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Studies on the effect of different spacing and fertilizer levels on yield and quality of radish (*Raphanus sativus* L.) cv. Pusa Chetki

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Abstract
The present investigation entitled "Studies on the effect of different spacing and fertilizer levels on yield and quality of radish (*Raphanus sativus* L.) cv. Pusa Chetki" was carried out during *rabi* season of 2021-22 at SKLTSHU, College of Horticulture, Rajendranagar, Hyderabad. The experiment was laid out in Factorial Randomized Block Design (FRBD) with nine treatments replicated thrice. Treatment consisted of the different levels of spacing (3 levels) are S_1 - 45 cm x 10 cm, S_2 - 45 cm x 15 cm, S_3 - 45 cm x 20 cm and fertilizer (3 levels) F_1 - 60% RDF, F_2 - 80% RDF, F_3- 100% RDF. The results revealed that the spacing S_3 - 45 cm x 20 and F_3- 100% RDF recorded significantly high fresh weight of roots, root length, root diameter, Vit-c, minimum root cracking and root forking percentage. While the highest yield was recorded in spacing level S_1 - 45 cm x 10 cm.

Keywords: Radish, spacing and fertilizer levels

Introduction
Radish (*Raphanus sativus* L.) is an important root vegetable crop belongs to the family Brassicaceae. It is grown for its young tender fusiform root and is a popular root vegetable in both temperate and tropical regions. The edible roots of this crop can be eaten as raw salad or cooked. It is a good source of Ca, P, K and vitamin C. Radish roots are considered as an appetizer and are also useful in recovering from piles, urinary complaints and in gastrodynia. In homeopathy, it is used for sleeplessness and chronic diarrhea (Kumar *et al.*, 2014) [10].

Radish is a nutritious vegetable providing a good source of Vitamin-C content in roots and shoots are 15 and 40 mg 100 g^{-1} of edible portion, respectively (Gopalan and Balasubramanium, 1966) [6]. The tracer mineral elements found in radish include aluminum, titanium, barium, lithium, silicon, fluorine and iodine.

Radish is one of the highest value nutritive root crop containing per 100 g edible portion as 94.4 g moisture, 3.4 g carbohydrate, 0.1 g fat, 0.8 g fiber, 0.6 g mineral and 0.7 g protein. It consists of glucose as the major sugar and smaller quantities of fructose and sucrose. The characteristic pungent flavor of radish is due to the presence of volatile isothiocyanate (trans-4-methyl thiobutenyl isothioyanate). Accumulation of isothiocyanate yielding components is altered by nutrients. With increasing sulphur level thiocynate increases linearly. (Bible and Chong, 1975) [3].

In India major radish growing states are Haryana, Punjab, Bihar, West Bengal, Assam, and Madhya Pradesh. Nationally radish is grown in an area of 2.05 lakh hectares with an annual production of 31.07 lakh MT (Anonymous, 2019) [1].

The growing of radish plants has been affected most severely due to lack of N and subsequently by P as well as K. Growth and yield of radish have been found to increase significantly in response to the application. According to the phosphorus deficient radish plants were shorter in height, leaves were distorted in shape and pink tinge appeared along the margins and veins. In potassium-deficient plants the color of leaves changed from green to pale yellow and brown scorches appeared on the leaves at later stages. Violet streaks appeared on roots which ultimately spread all over. While overall affected yield and quantity of radish the TSS content of radish significantly increased with increasing level of nitrogen (Desuki *et al.*, 2005) [5]. Thus, it is essential to find out adequate nutrient requirements of nitrogen, phosphorus and potash along with organic manure in radish crop.

Optimum spacing avoids shading effect on plants and intraspace competition. Higher yield per

unit area can be obtained by from proper plant geometry. It is due to the fact that proper plant geometry minimizes competition for nutrition, light, radiation, water *etc.* The optimum use of spacing or plant population has dual advantages. It also avoids strong competition between plants for growth factor such as water, nutrient and light. Conversely, optimum plant population enables efficient use of available crop land without wastage. Spacing and planting density recommendations for crops in general have sought to meet specific needs of cultural practices and improve productivity. However, changes in these recommendations induce a series of changes in the plant growth and development requiring adaptations to meet local peculiarities.

Materials and Methods

The experiment was carried out at College of Horticulture, Rajendranagar, Hyderabad, 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 nine treatments. The meteorological data were collected from ARI, Rajendranagar. The minimum and maximum temperatures recorded were 20 ^{0}C and 31.7 ^{0}C respectively. The average relative humidity ranges from 41 to 95%.

Details of experimental treatments

Factor 1: S_1 - 45 cm x 10 cm, S_2 - 45 cm x 15 cm, S_3 - 45 cm x 20 cm and factor 2: fertilizer (3 levels) F_1 - 60% RDF, F_2 - 80% RDF, F_3- 100% RDF. The experiment was conducted in Factorial Randomized Block Design with three replication and two factors, Factor 1spacing levels and Factor 2 fertilizer levels. The observations were recorded on yield and quality characters fresh weight of roots (g), root length (cm), root diameter (cm), yield per plot, yield per hectare, vit-c mg 100 g^{-1}, root cracking and root forking percentage.

Results and Discussion

Yield Parameters

Fresh weight of root (g plant^{-1})

The data on fresh weight of root, root length, root diameter and yield as influenced by various spacing level, fertilizer level and their interaction treatments presented in table 1

Among all the treatments S_3 level (45 cm x 20 cm) recorded significantly maximum value (161.01 g). Among the fertilizer level F_3 (100% RDF) was recorded significantly maximum value (156.81 g). Among all the treatment combinations, S_3F_3 (45 cm x 20 cm, 100% RDF) recorded significantly maximum fresh weight of root (163.65 g). The highest fresh weight of root was registered in S_3 (45 cm x 20 cm) which was due to the fact that wider spacing provides increase in girth of root ultimately resulting in more fresh weight of root. These results are in accordance with the findings of and Brintha and Seran (2009) [4] in radish and Thirupal *et al*. (2014) [15] in broccoli. Maximum fresh weight of root was recorded in F_3 (100% RDF) which was due to the food material with high dose of fertilizers which later on translocated and accumulated in root resulting in higher weight of root. Similar results were also reported by Jilani *et al*. (2010) [9] in radish.

Root length (cm)

There was significant difference observed among the spacing level treatments with respect to root length. Among them S_3 (45 cm x 20 cm) recorded significantly maximum value (30.42 cm), while it was significantly minimum in spacing level S_1 (45 cm x 10 cm) (22.00 cm). Significantly maximum root length (27.27 cm) was recorded in fertilizer level F_3 (100% RDF) and it was significantly minimum in the fertilizer level F_1 (60% RDF) (25.09 cm). The interaction effect of different spacing and fertilizer levels was found to be significant on root length. The highest root length (31.00 cm) was recorded in treatment combination S_3F_3 (45 cm x 20 cm, 100% RDF). The lowest root length (20.40 cm) was recorded in S_1F_1 (45 cm x 10 cm, 60% RDF). Higher root length was registered in S_3 (45 cm x 20 cm) which was due to the lesser competition for moisture, light and nutrients. The results were in accordance with Shiberu and Tamiru (2016) [14] in carrot. The maximum root length was recorded with F_3 (100% RDF) might be due to the fact that fertilizers are starting material for the biological synthesis of other types of compounds in the plants such as certain amino acid, fatty acids etc. Thus, the increased availability of photosynthesis finally results into large quantity of stored compounds. Such a situation is ultimately reflected in the increased root lenth. Such findings are in agreement with the results of Raut *et al*. (2006) [12] in tomato.

Root diameter (cm)

Root diameter was found to be statistically significant due to different spacing level treatments. Among them spacing level S_3 (45 cm x 20 cm) recorded significantly more value (3.75 cm), whereas spacing level S_1 (45 cm x 10 cm) registered significantly less value (2.65 cm). Significant difference was observed among the different fertilizer levels on root diameter. The fertilizer level of F_3 (100% RDF) recorded significantly maximum root diameter (3.39 cm), while the minimum root diameter (3.15 cm) was significantly recorded in the fertilizer level F_1 (60% RDF). Root diameter was found to be significantly highest (3.98 cm) in treatment combination S_3F_3 (45 cm x 20 cm, 100% RDF), while it was minimum in (2.59 cm) S_1F_1 (45 cm x 10 cm, 60% RDF) (2.59 cm). Maximum root diameter was observed in S_3 (45 cm x 20 cm) which was due to wider spacing encourages more absorption of nutrients resulted in higher girth of root. These results are in accordance with the findings of Thirupal *et al*. (2014) [15] in broccoli. The highest root diameter was recorded in F_3 (100% RDF) due to the same reason as mentioned in root length parameter. The reason might be due to the same treatment was registered the best values with respect to vegetative parameters. Such findings are in agreement with the results of Basavaraju *et al*. (2003) [2], Jilani *et al*. (2010) [9] in radish and Gupta *et al*. (2010) [7] in knol khol.

Root yield (kg plot^{-1})

Root yield per plot was found to be statistically significant due to different spacing levels. Among the treatments, spacing level S_1 (45 cm x 10 cm) recorded significantly more root yield (8.58 kg plot^{-1}), whereas spacing level S_3 (45 cm x 20 cm) registered significantly less value (6.72 kg plot^{-1}). The maximum root yield per plot (8.10 kg plot^{-1}) was significantly recorded in the fertilizer level F_3 (100% RDF), whereas fertilizer level F_1 (60% RDF) recorded significantly minimum root yield (7.15 kg plot^{-1}). The interaction effect of spacing and fertilizer levels had significant influence on yield of radish. Significantly highest yield (9.42 kg plot^{-1}) was

observed in treatment combination S_1F_3 (45 cm x 10 cm, 100% RDF) while the lowest yield (6.42 kg plot^{-1}) was obtained from S_3F_1 (45 cm x 20 cm, 60% RDF).

Root yield (t ha^{-1})

All treatments had significant influence on root yield per hectare. Among all the treatments, spacing level S_1 (45 cm x 10 cm) recorded significantly higher value (21.44 t ha^{-1}), whereas S_3 (45 cm x 20 cm) recorded minimum value (16.78 t ha^{-1}). The maximum root yield (20.23 t ha^{-1}) was recorded significantly in the fertilizer level F_3 (100% RDF), whereas significantly minimum root yield (17.86 t ha^{-1}) was recorded in the fertilizer level F_1 (60% RDF). The interaction effect of spacing and fertilizer levels had significant influence on yield of radish. Significantly highest yield (23.52 t ha^{-1}) was observed in treatment combination S_1F_3 (45 cm x 10 cm, 100% RDF) while the lowest yield (16.02 t ha^{-1}) was obtained from S_3F_1 (45 cm x 20 cm, 60% RDF). Among the spacing levels, the closer spacing S_1 (45 cm x 10 cm) was resulted in maximum yield over other spacings. This might be due to the fact that the same treatment registered the highest yield per plot over other treatments. These findings are in line with the other reports of Jan *et al*. (2003) [8] and Jilani *et al*. (2010)) [9] in onion. Maximum root yield (t ha^{-1}) was recorded in F_3 (100% RDF) was due to the same treatment registered the higher root yield per hectare as compared to others. Similar results were reported by Verma and Nawange (2015) [16] in cabbage and Satari *et al*. (2020) [13] in radish.

Table 1: Effect of different spacing and fertilizer levels on yield characters of radish

Treatment no.	Treatment	Fresh weight of root (g)	Root length (cm)	Root diameter (cm)	Root yield (kg plot^{-1})	Root yield (t ha^{-1})
Factor S: Spacing levels						
1	**S_1**	144.93	22.00	2.65	8.58	21.44
2	**S_2**	152.20	26.23	3.40	7.48	18.69
3	**S_3**	161.01	30.42	3.75	6.72	16.78
S.Em±		1.53	0.24	0.03	0.06	0.15
CD at 5%		4.58	0.71	0.08	0.19	0.46
Factor F: Fertilizer levels						
1	F_1	147.89	25.09	3.15	7.15	17.86
2	F_2	153.43	26.30	3.25	7.53	18.81
3	F_3	156.81	27.27	3.39	8.10	20.23
S.Em±		1.53	0.24	0.03	0.06	0.15
CD at 5%		4.58	0.71	0.08	0.19	0.46
Interaction effect (SXF)						
S.Em±		2.65	0.41	0.04	0.11	0.27
CD at 5%		7.94	1.24	0.13	0.33	0.80

Quality parameters

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

The data related to ascorbic acid content, root cracking and root forking as influenced by spacing levels, fertilizer levels and their interaction is presented in the table 2.

Spacing levels showed significant effect on this parameter. Significantly maximum ascorbic acid content (17.64 mg 100 g^{-1}) was recorded in spacing S_3 level (45 cm x 20 cm), whereas lowest value was recorded in S_1 (45 cm x 10 cm) (15.67 mg 100 g^{-1}). Significantly maximum value (16.91mg 100 g^{-1}) was registered in the fertilizer level F_3 (100% RDF), while it was minimum in (15.86 mg 100 g^{-1}) fertilizer level F_1 (60% RDF). The highest ascorbic acid content (17.83 mg 100 g^{-1}) was observed in treatment combination S_3F_3 (45 cm x 20 cm, 100% RDF), while the lowest ascorbic acid content (15.27 mg 100 g^{-1}) was recorded from S_1F_1 (45 cm x 10 cm, 60% RDF). The highest ascorbic acid content was recorded in F_3 (100% RDF) might be due to better availability of nutrients in addition to nitrogen and phosphorus fertilizers which in turn improved the fresh bio mass production of root through increased nutrients uptake by the plant. The present findings are in line with the Gupta *et al.* (2010) [7] in knol khol.

Percentage of root cracking

The results indicated that there was significant difference observed among the spacing level treatments. Significantly minimum value (4.87%) was recorded in spacing level S_3 (45 cm x 20 cm), and it was maximum (7.15%) in spacing level S_1 (45 cm x 10 cm). Significant variation was observed among the treatments when fertilizers applied at different doses. Among the fertilizer levels, F_3 level (100% RDF) was recorded significantly minimum value (5.40%) and it was maximum (6.35%) in F_1 level (60% RDF). The treatment combination S_3F_3 (45 cm x 20 cm, 100% RDF) recorded significantly lower root cracking (4.52%), while it was higher (7.83%) in treatment combination S_1F_1 (45 cm x 10 cm, 60% RDF). The lowest percentage of root cracking was observed in S_3 (45 cm x 20 cm) which was due to the wider spacing provided lesser competition for soil moisture, light and nutrients. The results were in accordance with Shiberu and Tamiru (2016) [14] in carrot and Lavanya *et al.* (2017) [11] in radish.

Percentage of root forking

Significant difference was observed among the treatments on this parameter. Minimum percentage of root forking (1.28%) was recorded significantly in spacing level S_3 (45 cm x 20 cm) and it was significantly maximum (3.77%) in spacing level S_1 (45 cm x 10 cm). Significant variation was observed among the fertilizer levels at different doses. Among them, F_3 level (100% RDF) recorded significantly minimum value (1.99%), while it was maximum (3.03%) in F_1 level (60% RDF). The treatment combination S_3F_3 (45 cm x 20 cm, 100% RDF) recorded significantly minimum percentage of root forking (0.97%). Maximum value (4.60%) was reported significantly in treatment combination S_1F_1 (45 cm x 10 cm, 60% RDF). The lower percentage of root forking was recorded in S_3 (45 cm x 20 cm) spacing level which was due to the same reason as mentioned in percentage of root cracking parameter. The results were in accordance with Shiberu and Tamiru (2016) [14] in carrot and Lavanya *et al.* (2017) [11] in radish.

Table 2: Effect of different spacing and fertilizer levels on quality characters of radish

Treatment no.	Treatment	Ascorbic acid content (mg 100^{-1})	Root cracking (%)	Root forking (%)
Factor S: Spacing levels				
1	S_1	15.67	7.15	3.77
2	S_2	16.62	5.66	2.46
3	S_3	17.64	4.87	1.28
S.Em±		0.16	0.04	0.02
CD at 5%		0.48	0.13	0.08
Factor F: Fertilizer levels				
1	F_1	16.30	6.35	3.03
2	F_2	16.72	5.94	2.49
3	F_3	16.91	5.40	1.99
S.Em±		0.16	0.04	0.02
CD at 5%		0.48	0.13	0.08
Interaction effect (S x F)				
S.Em±		0.28	0.07	0.05
CD at 5%		0.83	0.23	0.15

Conclusion

Among the different levels of spacing, the level S_3 (45 cm x 20 cm) was observed superior for root characters, while S_1 (45 cm x 10 cm) was found superior in yield characters. Among the different levels of fertilizers, the level F_3 (100% RDF) was observed superior for growth and yield characters. Based on the results it can be concluded that spacing S_1 (45 cm x 10 cm) with F_3 (100% RDF) produced higher root yield per hectare.

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