Effect of spacing, and size of seed-tubers on the growth and productivity of potato (*Solanum tuberosum)* cv Kufri chipsona-1

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Abstract

A field experiment was carried out during 2019-20 to 2020-21 on light-textured soil at R.B.S. College, Bichpuri Agra on potato, variety KUFRI Chipsona to ascertain the effects of three intra-row planting spacing, i.e. S_1-15cm ,S_2-20cm and S_3-25 cm (at fixed ridge spacing 45 cm)and tree size (weight)of potato seed tubers viz. P_1 - 20g, P_2-30gand P_3 -40g in factorial R.B.D with tree replication. The effect of spacing and size of seed tuber are important agronomic practices in the production of potato. However, potato farmers in India often use haphazard plant spacing and size of seed tubers, which contribute to the low yield of the crop. A study was designed to elucidate the effect of varied plant spacing and size of seed tubers on the yield and quality of potatoes. Average tuber weight was significantly affected by the combined effects of plant spacing and the size of seed tubers. The highest average shoot height (47.73 cm) was obtained from 45 × 15 cm plant spacing and 20g seed tuber sizes at treatment combination S_1P_1. The highest average tuber weight (59.36 g) was obtained from 45 × 25 cm plant spacing and 30g seed tuber sizes at treatment combination S_3P_2. Total tuber yield was significantly affected by plant spacing and seed tuber size where the maximum tubers yield (446.6 q ha^{-1}) were obtained at S_3P_3 (45 × 25 cm plant spacing and 40g seed tuber sizes) treatment combination. The highest percentage of A Grade tubers (38.7%) was obtained from 45 × 20 cm plant spacing and 30g seed tuber sizes at treatment combination S_2P_2., B grade tubers (49.48%) were obtained from 45 × 25 cm plant spacing and 15g seed tuber sizes at treatment combination S_3P_1 and C grade tubers (28.63%) was obtained from 45 × 15 cm plant spacing and 20g seed tuber sizes at treatment combination S_1P_2. The use of treatment combinations S_3P_3 and S_3P_1 are recommended for potato production over other seed tubers size and plant spacing combinations, which farmers can use to get maximum yield.

Keywords*: Seed-sized tubers planting Spacing, tuber yield. Potato, Grade, and Solanum tubrosum*

I. Introduction

The potato is the most important vegetable which is used surrounding the world. the potato is used as a vegetable and also making of chips and a variety of sweets it is primarily an energy food containing on an average about 74.7% water,1.6% protein 0.6 % ash, 22.6% starch, and a minor quantity of vitamin A B C and D (**15)** Potato) are 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 mostly **(1,2).** The country has about 2117000 hectares of available agricultural land suitable for potato production and production of 4341700 tons **[3]** A major production problem of potato that accounts for such low yields could be the unavailability and high cost of seed tubers, lack of well-adapted cultivars, inappropriate agronomic practices management, diseases, insect pests and proper storage **[4].** Optimizing plant density is one of the most important agronomic practices of potato production because it affects plant development, seed cost, yield, and quality of the crop [**5].**

Farmers who grow potatoes frequently give less regard to the optimum plant population. The possibility of securing a high yield depends on the proper consideration of the optimum number of plants per unit area **[16**]. Narrow spacing increased the hectare yield and decreased the yield per plant. According to Rajadrai [**7]** the highest yield was obtained with large-sized tubers planted in narrow spacing. However, the combination of large-size seed tubers and narrow spacing produced many small-size tubers of low market value.

In all areas of India, there is no separate plot and management for ware and seed potato production. Mostly, potato tubers are sorted into ware and seed immediately after harvest. For most potato producers seed potato is usually considered as the by-product of ware potato **[2].** Potato tubers are planted by marginal, small, and medium landholder farmers at narrow and erratic spacing, with very small tuber sizes resulting in a non-optimum plant population and seed tuber size that may result in low tuber yields and quality of tubers. Production of maximum no. of tubers should be the main component of potato production program .but Available seed production technology produce (**16)** the objective of this research study was to determine optimum tuber seed size and plantation distance for maximum yield production and tuber quality

II. Experimental treatments and design

The treatments consisted of here tuber seed sizes in gram(gm)P_1 P_2 & P_3 (20g, 30g & 40g) and three plantings spacing $S_{1,}S_2$& S_3 (45 × 15 cm, 45 × 20 cm,& 45 × 25 cm). . The experiment was laid out as a factorial randomized block design (FRBD) arrangement nine treatment combination, three replication, and twenty-seven total treatments

III. Experimental site

The study was conducted under irrigation during the year 2019-20 to 2020-21 cropping season in on season at R.B.S. College horticulture research farm, Bichpuri, Agra. The location of the experiment remained unaltered in both years. The research farm is situated about 1 km near Bichpuri railway station in Uttar Pradesh India. Bichpuri Agra is located latitude of 27.2° North and a longitude of 77.9° east with an altitude of 163.4 meters above means sea level. Agra has a semi-arid and subtropical climate with hot and dry summers and severely cold. The average annual maximum and minimum temperature is 36 C° and 4 C° respectively. The soil type in the area is light-textured sandy loam.

IV. Data collection and analysis

Data on growth and yield, yield components, and quality variables were collected and subjected to analysis of variance (ANOVA) using the General Linear Model of the SAS statistical package (SAS, 2007). All significant pairs of treatment means were compared using the critical difference (CD) at a 5% level of significance, coefficient of variation (C.V.), and standard error of the mean (SEM)

V. Results and Discussion

A. **Shoot height (cm):** showed highly significant CD at 5% (.68) on average Height (**Table 1)** Highest average shoot height (47.43 cm) was recorded in Treatment $S_1 P_1$ and lowest average shoot height (38.19) was recorded in Treatment S_3P_3.

B. **Average tuber weight (g)**: From the analysis of the variance, seed tuber sizes and plant spacing showed a highly significant difference (p<0.01) in average tuber weight (**Table 1**). The highest average tuber weight (59.36 g) was recorded for plants grown from 30 Gram seed tuber sizes and at 45 × 25 cm plant spacing treatment combinations this might be due to medium seed tuber sizes produced by an optimum number of stems and wider plant spacing had fewer resource competitions they get the high potential of resources whereas lowest average tuber weight (33.72 g) was obtained at 45 × 15 cm plant spacing and 30-gram seed tuber sizes treatment combinations. The present result agreed with the finding of Berga et al. **[1]** that average tuber weight decreased with an increase in mother tuber size. Similarly, Zabihi-Mahmoodabad et al. **[8]** reported that an increase in density probably causes the increase in competition between and within plants and hence, leads to a decrease in the availability of nutrients to each plant and consequently, results in a decline of mean tuber weight. The production of higher average tuber weight at wider plant spacing as compared to closer plant spacing was also reported by other authors **[5, 9,].**

C. **Total tuber yield**: Plant spacing and seed tuber size significantly affected total tuber yield, but the two factors interact with the parameter (**Table 1**). The results showed that the maximum total tuber yield (446.69 q ha^{-1}) was obtained at 40g tuber size and plant spacing of 45 × 25 cm whereas the lowest (301.72 q ha^{-1}) was obtained at 40-gram tuber size and 45 × 15 cm. Plants grown at plant spacing of 45 × 25 cm produced higher total tuber yield higher than plants spaced at 45 × 15cm and 45 × 20 cm by about 9.53 and 10.30%, respectively. In this study, plants spaced at 45 × 15 cm and 45 × 20 cm produced total tuber yields that exhibited statistically non-significant differences. The maximum yield was obtained at closer plant spacing than wider plant spacing except for plants spaced 45 × 15 cm. This might be attributed to the efficient use of available soil nutrients and other growth factors in plants grown at closer plant spacing than wider plant spacing. This result consistent with Beukema and Van der-Zaag [10] indicated that increased yield at higher densities might be due to the ground being covered with green leaves earlier (earlier in the season, light is intercepted and used for assimilation), fewer lateral branches are being formed and tuber growth starting earlier. In other words, increased plant population increased yield due to more tubers being harvested per unit area of land.

Based on the result the highest tuber yield (446.69 q ha^{-1}) was obtained from large seed tuber sizes (40g) whereas the lowest yield (301.72 q ha^{-1}) was obtained from small seed tuber sizes. The use of large seed tuber size as planting material to produce higher total tuber yield significantly exceeded. The results showed that total tuber yield increased when seed tuber sizes increased from small to large as planting materials. The significant difference in tuber yield might be due to large seed tuber size attributed to the high amount of food reserves that produce the highest tuber yields. This result agreed with the results reported by Rojoni et al. **[11]** that yield was increased with increasing seed tuber size. The highest gross tuber yield was recorded in large seed size while the lowest was in small seed size. Gulluogl and Arıoglu **[9]** also indicated that small seeds gave the lowest tuber yield per plant due to increasing competition in stem m2 density, whereas large tubers encountered the least competition and gave the highest tuber yield per plant at the same stem density

Treatment	shoot height (cm)	Weight per tuber (g)	Yield (q/ha)	Percentage of A Grade tubers (%)	Percentage of B Grade tubers (%)	Percentage of C Grade tubers (%)

Combination	Year 1	Year 2	Pooled	Year 1	Year 2	Pooled	Year 1	Year 2	Pooled	Year 1	Year 2	Pooled	Year 1	Year 2	Pooled	Year 1	Year 2	Pooled
$S_1 P_1$	47.13	47.73	**47.43**	52.03	52.22	52.125	382.44	382.92	382.68	32.64	32.49	32.565	44.69	44.75	44.72	22.6	22.75	22.675
$S_1 P_2$	47.06	46.93	46.995	51.5	51.69	51.595	304.55	304.63	304.59	24.69	24.71	**24.7**	46.63	46.72	46.675	28.67	28.59	**28.63**
$S_1 P_3$	40.88	41.26	41.07	42.08	42.34	42.21	301.8	301.64	**301.72**	28.28	28.16	28.22	47.62	47.65	47.635	24.09	24.18	24.135
$S_2 P_1$	44.6	44.6	44.6	33.63	33.81	**33.72**	378.58	378.27	378.425	29.45	30.15	29.8	44.63	44.47	44.55	25.58	25.54	25.56
$S_2 P_2$	44.53	43.55	44.04	44	44.31	44.155	362.66	362.99	362.825	38.76	38.64	**38.7**	35.77	35.83	**35.8**	25.45	25.5	25.475
$S_2 P_3$	45.21	43.91	44.56	34.57	35.45	35.01	350.44	350.49	350.465	34.46	34.39	34.425	45.3	45.33	45.315	20.19	20.25	20.22
$S_3 P_1$	40.98	40.6	40.79	45.74	46.33	46.035	418.52	419.59	419.055	31.63	31.63	31.63	49.49	49.48	**49.485**	18.87	18.88	18.875
$S_3 P_2$	43.74	42.75	43.245	59.1	59.63	**59.365**	420.64	420.3	420.47	35.09	35.12	35.105	47.19	47.27	47.23	17.7	17.82	**17.76**
$S_3 P_3$	38.96	37.43	**38.195**	43.82	44.4	44.11	446.56	446.82	**446.69**	32.51	32.68	32.595	42.39	42.24	42.315	25.09	25.1	25.095
C.V.	1.61	1	**1.305**	0.68	0.41	**0.545**	0.037	0.21	**0.1235**	0.92	0.86	**0.89**	0.49	0.54	**0.515**	0.88	0.99	**0.935**
S.Em+/-	0.4	0.25	**0.325**	0.17	0.1	**0.135**	0.081	0.46	**0.2705**	0.17	0.16	**0.165**	0.12	0.14	**0.13**	0.118	0.13	**0.124**
CD at 5%	1.21	0.74	**0.68**	0.53	0.32	**0.29**	0.24	1.39	**0.56**	0.5	0.48	**0.34**	0.38	0.42	**0.28**	0.35	0.4	**0.26**

Table: 1 Effect of spacing and size of seed tubers on the height of main shoot (cm), Weight per tuber (gram), Yield of tubers (q/ha), and Grade percentages (A grade, B grade & C grade)

Table 1: Average shoot height, tuber weight, and yield. Percentage and grade of tuber A, B & C as influenced by the interaction factors of plant spacing and size of seed-tuber. Means followed by the same letter(s) within a row and column are not significantly different at a 5% level of significance. CD= critical difference, CV= coefficient of variation.

D. **Percentage of A grade tuber (>3 cm diameter):** The main factors of plant spacing, and seed tuber size had a highly significant ($p<0.01$) affected on the Percentage of A grade tuber**.** However, the interaction factors of plant spacing and seed tuber size did not influence on yield of the Percentage of A-grade tuber **(**Table 1**).** The highest percentage of A grade tuber was recorded (38.7%) was obtained at wider plant spacing (45 × 20)and tuber size 30g whereas the lowest Percentage of A grade tu**ber** (24.7%) was obtained at closer plant spacing (45 × 15 cm) and tuber seed size 30. The results showed that when plant spacing increased closer plant spacing to wider plant spacing the yield of large tuber size was increased. This might be due to wider plant spacing having a slight competition between plants for nutrients and growth factors than closer plant spacing which leads to producing a high yield of large tuber sizes. This result agreed with the results reported by Khalafalla [13] that produce large-size tubers increased with the spacing increase but closer spacing produced more small-size tubers.

E. **Percentage of B grade tuber (2-3 cm diameter):** The analysis of variance showed that the main factors of seed tuber size and plant spacing had a highly significant ( ) influence on the yield of medium tuber size, but the two factors interact to the parameter **(Table 1**). Plants were grown at 45 × 25 cm plant spacing and seed tuber size 20g produced a significant maximum Percentage of B grade tuber (49.36%) whereas the lowest Percentage of B grade tuber (35.8%) plant spacing (45 × 20 cm) and tuber seed size (30g). At closer plant spacing had a high yield of medium tuber sizes than wider plant spacing. When plant density increased the yield of medium tuber sizes was increased. This result might be due to a higher number of plants per unit area produced at closer plant spacing than plants at a wider spacing which leads to produced high yield of medium tuber size. This result agreed with the finding of Tesfa **[12]** reported maximum yield of medium size tubers was recorded for closer spacing (50 × 25 cm) whereas the lowest yield of medium size tuber was observed with wider (80 × 30 cm) plant spacing.

The use of small seed tuber sizes (20 g) in potato production had a high potential of producing the highest Percentage of B grade tuber of medium tuber sizes whereas large seed tuber sizes produced the lowest Percentage of B grade tuber of medium tuber sizes(30g). . When increased seed tuber size used for planting material from small to large seed tuber sizes the yield of medium seed tuber size also increased. This result might be due to the presence of a high number of eyes on large seed tubers than on small seed tuber sizes consequently produced a high yield of medium tuber sizes. A related study was reported by Khalafalla **[13]** that tuber number m^2 increased with increasing seed tuber weight.

F. Percentage of C grade tuber (<2 cm diameter): The main factors of plant spacing, and seed tuber size had significant($p<0.01$) affected on the Percentage of C grade tuber of small tuber size. However, the interaction factors of seed tuber size and plant spacing did not influence the Percentage of C grade tuber **of** smal**l** tuber size. The highest percentage of C grade tuber (28.63%) of medium tuber sizes (30 g) was obtained at plant spacing (45 × 15 cm) whereas the lowest Percentage of c grade tuber **(17.**76%) S_3 P_2 seed tuber size This result might be due to the high number of plants produced per unit area at closer plant spacing that results from strong competition between plants for nutrients and growth factors and leads to the production of a high yield of small tuber size. This result agrees with the finding that reported the highest number of small tubers was obtained at closer plant spacing whereas the lowest number of small potato tubers was found at wider plant spacing **[14].**Effects of treatments on the number of tubers produced in different grades. The increased plant density reduced the availability of assimilates for individual tubers to grow and this resulted in an increased number and yield of tubers up to 40 g in size and a decrease in the number and yield of tubers weighing more than 40g. The results of the findings by Roy et al (17). wer~ recorded. The number of tubers weighing less than 40 g was considered as seed and above as large-sized tubers. The interaction between spacing, farmyard manure, and de-hauling time on different plant parameters in trial I was non-significant. Hence main effects of the treatments are reported (Table 1). The crop emergence (%) was higher when the tubers were planted at 50 em x ! 0 em than 50 COl xl 5 cm spacing, The differences in the emergence count might be attributed to the improved soil moisture maintained by closer ridging due to reduced exposure of soil surface to evaporation. Farmyard manure did not affect crop emergence. The plant height was not influenced by any treatment. However, stems/plants increased with closer intra-row spacing (10 cm) compared with 15 cm spacing. Farmyard manure tended to decrease stem number although the effect was non-significant. Delay in haulm cutting decreased the number of stems/plant. (30g) and planting spacing (45× 25).tube~s along with good health standards and optimum physiological maturity of seed. Therefore the investigation was undertaken to study the influence of different factors on the seed tuber yield (both in number and yield

VI. Conclusion and Suggestion

field experiment was carried out during 2019-20 to 2020-21 on light-textured soil at R.B.S. College, Bichpuri Agra on potato, variety KUFRI Chipsona to ascertain the effects of three Intra row planting spacing, i.e. S_1-15cm, S_2-20cm and S_3-25 cm (at fixed ridge spacing 45 cm)and tree size (weight)of potato seed tubers viz. P_1 - 20g, P_2-30gand P_3 -40g in factorial R.B.D with tree replication. The yield data of this experiment are suggestive of growing Kufri chipsona at 45×25 cm spacing by planting the seed tuber weight 20g each Making recommendations of both aspects of agro–practices, the experiment should be conducted at least once again

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