. Similar findings have been reported by Zamil *et al*. Zewide *et al*. and Kumar *et al*. [12, 14,13] in potatoes.

3.2 Yield attributes and Yield

The data as shown in Table 3 revealed that different plant spacings and potato varieties had a remarkable impact on total tuber yield (q/ha),

Table 3. Effect of plant spacing using cut seed tuber of different potato varieties on yield attributes and yield

Plant spacing	Total tuber yield (q/ha)	Marketable tuber yield (q/ha)	Biological yield (q/ha)
S_1	389.0	363.6	568.8
S_2	380.9	349.9	548.8
S_3	357.3	323.4	506.0
S_4	395.8	373.0	583.9
SEm ±	10.42	6.75	12.58
CD at 5%	21.75	19.94	26.25
Varieties			
V_1	394.5	354.3	582.2
V_2	361.5	328.7	520.5
V_3	386.2	374.4	552.8
SEm ±	9.03	5.85	10.89
CD at 5%	18.84	17.27	22.74

marketable yield and biological yield (q/ha). The maximum total tuber yield (395.78 q/ha) was obtained with plant spacing 60×20 cm using whole tuber for planting, which was significantly at par with 60×10 cm and 60×15 cm using cut tuber for planting and the maximum total marketable tuber yield (373.0 q/ha) was noticed with plant spacing 60×20 cm using whole tuber for planting, which was significantly higher as compared to other spacing except 60×10 cm spacing using cut tuber for planting (363.6 q/ha). Significantly, the maximum biological yield (583.86 q/ha) was gained with plant 60×20 cm spacing using whole tuber for planting, which was significantly at par (568.81 q/ha) with plant 60×10 cm spacing using cut tuber for planting.

This may be due to that under wider spacing and whole tuber planting there was proper growth and development of the plant resulting in more yield of large-size tubers which ultimately increases the marketable yield, total yield as well and biological yield, while under closer spacing using cut tubers, there was higher plant population per unit area which increases the yield of all of the size tuber. The present finding also confirmed the results of Malik *et al.* and Birhanu *et al.* [15,11] who reported that the tuber yield per hectare was higher with whole tubers planting as compared to cut tubers under the same plant spacing.

Among potato varieties, the total tuber yield varied between the range of 361.52 to 394.52 q/ha. A significant maximum (394.53 q/ha) total tuber yield was observed in Kufri Neelkanth, which was statistically at par with Kufri Lima (386.18 q/ha), while Kufri Lima resulted in a maximum total marketable tuber yield (374.4 q/ha) which was significantly higher as compared to other varieties. The biological yield varied between from 520.54 to 582.21 q/ha. A significant maximum (582.21 q/ha) biological yield was observed in Kufri Neelkanth as compared to other varieties. The maximum tuber yield in Kufri Neelkanth may be due to better growth parameters which resulted higher yield. Kufri Lima produced more number of larger size tuber because of their genetic behaviour resulting in higher marketable and biological yield. The varietal difference in potato varieties concerning tuber yield, marketable yield as well and biological yield was also noticed by Yadav *et al*. [16]. The present findings are following results reported by Abrha *et al.* [17], Lal *et al*. [18] and Birhanu *et al.* [11]. The interaction effect between different plant spacings and potato varieties was found non-significant for tuber yield, marketable yield as well and biological yield. This may be due to that all varieties respond equally to different spacings using whole or cut tuber for planting.

4. CONCLUSION

In conclusion, the study examining the impact of plant spacing using cut seed tubers of different varieties has provided valuable insights into optimizing potato cultivation. The observed variations in growth parameters and yield attributes underscore the importance of tailoring planting practices to specific varieties and spacing configurations. These findings offer practical guidance for farmers aiming to enhance crop performance and achieve optimal yields. However, further research is recommended to validate these conclusions across diverse environmental conditions and potato varieties.

Overall, this research contributes valuable knowledge for informed decision-making in potato cultivation, emphasizing the need for a subtle approach to plant spacing for improved agricultural sustainability and productivity. The present study adds up the knowledge to previous works carried out worldwide and provides an approachable practice to enhance the yield of potatoes. The present study may benefit the farmers and growers at the global level.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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