***Original Research Article***

# Growth and Quality Responses to Plant Spacing in potato (*Solanum tuberosum L.*) Varieties


## ABSTRACT

The present investigation was conducted during rabi season of 2020 at Experimental Farm of Vegetable Sciences, DAV University, Jalandhar to study the growth and quality responses to plant spacing in potato ( *Solanum tuberosum L.*) varieties. Experimental material consisted of four varieties (Kufri Pukhraj, Kufri Jyoti, Kufri Badshah, Kufri Chandramukhi ) sown at three spacings (70cm x 20cm, 60cm x 20cm, 50cm x 20cm) laid in Factorial Randomized Block design with three replications. Observations on number of leaves per plant at 30 DAS, number of leaves per plant at 60 DAS, number of leaves per plant at 90 DAS, Plant height (cm) at 30DAS, Plant height (cm) at 60DAS, Plant height (cm) at 90 DAS, average tuber weight (g), number of tuber plant, marketable tuber yield per plot(kg), unmarketable tuber yield per plot(kg),tuber yield per plot (kg), TSS, ascorbic acid(mg/100g), starch content(%) and dry matter content(%) were recorded. ~~Analysis of variance (ANNOVA)~~ Analysis with Non-parametric statistics revealed significant effect of spacing, varieties and their interaction for all the characters under study. It was observed that plants sown at spacing $S_1$ (70cm x 20cm) resulted in superior performance for most of the traits studied. Among cultivars, desirable results were observed in $V_1$(Kufri Pukhraj). Considering the interaction of varieties and spacing it was concluded that Kufri Pukhraj sown at a spacing of 70 cm x 20 cm can result in superior performance with respect to growth, yield, and quality parameters of potato.

## Introduction

Potato (*Solanum tuberosum* L.) popularly known as ‘king of vegetables’ occupies a preponderant place in the food of many countries by the surface which it occupies, the jobs which it provides and the volume of production which it generates. It is most important vegetable crop, constituting the fourth most important food crop in the world. Potato crop is graded as a high potential food security and cash crop because of its ability to provide a high yield of high-quality product per unit input with a shorter crop cycle. India in particular and Asia in general are showing rapid growth in potato production. Potato is highly remunerative crop of Punjab and has large area cover. During the fiscal year 2020- 21, the volume of potato produced across India accounted for over 48 million metric tons. With a projected population increase of 19% by 2050, India faces a tremendous challenge to increase production of all food crops, including potatoes, to meet future demands. (Annonymus, 2021)

Potatoes are grown across India under diverse agro-climatic conditions in almost all states except the coastal belt. Nearly 82% of potatoes are grown in northern India, in the vast Indo-Gangetic Plain (IGP) during short winter days from October to February/March. Since the Central IGP has milder winters, agriculture intensification is high, and farmers frequently cultivate three crops in a year. Punjab is known as the ‘Seed Bowl’ of the country because of absence or low presence of aphids during October. Potato varieties suited to the country's climate - hot summers and short winters - are grown on the Indo-Gangetic plain during the short winter days from October to March, while some year-round production takes place in relatively high altitude areas in the south and Northern hills.

There are many factors that affect yield and quality of specific vegetables which include fertilizer application, cultural practices, soil type, sowing method and cultural practices etc. The population of plant which is dependent on the spacing affects the growth and yield of vegetables. In case of spacing the yield is poor due to the improper spacing (Pervez *et al*., 2004). The use of spacing in crop production is very important, because it reduces competition between plants and weeds. Increased spacing reduces the number of plants per hectare thus affecting the yield. However decreased spacing increases plant population and yield per unit area up to a certain limit, beyond which the yield decreases due to limitation in natural resources required for plant growth. Overcrowding of seedlings or plant in a particular area or spot may lead to increased competition among adjacent plants for available essential growth resources like sunlight, space, water and nutrient, as well as for aerial space for canopy formation which affects plant growth, yield and quality (Zibelo *et al.*,2016). In potato factors which influence yield and quality are cultivar, plant population, soil type, weather conditions, water management, fertilization, seed piece size, pests and diseases (Khalafalla, 2000).

Planting density strongly affects yield and more tubers and yield per square meter are expected at higher planting densities. Bussan *et al*., (2007) and Creamer *et al*.,(1999), argued that optimizing plant density was one of the most important practices in potato production management, as it affects seed cost, plant development, yield and the quality of the crop. Plant population studies in potato are thought to be never out dated because newly developed cultivars have unique tuber characteristics and evolving industries constantly come up with new tuber size requirements. Barry *et al*., (1990) and conditions and cultivars. In view of importance of the crop and role of spacing in its production the Güllüoglu and Arıoglu (2009) noted that the optimal planting density differed depending on environmental present study was planned and executed to study the response of plant spacing on growth and quality of potato**.**

## MATERIALS AND METHODS

The present investigation was carried out at the Experimental Farm of Faculty of Agricultural Sciences, DAV University, Jalandhar during winter season of 2020-2021.The experiment was laid out in Factorial Randomized Block Design (FRBD) with the three replications. The experiment material consisted of four varieties *viz*., Kufri Pukhraj, Kufri Jyoti, Kufri Badshah, Kufri Chandramukhi and three spacings *viz*., 70cm x20cm, 60cm x20cm and 50cm x20cm. The organic manure ( FYM) and inorganic fertilizers were applied in the experimental field and the cultural practices were done as per the package of practices of Punjab Agricultural University. The bservations on number of leaves per plant at 30 DAS, number of leaves per plant at 60 DAS, number of leaves per plant at 90 DAS, Plant height (cm) at 30DAS, Plant height (cm) at 60DAS, Plant height (cm) at 90 DAS, average tuber weight (g), number of tuber plant, marketable tuber yield per plot(kg), unmarketable tuber yield per plot(kg),tuber yield per plot (kg), TSS, ascorbic acid(mg/100g), starch content(%) and dry matter content(%)were recorded and analyzed statistically. The Non-parametric statistical analysis was performed (Terentyeva, Hayakawa, et al. (1997)). ~~of data recorded during the course of investigation for all the characters was done by the analysis of Median variance method for factorial randomized block design described by Panse and Sukhatme (1985)~~.

## RESULTS AND DISCUSION

### 1. ~~Analysis of Variance (ANOVA)~~ : Analysis of Median:

~~Analysis of variance (ANOVA)~~ Analysis of Median revealed significant differences among plant spacing and varieties for all the traits while, the interaction between varieties and spacing showed significant differences for all the characters except TSS and dry matter content (%) (Table 1).

### 2. Number of leaves per plant at 30DAS, 60DAS and 90DAS

Perusal of data (Table 2) revealed maximum number of leaves per plant at 30 DAS (11.22) in $V_4$ ( Kufri Chandramukhi ) which was statistically at par with $V_1$ (Kufri Pukhraj ) which produced ( 9.89) leaves per plant. Minimum number of leaves per plant (6.55) observed in $V_2$ (Kufri Jyoti ) was statistically at par with $V_3$ ( Kufri Badshah ) producing ( 8.22) leaves per plant at 30 DAS . Among spacing , maximum number of leaves per plant at 30 DAS ( 9.50) was observed in plants sown at $S_1$ ( 70cm x 20cm ) which was statistically at par with the number of leaves per plant ( 9.16) observed in plants sown at $S_3$ ( 50cm x 20cm ). Minimum number of leaves per plant ( 8.25) was observed in $S_2$ ( 60cm x 20cm ) which was statistically at par with leaves of plants at 30 DAS sown at $S_3$ ( 50cm x 20 cm ) ( 9.16 ). Number of leaves per plant at 30 DAS showed significant differences in interaction between varieties and spacing .Table 2.1 depicted that maximum number of leaves per plant ( 12.67) in $V_4$ x $S_1$ ( Kufri Chandramukhi x 70 cm x 20cm ) which was statistically at par with $V_4$ x $S_3$ ( Kufri Chandramukhi x 50cm x 20cm ) (12.00) . Minimum number of leaves per plant ( 6.00) was observed in $V_2$ x $S_2$ ( Kufri Jyoti x 60cm x 20 cm ) which was statistically at par with $V_2$ x $S_3$ ( Kufri Jyoti x 50 cm x 20cm ) and $V_2$ x $S_1$ ( Kufri Jyoti x 70cm x 20cm ) which produced 7.00 and 7.67 leaves per plant at 30 DAS respectively. At 60 DAS maximum number of leaves per plant (40.77) were observed in $V_1$ ( Kufri Pukhraj ) which was statistically at par with $V_4$ ( Kufri Chandramukhi ) which produced ( 40.44) leaves per plan. Minimum number of leaves per plant (36.55) was observed in $V_2$ ( Kufri Jyoti ) which was statistically at par with $V_3$ ( Kufri Badshah ) which produced ( 38.22) leaves per plant at 60 DAS. Among spacing, maximum number of leaves per plant ( 40.17) was observed in plants sown at $S_1$ ( 70cm x 20cm ) which was statistically at par with the number of leaves per plant ( 39.17) observed in plants sown at $S_3$ ( 50cm x 20 cm) while, significantly minimum number of leaves per plant (37.67) was observed in $S_2$ (60cm x 20 cm). Among interactions, maximum number of leaves per plant (42.67) were observed in $V_4$ x $S_1$ (Kufri Chandramukhi x 70cm x 20cm) which was statistically at par with $V_1$ x $S_1$ (Kufri Pukhraj x 70cm x 20cm) ( 42.33), $V_4$ x $S_3$ (Kufri Chandramukhi x 50cm x 20cm) (42.00), $V_1$ x $S_2$ (Kufri Pukhraj x 60cm x 20cm) (40.00) and $V_1$ x $S_3$( Kufri Kufri Pukhraj x 50cm x 20cm) (40.00). Minimum number of leaves per plant (36.00) was observed in $V_2$ x $S_2$ ( Kufri Jyoti x 60cm x 20cm ) which was statistically at par with $V_2$ x $S_3$ ( Kufri Jyoti x 50 cm x 20 cm) and $V_2$ x $S_1$ ( Kufri Jyoti x 70cm x 20cm ) which produced 37.00 and 36.67 leaves per plant at 60 DAS respectively. Maximum number of leaves per plant at 90 DAS (60.77) was observed in $V_1$ ( Kufri Pukhraj ) which was statistically at par with $V_4$ (Kufri Chandramukhi) which produced (60.44) leaves per plant. Minimum number of leaves per plant (56.56) was observed $V_2$ (Kufri Jyoti) which was statistically at par with $V_3$ (Kufri Badshah) producing (58.22) leaves per plant. Among spacing , maximum number of leaves per plant (60. 17) was observed in plants sown at $S_1$ ( 70cm x 20 cm ) which was statistically at par with the number of leaves per plant (59.17) observed in plants sown at $S_3$ ( 50cm x 20cm). Minimum number of leaves per plant (57.67) was observed in $S_2$ ( 60cm x 20cm ) which was significantly lowest than other spacing . Among interaction effects at 90DAS, maximum number of leaves per plant (62.67) was observed in $V_4$ x $S_1$ ( Kufri Chandramukhi x 70cm x 20 cm ) which was statistically at par with $V_4$ x $S_1$ ( Kufri Chandramukhi x 70cm x 20cm) (62.33) . Minimum number of leaves per plant (56.00) was observed in $V_2$ x $S_2$ ( Kufri Jyoti x 60cm x 20cm ) and $V_2$ x $S_3$ ( Kufri Jyoti x 50cm x 20cm) which was statistically at par with $V_4$ x $S_2$ ( Kufri Chandramukhi x 60cm x 20cm ) (56.67) , $V_2$ x $S_1$ (Kufri Jyoti x 70cm x 20cm ) (57.67), $V_3$ x $S_1$ ( Kufri Badshah x 70cm x 20cm ) (58.00) and $V_3$ x $S_2$ (Kufri Badshah x 60cm x 20cm ) (58.67).

The wider spacing results in maximum number of leaves per plant at 30 DAS, 60 DAS and at 90 DAS. The reduced spacing caused increased population density which might have promoted plant competition for sunlight, nutrients, water and space. The findings corroborates with the findings of earlier researchers *viz* ., Mvumi *et al.*, (2008) ; Mangani *et al.*,(2015) and Takele *et al.*,(2017) who observed higher number of leaves with increased plant spacing in potato. Significant variations among varieties for number of leaves per plant could be due to their genetic makeup differences. Similar results were obtained by earlier resaerchers *viz* ., Mangani *et al* ., (2015) in potato. Interaction effects of varieties and spacing were also significant for number of leaves per plant indicating the influence of spacing on varieties for the number of leaves per plant. The results are in line with the findings of Mvumi *et al* .,(2008) ; Mangani *et al* (2015) ; Takele *et al*.,(2017).

**3. Plant height (cm) at 30DAS, 60 DAS and 90DAS**

Effect of varieties and spacing on plant height (cm) at 30DAS, 60 DAS and 90DAS has been presented in table 2. Plant height at 30 DAS was observed maximum (26.97cm) in $V_1$ (Kufri Pukhraj) which were statistically at par with plant height of $V_4$ ( Kufri Chandramukhi ) (26.36 cm). Minimum plant height (24.73cm) was observed in $V_3$ (Kufri Badshah) which was significantly lowest than all the varieties. Among spacing, maximum plant height (26.56cm) was observed in plants sown at $S_1$ (70cm x 20cm) which was statistically at par with the plant height (25.93cm) observed in plants sown at $S_2$ (60cm x 20cm). Minimum plant height (24.73 cm ) was observed in $S_3$ (50cm x 20cm) which was significantly lowest than height of plants sown in other spacing. Interaction effect of varieties and spacing at 30DAS, 60 DAS and 90DAS has been presented in table 2.1. Plant height at 30 DAS showed significant differences in interaction between varieties and spacing. Maximum plant height (28.90cm) was observed in $V_4$ x $S_2$ (Kufri Chandramukhi x 60cm x 20cm) which was statistically at par with $V_1$ x $S_1$ (Kufri Pukhraj x70cm x 20cm), $V_1$ x $S_2$(Kufri Pukhraj x 60cm x20cm) and $V_2$ x $S_1$ (Kufri Jyoti x70cm x20 cm) which produced plant height at 30 DAS to the tune of 28.10 cm, 27.09 cm and 27.26cm, respectively. Minimum plant height (23.20cm) was observed in $V_4$ x $S_3$ (Kufri Chandramukhi x 50cm x 20cm) which was statistically at par with $V_3$ x $S_3$ (Kufri Badshah x 50cm x 20 cm), $V_2$ x $S_2$ (Kufri Jyoti x 60cm x 20cm)and $V_4$ x $S_1$ (Kufri Chandramukhi x 70cm x 20 cm) which produced 23.30 cm, 23.84cm and 24.45 cm, respectively tall plants at 30 DAS.

Data depicted that at 60DAS maximum plant height (66.67cm) was observed in $V_4$ (Kufri Chandramukhi) which was statistically at par with plant height of $V_3$ (Kufri Badshah) (66.22cm) while, $V_1$ (Kufri Pukhraj) produced shortest plants with the plant height of (56.89 cm) which was statistically at par with $V_2$ (Kufri Jyoti ) having 61.22 cm plant height . Among spacing tallest plants (66.17 cm) were observed at $S_1$ ( 70cm x 20cm ) which was statistically at par with the plant height of plants spaced at $S_3$ ( 50cm x 20cm) ( 62.25 cm ). Among interaction effects of varieties and spacing, it was maximum ( 68.33 cm ) in $V_3$ x $S_1$ ( Kufri Badshah x 70cm x 20cm ) which was statistically at par with all the interactions effects except $V_1$ x $S_2$ ( Kufri Pukhraj x 60cm x 20cm ) (53.33 cm ) , $V_1$ x $S_3$ ( Kufri Pukhraj x 50cm x 20cm ) (53.00 cm) and $V_2$ x $S_2$ ( Kufri Jyoti x 60cm x 20cm ) (50.67cm). Minimum plant height was observed in $V_2$ x $S_2$ (Kufri Jyoti x 60cm x 20cm ) which produced plants with the plant height of (50.67cm) which was statistically at par with plant height observed in $V_1$ x $S_1$ ( Kufri Pukhraj x 70 cm x 20 cm ) and $V_1$ x $S_3$ ( Kufri Pukhraj x 50cm x 20cm ) which produced (53.33cm) and (53.00cm) tall plants, respectively.

At 90 DAS, $V_1$ ( Kufri Pukhraj ) produced tallest plants ( 66.67cm) which were statistically at par with $V_4$ ( Kufri Chandramukhi) and $V_2$ ( Kufri Jyoti ) which produce (67.44cm) and (67.22cm) tall plants, respectively. Among spacing, tallest plants (68.25cm) were observed when sowing was done at a spacing of $S_1$ ( 70cm x 20cm) which was statistically at par with plants sown at a spacing of $S_2$ ( 60cm x 20cm ) having plant height of (67.25 cm). Interaction effect of varieties and spacing for plant height at 90DAS was maximum (71.33cm) in $V_1$ x $S_1$ ( Kufri Pukhraj x70cm x 20cm ) which was statistically at par with the plants sown in interaction of $V_4$ x $S_3$ ( Kufri Chandramukhi x 50cm x 20cm ) which produced 69.67 cm tall plants . Shortest plants (65.33cm) were observed in $V_4$ x $S_1$ (Kufri Chandramukhi x 70cm x 20cm) which were statistically at par with plant height of $V_2$ x $S_2$ ( Kufri Jyoti x 60cm x 20cm ) (65.67cm ) , $V_4$ x $S_2$ (Kufri Chandramukhi x 60cm x 20cm) (67.33cm), $V_2$ x $S_3$ (Kufri Jyoti x 50cm x 20cm) ( 67.67cm) and $V_3$ x $S_3$ ( Kufri Badshah x 50cm x 20cm ) (66.11cm).

Increase in plant height with increase in plant spacing was observed in the experiment at 30 DAS, 60 DAS and 90 DAS. This could be due to reduced plant competition for sunlight, water and nutrients in wider spacing. The results are in conformity with the study done by Barry *et al* (2000) who stated that decreased spacing resulting in increased population density, increase the plant competition for nutrients , water and space resulting in short plant height in potato. Similar results were also observed by Arega *et al* ( 2010) in potato, Hussain *et al* (2013) in tomato and Idoko *et al* (2015) in sweet potato.

Varietal response towards plant height was significantly different at 30 DAS , 60 DAS , 90 DAS. These differences are likely due to varietal differences associated with their canopy structure and growth habit. Simongo *et al.*, ( 2011) attributed differences in stem height to the differences that the cultivar had in canopy structure . The Canopy structure has an effect on photosynthesis as it increases the rate at which incoming solar radiation is intercepted. This occurs when the canopy has features that increase photosynthesis like erect leaves . Overall a canopy that has higher photosynthetic rate will have a higher growth rate and stem growth. The results were in agreement with the finding of Mangani *et al.* (2015). Interaction effect of varieties and spacing on plant height at 30 DAS , 60 DAS , 90 DAS indicates the strong influence of spacing on varietal response . It was maximum when spacing was wider. The results are in agreement with earlier researchers Viz., Zamil *et al* (2010) and Arega *et al* (2018) who observed taller plants when plant spacing was increased in potato.

**4. Average weight of tuber (g)**

The data pertaining to effect of varieties and spacing on average weight of tuber (g) is presented in Table 3. It revealed that average weight of tuber was maximum (107.76g) in $V_1$ (Kufri Pukhraj) which was significantly superior to all other varieties.

Minimum average weight of tuber (27.70g) was produced by $V_4$ (Kufri Chandramukhi) which was significantly lowest than all other varieties. Among spacing, maximum average weight of tuber (79.00g) was observed in $S_1$ (70cm x 20cm) which was significantly highest among all other spacings. Minimum average tuber weight (57.29g) was observed when spacing was $S_3$ (50cm x 20cm) which was statistically at par with average weight of tubers of plants sown at $S_2$ (60cm x 20cm) (66.14g). mong interaction effects of varieties and spacing, maximum average weight of tuber (159.35g) was observed in $V_1$ x $S_1$ (Kufri Pukhraj x 70cm x 20cm) which was statistically at par with the average tuber weight observed in $V_1$ x $S_2$ (Kufri Pukhraj x 60cm x 20cm) producing (137.54g) average tuber weight. Minimum tuber weight (23.20g) was observed in interaction $V_4$ x $S_2$ (Kufri Chandramukhi x 60 cm x 20 cm) which was statistically at par with tuber weight observed in $V_1$ x $S_3$ ( Kufri Pukhraj x 50cm x 20cm) (26.25g), $V_4$ x $S_1$ (Kufri Chandramukhi x 70cm x 20 cm) (31.01g), $V_2$ x $S_2$ (Kufri Jyoti x 60cm x 20 cm) (50.68g) , $V_2$ x $S_3$ (Kufri Jyoti x 50cm x 20cm) (102.81g) and $V_3$ x $S_2$ (Kufri Badshah x 60cm x 20cm) (53.15g) (Table 3.1).

Average tuber weight showed a decreasing trend with decrease in inter row spacing. This could be due to decreased plant competition due to increased plant spacing. Similar results were obtained by earlier researchers *Viz* ., Zabihi *et al.*, (2011) ; Arega *et al* (2018) ; and Dagne *et al.*, (2018) in potato who also observed significant effect of spacing on tuber weight and more tuber size was observed with increased spacing. Significant varietal response in terms of tuber size weight could be due to their different genetic makeup. Significant interaction effect of varieties and spacing for average tuber weight indicates the role spacing in determining the tuber weight. The results are in line with the finding of Zabihi et *al.*, (2011); Arega *et al.*, (2018) and Dagne *et al* ., (2018) .

**5. Number of tubers per plant**

Data on number of tubers per plant as affected by varieties and spacing is presented in Table 3. Persual of data revealed that $V_1$ ( Kufri Pukhraj ) produced maximum number of tubers per plant (30.10) which was significantly highest than other varieties. While, minimum number of tubers per plant (17.06) was observed in $V_4$ (Kufri Chandramukhi) which was significantly lowest than other varieties. Among spacing $S_1$ (70cm x 20cm) resulted in maximum number of tubers per plant (24.47) which were significantly superior than other spacing. Minimum number of tuber per plant (22.69) was observed in spacing $S_3$ (50cm x 20cm) which was statistically at par with the number of tuber per plant observed in $S_2$ (60cm x 20cm ) producing 23.52 tuber per plant .

Number of tubers per plant showed significant differences in interaction between varieties and spacing. It was maximum (31.53) when plants were sown in interaction $V_1$x $S_2$ (Kufri Pukhraj x 60cm x 20cm) which was statistically at par with $V_1$ x $S_1$ ( Kufri Pukhraj x70cm x 20cm) (29.40) and $V_1$ x $S_3$( Kufri Pukhraj x 50cm x 20cm) (29.37) . $V_4$x$S_2$ (Kufri Chandramukhi x 60cm x 20cm) produced minimum number of tuber per plant (17.06) which was statistically at par with the tubers per plant produced by plants sown in interaction $V_4$x $S_1$(Kufri Chandramukhi x70cm x 20cm) (17.10) and $V_4$x$S_3$(Kufri Chandramukhi x 50cm x 20cm) (18.20) (Table 3.1).

Significant differences for number of tubers per plant was observed among spacing and varieties and their interaction effects . It was observed that number of tubers per plant reduced with increased plant spacing . Arega *et al* ., (2018) also reported that with increased plant spacing there was decreased number of tubers per plant. Significant influence of plant spacing on important yield and yield contributing traits in potato was also observed by Zabihi *et al* ., (2011). Varied response of different varieties with respect to number of tubers per plant was also observed by earlier researchers Sultana and Shahiduzzam.,(2016) in sweet potato. Interaction effect of varieties and spacing was also found significant for number of tuber per plant by Mvumi *et al* .,(2018) in sweet potato.

**6. Marketable yield per plot (kg)**

The data pertaining to marketable yield per plot as affected by varieties and spacing is presented in Table 3. Maximum marketable yield per plot (13.86 kg) was observed in $V_1$ (Kufri Pukhraj) which was statistically at par with $V_4$ (Kufri Chandramukhi) producing marketable yield per plot to the tune of 13.15 kg. $V_3$ (Kufri Badshah) produced minimum marketable yield per plot (6.48 kg) which was significantly lowest than all other varieties. Among spacing, maximum marketable yield per plot (13.05 kg) was observed in $S_1$ (70cm x 20cm) which was statistically at par with the marketable yield per plot (12.14 kg) of plants sown at a spacing of $S_2$ (60cm x 20cm). Minimum marketable yield per plot (9.92 kg) was observed at $S_3$ ( 50cm x 20cm) which was significantly lowest than all other varieties. Interaction effect of varieties and spacing was significant for marketable yield per plot. Maximum marketable yield per plot was observed in $V_1$x $S_1$(Kufri Pukhraj x70cm x 20cm) which was statistically at par with $V_4$x$S_3$ ( Kufri Chamdramukhi x 50cm x 20cm ), $V_1$x$S_3$ (Kufri Pukhraj x 50cm x 20cm) ,$V_2$x$S_3$ (Kufri Jyoti x 50cm x 20cm ),$V_1$x$S_2$ (Kufri Pukhraj x 60cm x 20cm) ,$V_4$x$S_2$ (Kufri Chandramukhi x 60cm x 20cm) and $V_4$x$S_1$ (Kufri Chandramukhi x70cm x 20cm) which resulted in marketable yield per plot to the tune of (14.15 kg),(13.91 kg), (13.91 kg), (13.27kg), (13.15 kg) and (12.14kg), respectively .

Significant interaction effect of varieties and Spacing for marketable yield per plot was also observed by earlier researchers Mangani *et al.*,(2015). There was increased marketable yield with wider spacing. Due to minimum competition at wider spacing, plants absorbed the significantly available resources and intercepted more light. This increased their photosynthetic efficiency for higher photo assimilates production and ultimately result in increased marketable yield. The results are similar to the finding of Khalafalla *et al* .,( 2001) in sweet potato and Takele *et al* .,(2017) who also observed higher marketable yield with wider spacing in potato and Ara *et al*., (2007) and Abrbha *et al*., (2015) in tomato. Marketable yield per plot (kg) varied significantly among varieties. It was maximum in Kufri Pukhraj which also showed maximum average tuber weight and number of tubers per plant. The variable response of varieties for marketable yield per plot attribute to their genetic makeup. The findings are in line with the results of earlier reserchers Mangani *et al*.,(2015) and Tessema *et al*.,( 2020) in potato.

**7. Unmarketable yield per plot**

Data presented in (Table 3) showed that maximum unmarketable yield per plot (1.45kg) was produced by $V_2$ ( Kufri Jyoti ) which was significantly highest among all the varieties. However minimum marketable yield per plot (0.16kg) was observed in $V_1$ ( Kufri Pukhraj ) which was significantly lowest among all varieties . Plants sown in spacing $S_1$ (70cm x 20 x cm) resulted in minimum unmarketable yield per plot ( 0.89 kg) which was significantly lowest than other spacing. Maximum unmarketable yield per plot (1.27kg) was observed in $S_3$ (50 cm x 20 cm) which was statistically at par with the unmarketable yield of plants (1.13kg) sown at a spacing of $S_2$ (60cm x 20 x cm) .

Interaction effect of varieties and spacing ( Table 3.1) revealed that minimum unmarketable yield per plot (0.61kg) was observed in $V_1$x $S_1$ ( Kufri Pukhraj x 70cm x 20cm) which was statistically at par with the unmarketable yield per plot produced by $V_1$x $S_2$ (Kufri Pukhraj x

60cm x 20 cm) (0.62kg) and $V_4$ x $S_1$ ( Kufri Chandramukhi x70 cm x 20 cm) ( 0.89kg). Maximum unmarketable yield per plot (1.66kg) was observed in $V_2$x $S_3$ ( Kufri Jyoti x 50cm x 20cm) which was statistically at par with $V_2$ x $S_2$ (Kufri Jyoti x 60cm x 20 cm) (1.58 kg) and $V_3$x $S_3$ (Kufri Badshah x 50 cm x 20 cm) (1.46 kg) .

Unmarketable yield responded significantly for varieties, spacing and their interaction. It was minimum for plants sown at 70cm x 20cm spacing . The results are in conformities in findings of Takele *et al*., ( 2017) and Arega *et al.*, (2018) who also observed more number of undersized, diseased and deformed tubers in closer spacing. Unmarketable yield was also significantly influenced by the varieties which could be due to their genetic makeup. The results are in line with the findings of Tessema *et al*., (2020) in potato. Significant interaction effect of varieties and spacing for unmarketable yield indicates the importance of spacing in decreasing unmarketable tubers in potato. It was reported higher in closer spacing. Similar results were observed by Mangani *et al*., (2015).

**8. Tuber yield per plant (g) and per plot (kg)**

Tuber yield per plant as affected by varieties and spacing ( Table 3) depicted that maximum tuber yield per plant (161.00 g) and per plot (2.90 kg) was observed in $V_1$ ( Kufri Pukhraj ) which was significantly highest than all other varieties. Minimum tuber yield per plant (105.00 g) was observed in $V_3$ (Kufri Badshah) which was statistically at par with $V_2$ ( Kufri Jyoti ) producing (110.60 g) tuber yield per plant while tuber yield per plot was significantly minimum (1.89kg) in $V_2$ ( Kufri Jyoti). Among spacing, maximum tuber yield per plant (148.05 g) and per plot (2.66 kg) was observed in spacing $S_1$ (70cm x 20cm) which was significantly highest than all other spacings. Minimum tuber yield per plant (107.10 g) and per plot ((1.93 kg) was observed in $S_2$ (60cm x 20cm) which was statistically at par with tuber yield of plants sown in $S_3$ (50cm x 20 cm ) (tuber yield per plant 119.70 g ) and (tuber yield per plot 2.05 kg). Interaction effect of varieties and spacing on tuber yield per plant and per plot ( Table 3.1) revealed maximum tuber yield per plant (197.40 g) and per plot (3.55 kg) in $V_1$ x $S_1$ (Kufri Pukhraj x70 cm x 20cm) which was statistically at par with $V_4$ x $S_3$ ( Kufri Chandramukhi x 50 cm x 20 cm), $V_4$ x $S_1$ (Kufri Chandramukhi x 70cm x 20cm) and $V_4$ x $S_2$ ( Kufri Chandramukhi x 60cm x 20cm) which produced 161.00 g, 155.40 g and 147.00g, tuber yield per plant and 3.25 kg, 2.79 kg and (2.64 kg) tuber yield per plot, respectively. Minimum tuber yield per plant (67.70g) and was tuber yield per plot was produced by $V_1$x $S_2$ (kufri Pukhraj x 60cm x20cm) which was statistically at par with the tuber yield per plant in all the interaction except $V_1$x $S_1$, $V_4$x $S_3$,$V_4$ x $S_1$ and $V_4$x$S_2$.

Tuber yield per plant and per plot revealed similar trend for different spacing and varieties and their interaction . It was observed highest with wider spacing (70cm x 20cm) where as lowest at medium spacing. This could be attributed to the compensation effect of closer spaced plants than the wider spaced plants by more number of tubers per plants and more average tuber weight which resulted in high tuber yield of potato per plant leading to higher tuber yield per plot. Masarirambi *et al* ., (2012) ; Lamessa and Zewdu (2016) ; Szarvas *et al* ., (2017) and Takele *et al*,.( 2017) also studied the effect of spacing on yield of potato and concluded that at wider spacing yield was more than narrow spaced plants in potato and Badge *et al*., (2021) in sweet potato. Significant differences for tuber yield per plant and per plot among different varieties was also observed by earlier researchers, Habtamu *et al.*, (2016), Eatan *et al.*, (2017), and Tessema *et al* ., (2020) in potato. Significant interaction effect for total yield per plant and plot among varieties, spacing and their interaction was also observed by Mangani *et al.*, (2015) . Higher yield in Kufri Pukhraj was also reported by Dash *et al.*,(2018).

**8. TSS (Total soluble solids)**

Data representing the effect of varieties and spacing on TSS (Table 3) revealed that $V_1$ (Kufri Pukhraj) resulted in maximum TSS (4.93$^0$B) which was significantly highest among all the varieties. Minimum TSS (3.53 $^0$B) was observed in $V_3$ (Kufri Badshah) which was at par with TSS of $V_4$ (Kufri Chandramukhi) (3.62 $^0$B). Among spacing, plants sown at a spacing of $S_3$ (50cm x 20cm) produced maximum TSS (4.26 $^0$B) which was significantly highest than all other spacing . Minimum TSS (3.71 $^0$B) was observed in plants sown at $S_2$ (60cm x 20cm) which was significantly lowest than all the spacing. Interaction effect of varieties and spacing on TSS was non significant .

Significant effect of spacing on TSS content was also observed by earlier researchers *viz*., Koodi *et al,*.(2017), Narayan *et al.*,(2017) in potato and Gohawar and Ughade., (2017) in beet root. Varieties also varied significantly for TSS content in research conducted by Abbasi *et al.*,(2019).

**9. Ascorbic Acid (mg/100g)**

Data representing the effect of varieties and spacing on ascorbic acid (Table 3) depicted that maximum ascorbic acid (21.11 mg /100g ) was observed in $V_1$ ( Kufri Pukhraj) which was significantly highest than all varieties. Minimum ascorbic acid (12.19mg/100g) was observed in $V_2$ ( Kufri Jyoti) which was statistically at par with $V_3$ ( Kufri Badshah) (12.88 mg / 100g). Among spacing, $S_2$ ( 60 cm x 20cm) resulted in maximum ascorbic acid content (16.70 mg / 100g) which was statistically at par with $S_1$ (70 cm x 20 cm) (15.59 mg /100g). Table 3.2 reveals that among interaction effects of varieties and spacing maximum ascorbic acid (25.24 mg / 100 g) was observed in $V_1$x $S_2$ (Kufri Pukhraj x 60cm x 20 cm) which was significantly higher than all the interaction effects except $V_1$x $S_1$ (Kufri Pukhraj x 70cm x 20 cm) which resulted in ascorbic acid content to the tune of (21.58 mg / 100g). Minimum ascorbic acid (10.33mg /100g) was observed in $V_2$ x $S_3$ (Kufri Jyoti x 50cm x 20cm) which was statistically at par with the ascorbic acid content of $V_2$x $S_2$ (Kufri Jyoti x 60cm x 20cm) (10.59), $V_4$x$S_1$ (Kufri Chandramukhi x 70cm x 20cm ) (12.40mg /100g) , $V_3$x$S_3$ (Kufri Badshah x 50 cm x 20 cm) (12.47 mg /100g) and $V_3$x$S_1$ (Kufri Badshah x 70cm x 20 cm) (12.70 mg / 100 g).

Ascorbic acid is one of the important antioxidant present in potato. It plays major role in preventing diseases related to aging. Effect of varieties, spacing and their interaction was significant for ascorbic acid content . It was reported to be high in wider plant spacing. Narayan *et al,*. (2017) and Koodi *et al.,* (2017) also observed higher ascorbic content at wider spacing on tomato and sweet potato, respectively. Varietal differences for ascorbic acid content was also observed by Valcarcel *et al,*.(2015) and Quequezana *et al.*, (2018) in potato. Significant differences among interaction of spacing and variety was also observed Narayan *et al*., (2017) in tomato.

**10. Dry matter content (%)**

Perusal of data (Table 3) revealed maximum dry matter content (17.10%) in $V_1$ (Kufri Pukhraj) which was statistically at par with the dry matter content observed in $V_4$ (Kufri Chandramukhi) (16.93%) and $V_2$ (Kufri Jyoti) (15.81%). Minimum dry matter content (14.26%) was observed in $V_3$ (Kufri Badshah) which was statistically at par with dry matter content observed in $V_2$ (Kufri Jyoti) ( 15.81%). Among spacing, maximum dry matter content (16.96%) was found in plants sown at a spacing of $S_1$ (70cm x 20cm) which was statistically at par with dry matter content observed in plants sown at $S_2$ (60cm x 20cm) (15.89%). Interaction effect of varieties and spacing on dry matter content was non significant .

Dry matter content is overriding factor governing the quality of potato. It determines the culinary quality of potato. A higher content is more desirable as it allows lesser oil uptake, desired texture and enhanced yield in finished products. A wider spacing resulted in higher dry matter content. The present findings are harmony with the finding of Getachew *et al*,.(2013) and Mangani *et al.*, (2015) in potato. Significant role of genetic makeup as depicted by the significant variation among different varieties for dry matter content was also advocated by Abebe *et al.*, (2012) and Tessema *et al* ., (2020) in potato

**11. Starch Content**

Starch content significantly varied with varieties and spacing. Data ( Table 3) showed maximum starch content ( 13.90%) in $V_1$ ( Kufri Pukhraj ) which was significantly highest than all other varieties. Minimum starch content (11.99 %) was observed in $V_4$ (Kufri Chandramukhi ) which was statistically at par with $V_2$ ( Kufri Jyoti ) (12.25) and $V_3$ ( Kufri Badshah) ( 12.12 %) . among spacings, $S_1$ (70cm x 20 cm ) resulted into maximum starch content (13.30%) which was significantly highest than all other spacing . Plants sown at $S_2$ (60cm x 20 cm ) spacing resulted in minimum starch content (12.11 %) which was statistically at par with the starch content (12.23 %) of the plants sown at $S_3$ ( 50 cm x 20cm).

Effect of interaction between varieties and spacing on starch content showed that $V_1$x $S_1$ (Kufri Pukhraj x 70cm x 20 cm) resulted in maximum starch content (15.92 %) which was significantly highest than other interaction effects. Minimum starch content (10.58 %) was observed in $V_4$x$S_1$ (Kufri Chandramukhi x 70cm x 20 cm) which was statistically at par with $V_3$x $S_2$ (Kufri Badshah x 60cm x 20cm ) ( 10.59%), $V_2$x $S_2$ (Kufri Jyoti x 60cm x 20cm) (11.54%), $V_3$x $S_3$ (Kufri Badshah x 50cm x 20cm) (12.47%) and $V_3$x$S_1$ (Kufri Badshah x 70cm x 20cm) (11.96%) (Table 3.2).

Wider spacing resulted in higher starch content which might be due to favorable conditions created by spacing by way of enhancing the availability of major nutrients. The present results are in close conformity with the finding of Koodi *et al.*, (2017) in Sweet potato and Dagne *et al*., (2018) in potato. Varietal differences for starch content was also observed by Abebe *et al.*, (2012) and Jatav *et al.*,( 2017) in potato . Interaction effect of varieties and spacing also indicates the influence of spacing . It was reported higher in wider spacing. The results are in line with the findings of Koodi *et al*,.(2017) and Dagne *et al.*,(2018) .

**CONCLUSION**

The discussion mentioned earlier about the effect of spacing on growth, yield and quality traits of potato boils down to one fact that spacing plays an important role in deciding the performance of cultivars in terms of growth, yield and quality traits. Among all the varieties studied Kufri Pukhraj performed best for growth, yield and quality traits. Spacing 70 cm x20cm favored growth, yield and yield and quality traits while, narrow spacing 50cm x 20cm has manifested the undesirable results. Thus it can be concluded that Kufri Pukhraj performed better when planted at 70cm

X 20cm in Jalandhar region. In order to arrive at field recommendation, the experiments on potato under the same treatments need to be conducted for more crop season.

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**Table 1: Analysis of variance for growth and yield parameters of potato**

| Observations | MSS<br>Factor A | MSS<br>Factor B | MSS<br>Factor A x B |
|---|---|---|---|
| Number of leaves per plant at 30 DAS | 36.92* | 5.02* | 3.35* |
| Number of leaves per plant at 60 DAS | 35.48* | 19.00* | 7.37 |
| Number of leaves per plant at 90 DAS | 34.55* | 20.36* | 8.22* |
| Average tuber weight (g) | 9602.83* | 1,429.45* | 5,752.24* |
| Plant height (cm) at 30 DAS | 8.15* | 4.14* | 15.76* |
| Plant height (cm) at 60 DAS | 171.00* | 151.08* | 80.31* |
| Plant height (cm) at 90 DAS | 9.88* | 8.44* | 20.29* |
| Number of tuber per plant | 259.45* | 9.46* | 13.14* |
| Marketable yield per plot (kg) | 103.41* | 24.15* | 18.16* |
| Unmarketable yield per plot (kg) | 0.82* | 0.43* | 0.24* |
| Tuber yield per plant (g) | 5719.75* | 5278.71* | 3532.43* |
| Tuber yield per plot (kg) | 1.85* | 1.71* | 1.15* |
| TSS | 3.75* | 0.91* | 0.19* |
| Ascorbic acid (mg/100g) | 147.47* | 23.002* | 28.12* |
| Starch Content (%) | 7.22* | 4.96* | 7.11* |
| Dry matter content (%) | 15.38* | 9.17* | 6.69* |

**Factor A = Varieties** **Factor B = Spacing**

**Table 2: Effect of varieties and spacing on growth parameters of Potato.**

| Treatment | Number of leaves per plant at 30 DAS | Number of leaves per plant at 60 DAS | Number of leaves per plant at 90 DAS | Plant height (cm) at 30 DAS | Plant height (cm) at 60 DAS | Plant height (cm) at 90 DAS |
|---|---|---|---|---|---|---|
| **Varieties** | | | | | | |
| **$V_1$** | 9.89 | 40.77 | 60.77 | 26.97 | 56.89 | 68.67 |
| **$V_2$** | 6.55 | 36.55 | 56.55 | 25.77 | 61.22 | 67.22 |
| **$V_3$** | 8.22 | 38.22 | 58.22 | 24.73 | 66.22 | 66.11 |
| **$V_4$** | 11.22 | 40.44 | 60.33 | 26.36 | 66.77 | 67.44 |
| **Median** | | | **57.39** | **0.99** | **5.49** | **67.33** |
| **Range** | **0.51** | **0.66** | **(56.55 – 60.77)** | **0.47** | **2.63** | **(66.11 - 68.67)** |
| **Plant spacing** | | | | | | |
| **$S_1$** | 9.50 | 40.17 | 60.17 | 26.56 | 66.16 | 68.25 |
| **$S_2$** | 8025 | 37.67 | 57.67 | 25.93 | 59.08 | 67.25 |
| **$S_3$** | 9.16 | 39.17 | **59.17** | 24.73 | 62.25 | 66.58 |
| **CD (5%)** | **0.94** | **1.20** | **1.25** | **0.85** | **4.76** | **1.28** |
| **SE (d)** | **0.44** | **0.57** | **0.59** | **0.41** | **2.28** | **0.62** |

**Table 2.1: Interaction effect of varieties and spacing on growth parameters of potato.**

| Varieties /Plant spacing | Number of leaves per plant at 30 DAS | | | Number of leaves per plant at 60 DAS | | | Number of leaves per plant at 90 DAS | | | Plant height (cm) at 30 DAS | | | Plant height (cm) at 60 DAS | | | Plant height (cm) at 90 DAS | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **$S_1$** | **$S_2$** | **$S_3$** | **$S_1$** | **$S_2$** | **$S_3$** | **$S_1$** | **$S_2$** | **$S_3$** | **$S_1$** | **$S_2$** | **$S_3$** | **$S_1$** | **$S_2$** | **$S_3$** | **$S_1$** | **$S_2$** | **$S_3$** |
| **$V_1$** | 9.67 | 10.00 | 10.00 | 42.33 | 40.00 | 40.00 | 62.33 | 60.00 | 60.00 | 28.10 | 27.09 | 25.71 | 64.33 | 53.33 | 53.00 | 71.33 | 68.00 | 66.67 |
| **$V_2$** | 7.67 | 6.00 | 6.00 | 37.67 | 36.00 | 36.00 | 57.67 | 56.00 | 56.00 | 27.26 | 23.84 | 26.21 | 67.33 | 50.66 | 65.66 | 68.33 | 65.66 | 67.67 |

| | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **$V_3$** | 8.00 | 8.00 | 8.66 | 38.00 | 38.00 | 38.67 | 58.00 | 58.00 | 58.67 | 26.42 | 26.48 | 23.30 | 68.33 | 66.00 | 64.33 | 68.00 | 68.00 | 66.11 |
| **$V_4$** | 12.67 | 9.00 | 12.00 | 42.67 | 36.67 | 42.00 | 62.67 | 56.67 | 62.00 | 24.45 | 28.90 | 23.20 | 64.66 | 66.33 | 66.00 | 65.33 | 67.33 | 69.66 |
| **CD (5%)** | | **1.85** | | | **2.40** | | | **2.48** | | | **1.71** | | | **9.52** | | | **2.56** | |
| **SE (d)** | | **0.88** | | | **1.15** | | | **1.47** | | | **0.83** | | | **4.56** | | | **1.22** | |

**Table 3: Effect of varieties and spacing on yield and quality parameters of potato.**

| **Treatments** | **Average tuber weight (g)** | **Number of tuber per plant** | **Marketable yield per plot (kg)** | **Unmarketable yield per plot (kg)** | **Tuber yield per plant (g)** | **Tuber yield per plot (kg)** | **TSS (°B)** | **Ascorbic acid (mg/100g)** | **Starch Content (%)** | **Dry matter content (%)** |
|---|---|---|---|---|---|---|---|---|---|---|
| **Varieties** | | | | | | | | | | |
| **$V_1$** | 107.71 | 30.10 | 13.86 | 0.16 | 161.00 | 2.90 | 4.94 | 21.11 | 13.90 | 17.10 |
| **$V_2$** | 67.35 | 25.12 | 9.85 | 1.45 | 110.60 | 1.99 | 3.87 | 12.19 | 12.26 | 15.81 |
| **$V_3$** | 67.14 | 21.57 | 6.47 | 1.24 | 105.00 | 1.89 | 3.53 | 12.87 | 12.11 | 14.26 |
| **$V_4$** | 27.70 | 17.45 | 13.15 | 0.89 | 123.00 | 2.22 | 3.62 | 15.48 | 11.99 | 16.93 |
| **CD (5%)** | **19.45** | **1.17** | **1.59** | **0.19** | **36.00** | **0.65** | **0.29** | **2.50** | **0.86** | **1.61** |
| **SE (d)** | **9.31** | **0.56** | **0.76** | **0.09** | **17.25** | **0.31** | **0.14** | **1.19** | **0.41** | **0.77** |
| **Plant spacing** | | | | | | | | | | |
| **$S_1$** | 79.00 | 24.47 | 9.92 | 0.89 | 148.05 | 2.06 | 3.99 | 15.58 | 13.30 | 16.96 |
| **$S_2$** | 66.14 | 23.52 | 12.14 | 1.33 | 107.10 | 1.93 | 3.71 | 16.69 | 12.11 | 15.89 |
| **$S_3$** | 57.29 | 22.69 | 13.04 | 1.26 | 119.70 | 0.25 | 4.26 | 13.94 | 12.22 | 15.22 |
| **CD (5%)** | **16.84** | **1.01** | **1.38** | **0.17** | **31.17** | **0.56** | **0.25** | **4.33** | **0.74** | **1.39** |
| **SE (d)** | **8.07** | **0.48** | **0.56** | **0.08** | **14.94** | **0.27** | **0.12** | **2.07** | **0.59** | **0.66** |

**Table 3.1: Interaction effect of varieties and spacing on yield parameters of potato.**

| Varieties/Plant spacing | Number of tuber per plant | | | Marketable yield per plot (kg) | | | Unmarketable yield per plot (kg) | | | Average tuber weight (g) | | | Tuber yield per plant (g) | | | Tuber yield per plot (kg) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $S_1$ | $S_2$ | $S_3$ | $S_1$ | $S_2$ | $S_3$ | $S_1$ | $S_2$ | $S_3$ | $S_1$ | $S_2$ | $S_3$ | $S_1$ | $S_2$ | $S_3$ | $S_1$ | $S_2$ | $S_3$ |
| $V_1$ | 29.40 | 31.53 | 29.37 | 14.47 | 13.21 | 13.91 | 0.61 | 0.62 | 1.18 | 159.35 | 137.54 | 26.25 | 197.40 | 67.20 | 123.20 | 3.55 | 1.21 | 1.89 |
| $V_2$ | 24.67 | 26.20 | 24.50 | 4.43 | 11.22 | 13.91 | 1.10 | 1.58 | 1.66 | 48.57 | 50.68 | 102.81 | 113.40 | 121.80 | 110.60 | 2.04 | 2.19 | 1.74 |
| $V_3$ | 19.60 | 19.30 | 25.80 | 6.28 | 5.40 | 7.22 | 1.24 | 1.03 | 1.46 | 79.18 | 53.15 | 59.12 | 126.00 | 92.40 | 105.00 | 2.27 | 1.66 | 1.73 |
| $V_4$ | 17.10 | 17.06 | 18.20 | 12.14 | 13.15 | 14.15 | 0.89 | 1.33 | 1.26 | 28.90 | 23.20 | 31.01 | 155.40 | 147.00 | 161.00 | 2.79 | 2.64 | 3.25 |
| CD (5%) | 2.03 | | | 2.76 | | | 0.34 | | | 33.68 | | | 62.35 | | | 1.12 | | |
| SE (d) | 0.97 | | | 1.32 | | | 1.16 | | | 16.14 | | | 29.87 | | | 0.53 | | |

**Table 3.2: Interaction effect of varieties and spacing on quality parameters of potato.**

| Varieties/Plant spacing | TSS | | | Ascorbic acid (mg/100g) | | | Dry matter content (%) | | | Starch Content (%) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $S_1$ | $S_2$ | $S_3$ | $S_1$ | $S_2$ | $S_3$ | $S_1$ | $S_2$ | $S_3$ | $S_1$ | $S_2$ | $S_3$ |
| $V_1$ | 4.90 | 4.41 | 5.48 | 21.58 | 25.24 | 16.50 | 18.64 | 18.36 | 14.29 | 15.92 | 13.82 | 11.96 |
| $V_2$ | 4.03 | 3.37 | 4.20 | 15.66 | 10.59 | 10.33 | 15.23 | 15.99 | 16.20 | 12.77 | 11.54 | 12.46 |
| $V_3$ | 3.50 | 3.43 | 3.66 | 12.17 | 13.48 | 12.47 | 15.17 | 13.75 | 13.32 | 13.93 | 10.55 | 11.87 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **$V_4$** | 4.76 | 3.63 | 3.70 | 12.41 | 17.47 | 16.47 | 18.24 | 15.47 | 15.22 | 10.58 | 12.53 | 12.86 |
| **CD (5%)** | **NS** | | | **4.33** | | | NS | | | | | |
| **SE (d)** | **0.24** | | | 2.07 | | | 1.33 | | | | | |