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Studies on the effect of spacing and method of planting on tuber quality of potato (*Solanum tuberosum* L.) cv. Kufri Chandramukhi for maximum tuber production under Southern Telangana agro-climatic conditions

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Abstract
The present investigation entitled "Studies on the effect of spacing and method of planting on tuber quality of potato (*Solanum tuberosum* L.) Cv. Kufri Chandramukhi for maximum tuber production under Southern Telangana agro- climatic conditions" was carried out during *Rabi* season of 2021-22 at SKLTSHU, College of Horticulture, Rajendranagar, and Hyderabad. The experiment was laid out in Factorial Randomized Block Design (FRBD) with two factors, eight treatment combinations which were replicated thrice. Two factors are two planting methods Raised bed (M_1) and Ridge and furrow (M_2) and four different spacings are 50 cm × 20 cm (S_1), 50 cm × 30 cm (S_2), 60 cm × 20 cm (S_3) and 60 cm × 30 cm (S_4). The results revealed that the quality parameters like maximum starch content (21.52%), ascorbic acid (15.11 mg 100 g^{-1}), were significantly recorded when potato was grown on Raised bed with a spacing of 60 cm × 30 cm and the interaction effect on total sugars (%), reducing sugars (%), total soluble solids (ºBrix) was found to be non-significant.

Keywords: Potato, planting method, spacing, Kufri Chandramukhi

Introduction
Potato (*Solanum tuberosum* L.) is an annual, herbaceous plant in the nightshade family (Solanaceae) and is native to the Peruvian-Bolivian Andes. It was introduced in India in 17th century by Portugese in South India and its cultivation spread to North India by Britishers (Nath *et al*., 2008) [8]. Common cultivated potato varieties include tetraploid (2n =4x=48) with a basic chromosome number of (X=12) (Hawkes, 1990) [3]. India is the second largest producer of potato in the world after China and the crop occupies 2.2 Mha of area and 53.6 MMT of production in 2020-2021 as per (NHB Database, 2020-2021) [9]. In Telangana state potato is cultivated in 1200 hectares with a production around 37,700 tonnes in districts of Medak, Rangareddy and Khammam districts. Majority of the potato cultivation (70-80%) in Medak district is under drip irrigation system, a progressive system of cultivation which is yet to be followed by many of the major potato growing states. Being a short duration crop, it produces more quantity of dry matter, edible energy and edible protein in lesser duration of time compared to cereals like rice and wheat. Potato contains substantial quantity of energy, edible protein-2.8 g, starch-16.3 g, total sugar-0.6 g, crude fibre-0.5 g, carbohydrate-22.6 g and vitamin-C 25 mg per 100 g fresh weight of tubers (Bhuwneshwari *et al*., 2013) [2]. Potato also contains considerable quantities of niacin, thiamine, pyridoxine and its derivatives (Yadav *et al*., 2015) [16]. Antinutritional factor, Solanine is a glycoalkaloid found in all parts of the plant gets accumulated at high concentration in the tuber when exposed to sun light. Many factors influence potato yield and quality and among these are cultivar, plant population, soil type, weather conditions, water management, fertilization, tuber size, pests and diseases. Plant spacing and time of harvesting are among the factors which could affect the yield as well as the size of tubers in potato. Planting density strongly affects yield and more tubers and yield per square meter are expected at higher planting densities (Karafyllidis *et al*., 1996) [5]. Practicing best planting method can increase crop yield and reduce production costs. The conventional planting method commonly practiced for raising crops in India is raised bed method, ridge and flatbed planting methods have been more efficient in relation to water and nutrient use in other field crops.

Raised beds improved soil drainage, allowing soil to dry and provide better soil conditions for vegetable crops that need well-drained soils. (Rair *et al.*, 2011) [11].

Materials and Methods

The experiment was carried out at College of Horticulture, Rajendranagar, Hyderabad, and Telangana during Rabi season of 2021-22. The experimental site is situated at the altitude of the 542.3 m above the mean sea level on 17º 32' North latitude and 78º 40' East longitude. The experiment was laid out in factorial randomized block design (FRBD) with three replications and eight treatments. The meteorological data were collected from ARI, Rajendranagar. The minimum and maximum temperatures recorded were 20 °C and 31.7 °C respectively. The average relative humidity ranges from 41 to 95%.

Details of experimental treatments

Factor 1, Planting methods M_1-Raised bed, M_2- Ridge and furrow, Factor 2, different spacings S_1-50 cm×20 cm, S_2-50 cm×30 cm, S_3-60 cm×20 cm and S_4-60 cm×30 cm. The experiment was conducted in Factorial Randomized Block Design with three replication and two factors, Factor 1- M (method of planting) and Factor 2- S (spacings). There were 2 planting methods of M (method of planting) and 4 levels of S (spacings) were being tried as given in treatment details. The observations were recorded on quality characters (starch content (%), ascorbic acid (mg 100 g^{-1}), total sugars (%), reducing sugars (%) and total soluble solids (^{0}Brix).

Results and Discussion Quality Parameters

Starch content (%)

The data pertaining to starch content at fiteen days after harvest as influenced by the planting method and different spacings are presented in the table 1.

The maximum starch content (18.39%) was significantly recorded when potato was grown on raised bed (M_1) method of planting than on ridge and furrow (M_2) planting method (15.34%). Among different spacings, the maximum starch content (19.30%) was significantly recorded when potato is spaced at wider spacing S_4 (60 cm × 30 cm) and minimum starch content (14.60%) was recorded in closer spacing S_1 (50 cm × 20 cm). The interaction effect of planting method and different spacings was found significant for starch content. The maximum starch content (21.52%) was recorded in treatment combination M_1S_4 (Raised bed, 60 cm × 30 cm) and the minimum starch content (13.82%) was recorded in M_2S_1 (Ridge and furrow, 50 cm × 20 cm). Improved soil conditions in terms of better aeration and nutrition, particularly during tuber growth and bulking, provided by the raised bed planting method, which may adequately supply more photosynthates for tuber development. The present findings were in accordance with those of Rair *et al.* (2011) [11]. Maximum starch content was recorded in wider spacing due to efficient utilization of radient energy, good aeration, moisture holding capacity, micronutrient delivery. The present results are in close conformity with the findings of Koodi *et al.* (2022) [7] in sweet potato.

Ascorbic acid (mg 100 g^{-1})

The data pertaining to ascorbic acid at fifteen days after harvest as influenced by the planting method and different spacing are presented in the table 1.

The ascorbic acid content (13.76 mg 100 g^{-1}) was significantly higher when potato was grown on raised bed (M_1) method of planting than on ridge and furrow (M_2) planting method (13.12 mg 100 g^{-1}). Among different spacings, the maximum ascorbic acid content (14.72 mg 100 g^{-1}) was significantly recorded when potato is spaced at wider spacing S_4 (60 cm × 30 cm) and minimum ascorbic acid (12.06 mg 100g^{-1}) was recorded in closer spacing S_1 (50 cm × 20 cm). The interaction effect of planting method and different spacings was found significant for starch content. The maximum ascorbic acid (15.11mg 100g^{-1}) was recorded in treatment combination M_1S_4 (Raised bed, 60 cm × 30 cm) and the minimum ascorbic acid (11.26 mg 100g^{-1}) was recorded in M_2S_1 (Ridge and furrow, 50 cm × 20 cm). The higher bulk density prevailed in raised bed method enabled the soil to store more water per unit volume of soil, and nourished its tubers directly and also through nutrient solution thereby increase the ascorbic acid content. The present findings were in accordance with those of Rair *et al.* (2011). Maximum starch content was recorded in wider spacing due to efficient utilization of radient energy, good aeration, moisture holding capacity, micronutrient delivery. The present results are in close conformity with the findings of Koodi *et al.* (2022) [7] in sweet potato, Kishor *et al.* (2017) [6] in onion, Thirupal *et al.* (2014) [14] and Roni *et al.* (2017) [12] in broccoli.

Table 1: Effect of planting method and different spacing on statch content and ascorbic acid of potato. Cv. Kufri Chandramukhi**.**

Method of planting (m)	Starch (%)									Ascorbic acid (mg 100 g^{-1})
	Spacing (s)									
	S1	S2	S3	S4	Mean	S1	S2	S3	S4	mean
M1	15.38	17.54	19.12	21.52	18.39^a	12.87	13.01	14.08	15.11	13.76^a
M2	13.82	15.58	14.87	17.09	15.34^b	11.26	12.98	13.92	14.34	13.12^b
Mean	14.60^d	16.56b^c	16.99^b	19.30^a		12.06^d	12.99^c	14.00^b	14.72^a	
Factors	S.E. m±		CD at 5%					S.E. m±		CD at 5%
M	0.13		0.39					0.13		0.41
S	0.18		0.56					0.19		0.58
MXS	0.26		0.79					0.27		0.82
M_1= Raised bed, M_2= Ridge and furrow			S_1= 50 cm × 20 cm, S_2 = 50 cm × 30 cm, S_3 = 60 cm × 20 cm S_4=60 cm × 30 cm							

Total sugars (%)

The data pertaining to total sugars (%) at fifteen days after harvest as influenced by the planting method and different spacing are presented in the table 2.

The maximum total sugars (0.57%) was significantly recorded when potato was grown on raised bed (M_1) method of planting than on ridge and furrow (M_2) planting method (0.54%). Among different spacings, maximum total sugars

(0.61) was significantly recorded in wider spacing S_4 (60 cm × 30 cm) and minimum total sugars (0.51%) was recorded in closer spacing S_1 (50 cm × 20 cm). The interaction effect of planting method and different spacings was found non-significant for total sugars. Increased total sugars due to uniform distribution of soil moisture, nutrients availability and efficient use of solar energy under raised bed planting as compared to ridge and furrow. The present results are in close conformity with the findings of Rair *et al.* (2011) [11], Preetham *et al.* (2018) [10] in turmeric. The maximum total sugars in tuber was obtained from wider spacing and it must be due to maximum utilization of space, water, aeration and sunlight. The similar results are reported by Sharvati *et al.* (2018) [13] in sweet potato, Tripathi *et al.* (2017) [15] in radish, Kishor *et al.* (2017) [6] in onion, Kadam *et al.* (2018) [4] in beetroot.

Reducing sugars (%)

The data pertaining to reducing sugars (%) at fifteen days after harvest as influenced by the planting method and different spacing are presented in the table 2.

The reducing sugar (0.40%) was significantly higher when potato was grown on raised bed (M_1) method of planting than on ridge and furrow (M_2) planting method (0.38%). Among different spacings, maximum reducing sugars (0.42%) was significantly observed when potato is spaced at wider spacing S_4 (60 cm × 30 cm) and minimum reducing sugars (0.36%) was recorded in closer spacing S_1 (50 cm × 20 cm). The interaction effect of planting method and different spacings was found to be non-significant for reducing sugars. Increased reducing sugars due to uniform distribution of soil moisture, nutrients availability and efficient use of solar energy under raised bed planting as compared to ridge and furrow. The present results are in close conformity with the findings of Rair *et al.* (2011) [11], Preetham *et al.* (2018) [10] in turmeric. The maximum reducing sugars in tuber was obtained from wider spacing and it must be due to maximum utilization of space, water and sunlight. The similar results are reported by Sharvati *et al.* (2018) [13] in sweet potato, Kishor *et al.* (2017) [6] in onion, Kadam *et al.* (2018) [4] in beetroot.

Total soluble solids (%)

The data pertaining to total soluble solids (%) at fifteen days after harvest as influenced by the planting method and different spacings are presented in the table 2.

The total soluble solids (3.88 ^oB) was significantly higher when potato was grown on raised bed (M_1) method of planting than on ridge and furrow (M_2) planting method (3.66 ^0B). Among different spacings, maximum total soluble solids (4.23%) was significantly observed when potato is spaced at wider spacing S_4 (60 cm × 30 cm) and minimum total soluble solids (3.35%) was recorded in closer spacing S_1 (50 cm × 20 cm). The interaction effect of planting method and different spacings was found non-significant for total soluble solids. Increased TSS due to uniform distribution of soil moisture, nutrients availability and efficient use of solar energy under raised bed planting as compared to ridge and furrow. The present results are in close conformity with the findings of Rair *et al.* (2011) [11], Preetham *et al.* (2018) [10] in turmeric. The wider spacing resulted in larger potato tubers which gets its soluble solids diluted due to higher volume and more water content. The results are in conformity with the findings of Sharvati *et al.* (2018) [13] in sweet potato, Anjali *et al.* (2017) [1] and Kadam *et al.* (2018) [4] in beetroot.

Table 2: Effect of planting method and different spacing on total sugars, reducing sugars and total soluble solids of potato cv. Kufri Chandramukhi

Method of planting (m)	Total sugars (%)					Reducing sugars (%)					TSS (^{0}Brix)				
	Spacing (s)														
	S1	S2	S3	S4	Mean	S1	S2	S3	S4	mean	S1	S2	S3	S4	mean
M1	0.53	0.55	0.59	0.63	0.57^a	0.38	0.39	0.42	0.44	0.40^a	3.42	3.54	4.19	4.37	3.88^a
M2	0.49	0.52	0.57	0.59	0.54^b	0.35	0.37	0.39	0.41	0.38^b	3.29	3.36	3.92	4.09	3.66^b
Mean	0.51^d	0.53^c	0.58^b	0.61^a		0.36^d	0.38^c	0.40^b	0.42^a		3.35^d	3.45^c	4.05^b	4.23^a	
Factors	S.E. m±			CD at 5%		S.E. m±		CD at 5%			S.E. m±			CD at 5%	
M	0.004			0.013		0.002		0.007			0.02			0.07	
S	0.006			0.019		0.003		0.011			0.03			0.11	
MXS	0.009			NS		0.005		NS			0.05			NS	
M_1= Raised bed, M_2= Ridge and furrow						S_1= 50 cm × 20 cm, S_2 = 50 cm × 30 cm, S_3 = 60 cm × 20 cm, S_4=60 cm × 30 cm										

Conclusion

Based on the results, it can be concluded that the treatment combination of M_1N_4 (Raised bed, 60 cm × 30 cm) was significantly recorded maximum starch content (%) and ascorbic acid (mg 100 g^{-1}). Therefore for good tuber quality, potato can be grown on raised beds at 60 cm × 30 cm under southern Telangana Agroclimatic conditions.

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