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Evaluation of Cut and Whole Seed Tubers under different Planting Geometry on Potato (*Solanum tuberosum* L.) Production

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ABSTRACT: A field experiment was conducted entitled "Evaluation of cut and whole seed tubers under different planting geometry on potato (*Solanum tuberosum* L.) production" at research farm, ICAR-CPRI-RS, Gwalior (M.P.) during the winter season of 2021-22. The experiment was planted under Randomized Block Design having 4 treatment combinations replicated five times. Size of seed tubers and planting geometry determine the quantum of seed for a unit area. Availability of 40-50g tubers for planting is problem as it constitutes 20-25% of total seed production. Under the circumstances, farmers have option either use higher seed rate or optimize seed rate by cutting seed tubers. The maximum plant emergence percent (90.50%), highest growth parameters *viz.*, plant height (80.52 cm), number of stem per plant (6.34) and number of compound leaves per plant (78.82), yield parameters *viz.*, total number of tuber (560.4 thousand ha^{-1}), total tuber yield (46.33 t ha^{-1}), fresh haulm yield (18.94 t ha^{-1}), dry haulm yield (2.31 t ha^{-1}), biological yield (65.27 t ha^{-1}) were recorded with treatment whole seed tuber (60 × 20 cm^2). However in contrast to above results, maximum harvest index (71.54%) found with cut seed tubers (planted at 60 × 10cm^2). Economic parameter *viz.*, Highest cost of cultivation (₹134400 ha^{-1}) was recorded in cut seed tubers (planted at 60 × 10 cm^2) but gross return (₹370640 ha^{-1}) was recorded in whole seed tuber (60 × 20 cm^2). Highest net return (₹255663ha^{-1}) was recorded in whole seed tuber (planted at 60 × 20 cm^2). Similarly, highest benefit cost ratio (2.2) was also recorded with whole seed tuber (planted at 60 × 20 cm^2). The results indicate clear advantages of planting whole seed tubers (60 × 20 cm^2) compared to cut seed tubers. Whole tubers performed best under 60 × 20 cm^2 but under compulsion of planting cut seed tubers, planting at 60 × 10 cm^2 spacing performed best among different intra row spacings.

Key words: Cut seed, Whole seed, Planting geometry and Potato.

INTRODUCTION

The current global production of potato is around 368.1 million tonnes and China being the biggest producer globally, India ranks 2nd in area and production of potato in the world after China contributing 13% of world potato production (FAO STAT, 2018). In India, it is grown on an area of 2.05 million hectares with the production of 48.66 million tonnes and productivity of 23670 kg/ha (Agricultural Statistics at a Glance, 2022). The productivity of potato in this region is low as compared to some states and national productivity due to multiple factors. Out of them improper nutrient management is one of the important factors (Singh and Kushwah 2006). A major production problem of potato that account for such low yields could be unavailability and high cost of seed tubers, lack of well adapted cultivars, inappropriate agronomic practices, diseases, insect pests and inadequate storage facilities. Optimizing plant density is one of the most important agronomic practices for potato production, because it affects seed cost, plant development, yield and quality of the crop (Bussan *et al.*, 2007). The possibility of securing high yield depends on proper consideration for optimum number of plants per unit area. Planting geometry and types of seed tubers are among the major factors affecting the production, cost of cultivation and productivity of potato. Size of seed tubers and planting geometry determine the quantum of seed for a unit area (Lung'aho *et al*., 2007). Availability of 40-50g tubers for planting is problem as it constitutes 20-25% of total seed production. Under the circumstance, farmers have option either use higher seed rate or optimize seed rate by cutting seed tubers. The ideal spacing and planting

density are those that maximize marketable yield without unduly increasing costs. In order to achieve this, seed size and planting geometry must be exploited as these two components determine the amount of seed required per hectare for optimum population.

MATERIALS AND METHODS

A field experiment was conducted entitled "Evaluation of cut and whole seed tubers under different planting geometry on potato (*Solanum tuberosum* L.) production." at the research farm, ICAR-CPRI-RS, Gwalior (M.P.) during the winter season of 2021-22 under the agro-climatic and soil conditions of Northern Madhya Pradesh. The experiment was laid out in Randomized Block Design (RBD) with four treatments. Treatments were replicated 5 times. All the treatments were randomized separately in each replication. The experimental site of research farm, ICAR-CPRI RS, Gwalior (M.P.) is situated at 26º 13′N latitude and 78º 14′E longitudes at an altitude of 197 m above sea level in Gird belt (MLS). It has a subtropical climate with hot and summer where maximum temperature exceeds 45ºC in May-June. The winters are cold and the minimum temperatures reach as low as 4ºC in December and January. Frost is expected from last week of December to first week of February. Usually monsoon arrives in the second fortnight of June and lasts till September. Soil pH 6.88, electrical conductivity 0.32 (dS/m), organic carbon (0.39 %) low, available nitrogen (197.7 kg N ha^{-1}) low, available phosphorus (22.42 kg ha^{-1}) high, available potash (381.7 kg ha^{-1}) medium are indicates of soil structures. The experiment was laid out in Randomized Block Design (RBD) with four treatments. Treatments were replicated 5 times. All the treatments were randomized separately in each replication. Potato was planted on 24th October. Healthy tubers with uniform size weighing 40 g in weight were selected for planting for whole tubers, and 80 and 120 g tubers were selected for cutting into 2 and 3 pieces, respectively before 3-4 days of planting. Planting was done after proper chitting and suberization of cut tubers. Pre-planting seed treatment was done with Mancozeb 0.2% solution for 10 minutes and spread at a cool and dry place to check fungal infection. Healthy, uniform seed tubers weighing 40 g were used for planting as whole /cut tubers. The tubers were kept in marked furrows at a spacing of 60 cm × 20 cm and covered with soil making ridges using spade. The planting was done in the morning to avoid heating of tubers. Recommended dose of fertilizers was 180 : 80 : 120 kg N, P_2O_5, K_2O/ha^{-1}, respectively. Nutrients *viz.*, nitrogen, phosphorous and potassium were provided through ammonium sulphate (AS) and Urea, single super phosphate (SSP) and muriate of potash (MOP), respectively. The full quantity of potassium and phosphorous were applied as basal dose at the time of planting, and split dose of nitrogen in the form of ammonium sulphate was provided during planting time and remaining half dose of N, through urea during earthing up. After planting of potato tubers, irrigation was given as per need of the crop. Over all, four irrigations were applied during entire crop season. Earthing up was done at 25 DAP to protect the tuber from sunlight and potato tuber moth. Weeding was done manually no poor requirement to check the growth of weeds. Imidacloprid @ 6 ml /15 liter water was used to check the aphid population and to prevent the infestation of viral diseases in potato after planting at 35 DAP. Mancozeb @ 2kg/ha was sprayed at 60 DAP to check the infestation of late blight in potato. Haulm uprooting was done at 90 DAP. After 10 days of haulm uprooting, tuber digging was done manually on hardening of tubers skin to avoid bruising from each treatment separately. Growth and yield observations were recorded at 30, 60 DAP and at harvest.

Harvested tubers were graded in to five grade (<25g, 25-50g, 50-75g, 75-125g,>125g), counted and weighed grade wise. For different treatments total cost was calculated on the basis of prevailing market rates of fertilizer, field preparation, planting of seeds, labourers charge, cultural and intercultural operations etc.

RESULTS AND DISCUSSION

In general, the weather conditions, which prevailed during *rabi* 2021-22 were favorable for growth and development of the potato crop. The topography of experimental field was uniform. Fertility status of experimental site was homogenous. Variation in the growth and yield of crop was mainly due to effect of the treatments tested. However, the results on all aspects given in the preceding are being discussed as under.

Effect on growth parameters

Plant emergence. The maximum plant emergence (90.50%) was recorded under treatment T_4 (whole seed tubers planted at 60 × 20 cm^2) whereas, the minimum plant emergence (79.80%) was recorded under T_1(cut seed tubers planted at 60 × 20 cm^2). It is evident from the data (Table 1) that the whole and cut seed tubers intra row spacing didn't have any significant impact on emergence of potato tubers. Welch (1917); Khalafalla (2001) have also reported similar findings of cut and whole seed tubers under intra row spacing. According to Pandey (2017) tuber emergence depend on the physiological stage and sprouts present on the tubers. Beukema and Van der-Zaag (1990) also reported similar findig increased plant population increased yield due to more tubers being harvested per unit area of land.

Plant height (cm). The maximum plant height (47.43 cm, 63.48 cm and 80.52 cm) was obtained with T_4 at all the stages of the crop growth which was significantly higher over other treatments except T_1.

The minimum plant height (36.85 cm, 54.68 cm and 57.00 cm) was obtained with T_3 at 30, 60 and 90 DAP (Table 1). It could be due to closer spacing but in other factors whole seed tubers attain maximum plant height due to more number of eyes, plant height increased progressively with increase in intra-row spacing depending on variety while leafiness was generally lower at the lowest plant spacing which showed a progressive increase in leafiness with increase in intra-row spacing. Huaiyong (2009); Islam *et al.* (2012); Hossain *et al.* (2012) have also reported similar findings of cut and whole seed tubers under different plant spacing. According to Zebenay (2015) the maximum plant height was observed in wider spacing and medium to big tuber size.

Number of stems per plant. The maximum stems per plant (5.88, 6.34 and 6.03) were recorded with treatment T_4 at 30, 60 and 90 DAP, respectively. Which was at par to T_1 at 30, 60 and 90 DAP, respectively. The minimum numbers of stems per plant (3.88, 4.27 and 4.23) were observed in treatment T_3 (cut seed tubers planted at 60 × 20 cm²) at 30, 60 and 90 DAP, respectively. It is evident from the data that higher stem number could be due to more number of eyes. Number of stems decreased significantly with the increase in plant to plant spacing from 60 cm × 10 cm to 60 cm × 15cm . Lowest number of stems was recorded at 60 cm × 20 cm in cut seed tubers. The results are in close conformity with Kumar and Lal (2006); Masarirambi *et al.* (2012); Kumar *et al.* (2015); Zebenay (2015).

Yield attributes and yield

Grade wise tuber number. The maximum number of 0-25 g tuber (143.2 thousand ha⁻¹) was found with whole seed tubers planted at 60 × 20 cm² which was significantly higher than T_3 but statistically same with T_1 and T_2 . Maximum number of 25-50 g tuber (119.6 thousand ha⁻¹) was recorded with treatment whole seed tubers planted at 60 × 20 cm² which was significantly higher than T_3 but statistically same with T_1 and T_2. Maximum number of 50-75 g tuber (98 thousand ha⁻¹) was found with treatment whole seed tubers planted at 60 × 20 cm² which was significantly higher than all other treatments except T_1. Maximum number of 75-125 g tuber (109.2 thousand ha⁻¹) was found with treatment whole seed tubers planted at 60 × 20 cm² which was significantly higher than all other treatments except T_1. Maximum number of > 125g tuber (119.80 thousand ha^{-1}) was recorded with treatment whole seed tubers at 60 × 20 cm² which was statistically same with all other treatments. Total number of tuber (all grade) was maximum with whole seed tubers planted at 60 × 20 cm² which was significantly higher than all other treatments except T_1. In this experiment we found that number of tuber increased with increasing intra-row spacing. Wiersema (1989) found a similar pattern in their field study. Number of tubers produced per plant was higher with higher intra-row spacing than small one. These findings are in agreement with the findings of Roy *et al.* (2015); Sanli *et al.* (2015).

Grade wise tuber yield. The maximum yield of 0-25g tubers was found (2.03 t ha^{-1}) with whole seed tubers planted at 60 × 20 cm² which was significantly higher than all other treatments. Maximum yield 25-50 g of tubers (6.00 t ha^{-1}) was recorded with whole seed tubers planted at 60 × 20 cm² which was significantly higher than all other treatments. Maximum yield 50-75 g of tubers (7.18 t ha^{-1}) was found with hole seed tubers planted at 60 × 20 cm² which was significantly higher than all other treatments. In 75-125 g size, the maximum yield of tubers was found with treatment Whole seed tubers planted at 60 × 20 cm² which was significantly higher than all other treatments except Cut seed tubers planted at 60 × 10 cm². In above 125 g size, the maximum yield of tubers was recorded with treatment Whole seed tubers planted at 60 × 20 cm² which was significantly higher than all other treatments. Total tuber yield (all grade) was maximum with treatment Whole seed tubers at 60 × 20 cm²) which was significantly higher than all other treatments except T_1. 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 had slight competition between plants for nutrients and growth factors than closer plant spacing which lead to produce high yield of large tuber sizes. This result agreed with the results reported by Khalafalla (2001) that produce large size tubers increased with spacing increase but closer spacing produced more small size tubers. These findings are in agreement with the findings of Masarirambi *et al.* (2012).

Total haulm yield (kg plot⁻¹ and t ha⁻¹). The maximum fresh haulm yield (27.27 Kg plot⁻¹ and 18.94 t ha⁻¹) were found in T_4 –(whole seed tubers at 60 × 20 cm²) which was statistically same under different treatments. The minimum fresh haulm yield (24.00 Kg plot⁻¹ and 16.67 t ha^{-1}) was recorded in T_3 –(cut seed tubers at 60 × 20 cm²). The maximum dry haulm yield (3.33 Kg plot^{-1} and 2.31 t ha^{-1}) were recorded in T_4 –(Whole seed tubers at 60 × 20 cm²) which was significantly higher than all other treatment except T_1 –(cut seed tubers at 60 × 10 cm²). The minimum dry haulm yield (2.24 Kg plot⁻¹ and 1.56 t ha⁻¹) was recorded in treatment T_3 –(cut seed tubers at 60 × 20cm²). These findings are in close harmony with the result of Hossain *et al.* (2012); Sadawarti *et al.* (2021)

Total tuber yield (t ha^{-1}). The maximum fresh tuber yield 46.33 t ha^{-1} was found in treatment T_4 –(whole seed tubers at 60 × 20 cm²) which was significantly higher than all other treatments. The minimum fresh tuber yield 39.75 t ha^{-1} was recorded in T_3 –(cut seed tubers at 60 × 20 cm²). The maximum dry tuber yield

9.0 t ha^{-1} was found in treatment T_4 –(whole seed tubers at 60 × 20 cm²) which was significantly higher than all other treatments. The minimum dry tuber yield 7.05 t ha^{-1} was recorded in treatment T_3 – (cut seed tubers at 60 × 20 cm²). These findings are in close harmony with the result of Mishra (2013).

Biological yield (t ha^{-1}) and Harvest index (%). The maximum biological yield 65.27 t ha^{-1} was found with treatment T_4 – (whole seed tubers at 60 × 20 cm²) which was at par with the treatment T_1 – (cut seed tubers at 60 × 10 cm²) but significantly superior over other treatments. The minimum biological yield 56.42 t ha^{-1} was recorded with T_3 – (cut seed tubers at 60 × 20 cm²). Harvest index (%) was statistically same under different treatments. The maximum harvest index 71.54 was found in T_1 – (cut seed tubers at 60 × 10cm²). The minimum harvest index 70.4 was recorded in T_2 – (cut seed tubers at 60 × 15cm²). It might be due to association between yield and above ground biomass was not linear as higher canopy growth, negatively affect the harvest index. These findings are in close harmony with the result of Zebenay *et al.* (2015).

Effect on economics of treatments. Data examination revealed that highest cost of cultivation ₹1,34,400 ha^{-1} was incurred with T_1. The lowest cost of cultivation ₹1,14,977 ha^{-1} was recorded in T_4. Scrutiny of data revealed that highest gross return ₹3,70,640 ha^{-1} was recorded in T_4. The lowest gross return was recorded ₹3,18,000 ha^{-1} in T_3. However, read – through the data revealed that highest net return ₹2,55,663 ha^{-1} was recorded in T_4 and lowest net return ₹2,01,400 ha^{-1} was recorded in T_3. Perusal of data revealed that highest benefit: cost (2.2) was recorded in T_4 and the lowest benefit: cost (1.6) was recorded in T_2. The similar findings were recorded by Kawakami *et al.* (2003); Hossain *et al.* (2012); Alam *et al.* (2016); Basu (1989) recommended varying planting space for different sizes of seed tubers to obtain optimum economic yield.

Fig. 1. Geometry in field with 4 treatment combinations replicated five times.

Table 1: Effect of cut and whole seed tubers under different planting geometry on growth attributes of potato.

Treatments Details	Emergence count (%)	Plant height (cm)			Stems/plant			Compound leaves/plant		
		At 30 DAP	At 60 DAP	At harvest	At 30 DAP	At 60 DAP	At harvest	At 30 DAP	At 60 DAP	At harvest
Cut seed tubers (60 × 10cm²)	79.80	43.76	62.96	76.18	5.56	5.64	5.61	44.00	57.40	73.80
Cut seed tubers (60 × 15cm²)	84.20	43.56	58.20	69.84	3.97	5.20	4.90	40.68	53.88	68.40
Cut seed tubers (60 × 20cm²)	87.98	36.85	54.68	57.00	3.88	4.27	4.23	38.36	44.64	57.00
Whole seed tubers (60 × 20cm²)	90.50	47.43	63.48	80.52	5.88	6.34	6.03	46.20	61.00	78.82
SEm ±	2.505	1.353	1.972	1.883	0.161	0.323	0.178	1.832	1.656	1.877
CD 5%	NS	4.006	5.836	5.574	0.477	0.955	0.528	5.423	4.903	5.556

Table 2: Effect of cut and whole seed tubers under different planting geometry on grade wise number of tubers.

Treatments	Number of tubers ('000/ha)						Yield of tuber (tha^{-1})					
	<25g	25-50g	50-75g	75-125g	>125g	Total	<25g	25-50g	50-75g	75-125g	>125g	Total
Cut seed tubers (60 × 10cm²)	137.6	113.4	84.4	98.8	109.20	549.6	1.83	4.72	6.54	10.87	20.52	45.77
Cut seed tubers (60 × 15cm²)	115.0	101.6	78.2	81.4	99.0	476.2	1.48	3.97	5.22	8.73	20.35	40.64
Cut seed tubers (60 × 20cm²)	85.6	72.4	65.8	75.8	96.4	419.5	1.03	2.81	4.63	7.09	20.05	39.75
Whole seed tubers (60 × 20cm²)	143.2	119.6	98.00	109.2	119.80	560.4	2.03	6.00	7.18	12.35	25.07	46.33
SE m ±	11.30	8.13	6.27	7.40	14.68	18.29	0.11	0.55	0.70	0.72	1.70	1.18
CD at 5%	33.46	24.06	18.57	21.91	NS	54.12	0.33	1.63	NS	2.14	NS	3.51

Table 3: Effect of cut and whole seed tubers under different planting geometry on growth, yield attributes and yields and harvest index.

Treatments	Fresh haulm yield (kg plot^{-1})	Dry haulm yield (kg plot^{-1})	Fresh haulm yield (t ha^{-1})	Dry haulm yield (tha^{-1})	Total Fresh tuber yield (tha^{-1})	Total Dry tuber yield (tha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
Cut seed tubers (60×10cm²)	26.18	2.95	18.18	2.05	45.77	8.14	63.95	71.54
Cut seed tubers (60×15cm²)	24.82	2.34	17.24	1.62	40.64	8.09	57.87	70.40
Cut seed tubers (60×20cm²)	24.00	2.24	16.67	1.56	39.75	7.05	56.42	70.61
Whole seed tubers (60×20cm²)	27.27	3.33	18.94	2.31	46.33	9.00	65.27	70.95
SEm ±	**1.554**	**0.168**	**1.079**	**0.117**	**1.185**	**0.275**	**1.916**	**1.190**
CD at 5%	**NS**	**0.499**	**NS**	**0.346**	**3.506**	**0.813**	**5.672**	**NS**

Table 4: Effect of cut and whole seed tubers under different planting geometry on economics of experiment

Treatments	Cost of cultivation (`ha^{-1})	Gross income (` ha^{-1})	Net income (`ha^{-1})	B:C
Cut seed tubers (60×10cm²)	134400	366160	231760	1.7
Cut seed tubers (60×15cm²)	122800	325120	202320	1.6
Cut seed tubers (60×20cm²)	116600	318000	201400	1.7
Whole seed tubers (60×20cm²)	114977	370640	255663	2.2

CONCLUSIONS

On the basis of one year experiment on silty clay loam soil of Madhya Pradesh, it is concluded that the whole seed tubers are significantly superior as compared to cut seed pieces in growth parameters *viz*., plant emergence, plant height, number of shoots per plant, number of compound leaves per plant, and yield attributes *viz.*, fresh and dry haulm weight per plant, dry matter production and grade wise yield of tuber. Hence, planting of whole seed tubers is recommended. Under the situation of non-availability of whole seed tubers, planting of cut seed pieces is recommended at 60 × 10 cm² spacing.

FUTURE SCOPE

Further investigation possibilities for the research on potato cultivation in Madhya Pradesh include comparative studies under different soil type and agro-climatic condition. In order to confirm the validity of results the experiment must be repeated over 2-3 years and location with more accuracy. The different planting geometry treatments may also be tested for growth, yield and quality of potato.

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Conflicts of Interest. None.

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