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Influence of plant density and nutrient management on growth, yield and quality of radish (*Raphanus sativus* L.) cv. 'PUSA CHETKI'

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ABSTRACT : An experiment on influence of plant density and nutrient management on growth, yield and quality of radish (*Raphanus sativus* L.) cv. 'Pusa Chetki' was carried out at B. A. College of Agriculture, Anand in the year 2010-11. The results revealed that wider spacing (30 x 15 cm) recorded significantly higher number of leaves (13.96), fresh weight of leaves (113.7 g), leaf area (203.99 cm2), length of root (19.2 cm), volume of root (105.4 cm^3), diameter of root (4.0 cm), fresh weight of root per plant (134.3 g), moisture content (97.2 %) and dry weight of root (3.1 g) at 60 DAS. Though the closer spacing secured the highest leaf area index (0.55, 0.73 and 0.79, respectively at 30, 45 and 60 DAS), number of plants per square meter (49.00 and 35.61, respectively at 15 days and at the time of last picking), leaf : root ratio (0.87) and fresh root yield (29.0 t/ha). Higher fertilizer application (50 : 50 : 50 kg N:P:K + 5 t FYM +1.25 t vermicompost + 0.5 t castorcake/ha) significantly improved all the growth, yield and quality parameters as compared to the control. The interactions between spacings and fertilizers were found significant in respect to growth and yield attributes of radish, while it was found non significant in quality parameters. The maximum leaf area (238.8 cm^2) was recorded in the treatment combination of S_3F_5, while maximum leaf area index (2.73) was observed in treatment combination of $S_1 F_5$ at 60 DAS. With respect to yield attributes, the highest volume of root (125.3 cm^3) and fresh weight of root (160.1 g) were noticed under treatment combination $S_3 F_5$. Likewise, treatment combination of S_2F_5 recorded the highest leaf : root ratio (1.1). However, maximum yield (38.58 t/ha) was recorded in closer spacing with more source of fertilizer (S_1F_5).

KEY WORDS : Radish, Spacing, Fertilizers, growth, Yield, Quality

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Among the root vegetables, radish (*Raphanus stivus* L.) is a popular Brassicaceae vegetable. It can be cultivated extensively in almost all seasons of the year. Pusa chetki is a cultivated variety, suitable on account of its versatile adaptability and also suitable to tropical conditions. Among the various factors influencing yield, inadequate nutrition and plant spacing are the most important. Application of nitrogen, phosphorus and potash along with organic manures such as FYM, vermicompost, and castorcake significantly increased the leaf area, number of leaves, length and diameter of root as well as root yield. (Srinivas and Naik.,1990; Velmurugan *et al.*,2005).

The growing of radish plants has been affected most severely due to lack of N and subsequently by P as well as K (De Frietas, 1960). Growth and yield of radish have been found to increase significantly in response to the application of nitrogen (Pervez *et al.*, 2004; Jilani *et al.*, 2010). According to Roy Choudhury *et al*. (1982) phosphorus deficient radish plants were shorter in height, leaves were distorted in shape and pink tinge appeared along the margins and veins. Color of the leaves of potassium-deficient plants 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. The TSS content

of radish significantly increased with increasing level of nitrogen (Desuki *et al*.,2005). Adoption of suitable spacing is also increased the yield and good growth of root (Chatterjee and Som, 1991). Thus, it is essential to find out adequate nutrient requirements of nitrogen, phosphorus and potash along with organic manure and method of sowing to get optimum production of radish.

RESEARCH METHODS

A field experiment was conducted at Horticulture Research cum Demonstration Farm, Anand Agricultural University, during the winter season of the year 2010-11.

The treatment details are as follows.

Spacing:

S_1: Broadcasting
S_2: 20cm x 15cm
S_3: 30cm x 15cm

Fertilizers:

F_1: 100 : 50 : 100 kg N:P:K /ha
F_2: 75 : 50 : 100 kg N:P:K + 10 t FYM /ha
F_3: 50 :50 :50 kg N:P:K + 10 t FYM/ha (control)
F_4: 50:50:100 kg N:P:K+5 t FYM + 2.5 t vermicompost /ha
F_5: 50:50:50 kg N:P:K+5 t FYM +1.25 t vermicompost + 0.5 t castorcake/ha
F_6: 10 t FYM+2.5t vermicompost+0.5 t castorcake/ha.

Total eighteen treatment combinations were tried in Randomized Block Design (Factorial), comprising three levels of spacing in combination with six different levels of fertilizer along with control (recommended dose) with three replication in a plot size of 2.4 x 3.0 m for each treatment. The observations on growth, yield and quality parameters were recorded.

The application of FYM, vermicompost, castorcake, P_2O_5 in the form of single super phosphate and K_2O in the form of murate of potash were given as basal dose. While, 50% nitrogen in the form of urea was given as basal dose and remaining 50% at 20 days after sowing.

The observation on growth parameters were recorded at 30, 45 and 60 days after sowing (DAS). While, yield and its attributes as well as quality parameters were taken at harvest.

RESEARCH FINDINGS AND DISCUSSION

The results obtained from the present investigation as well as relevant discussion have been summarised under following heads:

Influence of plant density on growth characters:

The number of leaves was significantly increased with increase in spacing. The maximum number of leaves (8.77, 11.78 and 13.96 at 35, 45 and 60 DAS, respectively), fresh weight of leaves per plant (113.69 g), and leaf area (153.21, 190.59 and 203.99 sq.cm at 35, 45 and 60 DAS, respectively), were significantly higher in S_3 over S_1 and S_2 (Table 1). This might be due to wider spacing helped the individual plant to utilize more water, nutrient, light and air. In closer spacing, the plant population per unit area was higher, which led to keen competition among the plants, resulting in poor growth. These results are in agreement with the results of Joshi (1987) and Sounda *et al*. (1989) in radish. However, maximum leaf area index (0.55, 0.73 and 0.79 at 35, 45 and 60 DAS, respectively) and number of plants per square meter (49.0 and 35.6) at 15 DAS and at the time of last picking in broadcasting treatment as compared to S_2 and S_3. This might be due to the spacing between the plants is too less and thereby, it accommodated more number of plants than wider spacing S_2 and S_3.

Influence of plant density on yield characters:

The maximum length of root (19.2 cm), volume of root (105.4 cm3), maximum diameter of root (4.0 cm) and fresh weight of root (134.3 g) were recorded under wider spacing S_3 (30 x 15 cm). Which were significantly higher over closer spacing S_1 and S_2, respectively except root diameter in S_2 (Table 2). This could be due to the more land area available per plant. Widely spaced plant had less competition for nutrient uptake, water, light and air, which helped the plant to get more nutrient, water, light and air resulted in increasing yield parameters. This finding is in conformity with the result of Pervez *et al.* (2004). However, the maximum leaf: root ratio (0.87) was recorded under the closest spacing S_1 (broadcasting). It was higher than wider spacings S_2 and S_3, respectively. Similarly, the yield (t/ha) was significantly influenced by various spacing as shown in Table 2. The closer spacing S_1 (broadcasting) resulted in maximum yield (28.98 t/ha), which was higher than S_2 and S_3 spacings. While, the lowest yield of radish (22.45 t/ha) was obtained under wider spacing S_3. The final yield per unit area of land is the function of mainly two attributes *viz.*, the number of plants per unit area and the performance of an individual plant with respect to growth and yield characters. However, the better performance shown under wider spacing S_3 failed to compensate loss in yield due to less plant population. Therefore, plant population seems to be a major factor for determining the yield of radish. These findings are in accordance with the results reported by Singh and Saimbhi (1984) in carrot.

Influence of plant density on quality characters:

The TSS (%) was not significantly changed due to spacings. However, the highest T.S.S (5.39 %) was observed in the closest spacing S_1 (broadcasting), over S_2 and S_3. The maximum moisture content (97.16 %) was registered in the

Table 1 : Effect of spacing and fertilizers on number of leaves/plant, leaf area, leaf area index, fresh weight of leaves/plant and plant stand/m² in radish cv. PUSA CHETKI

Treatments	Number of leaves/plant			Leaf area (cm^2)			Leaf area index			Fresh weight of leaves/plant (g)	Plant stand/m^2	
	30 DAS	45 DAS	60 DAS	30 DAS	45 DAS	60 DAS	30 DAS	45 DAS	60 DAS	At the time of harvest	At 15 DAS	At the time of last picking
Spacing (S)												
S_1 - Broadcasting	7.92	10.43	12.96	138.77	164.89	178.23	0.55	0.73	0.79	93.00	49.00	35.61
S_2 - 20 x 15 (cm)	8.34	11.17	13.42	146.55	179.78	192.73	0.49	0.60	0.64	102.31	35.28	31.89
S_3 - 30 x 15 (cm)	8.77	11.78	13.96	153.21	190.59	203.99	0.40	0.42	0.45	113.69	21.78	18.67
S.E. ±	0.15	0.27	0.24	3.67	4.27	1.68	0.01	0.01	0.01	3.58	0.36	0.63
C.D. (P=0.05)	0.43	0.78	0.67	10.55	12.13	4.78	0.03	0.03	0.01	10.29	1.03	1.80
Fertilizers (F)												
F_1- 100 : 50 : 100 kg N:P:K/ha	7.99	10.73	13.19	141.23	151.99	172.05	0.46	0.50	0.56	90.14	35.67	27.78
F_2 - 75 : 50 : 100 kg N:P:K + 10 t FYM/ha	8.44	11.20	13.76	147.53	187.60	195.45	0.48	0.62	0.64	111.29	35.33	28.56
F_3- 50 :50 : 50 kg N:P:K + 10 t FYM/ha (control)	7.92	10.30	11.77	135.54	141.75	165.19	0.44	0.47	0.54	84.87	34.56	27.11
F_4 - 50 : 50 : 100 kg N:P:K + 5 t FYM + 2.5 t Vermicompost/ha	8.57	11.76	13.82	151.80	202.92	204.20	0.49	0.65	0.68	106.20	35.11	29.56
F_5 - 50 : 50 : 50 kg N:P:K + 5 t FYM +1.25 t Vermi compost + 0.5 t Castorcake/ha	8.80	11.87	14.56	158.15	214.89	220.73	0.55	0.71	0.72	118.56	35.78	31.00
F_6 - 10 t FYM + 2.5 t Vermicompost + 0.5 t Castorcake/ha	8.33	10.91	13.58	142.80	171.37	192.26	0.45	0.56	0.63	106.96	35.67	28.33
S.E. ±	0.21	0.39	0.33	5.19	6.03	2.38	0.02	0.02	0.01	5.06	0.51	0.89
C.D. (P=0.05)	NS	NS	0.94	NS	17.15	6.76	0.04	0.05	0.02	14.55	NS	NS
Interaction (S x F)												
S.E. ±	0.37	0.67	0.58	8.99	10.45	4.12	0.03	0.03	0.01	8.77	0.88	1.53
C.D. (P=0.05)	NS	NS	NS	NS	NS	Sig	NS	NS	Sig	NS	NS	NS
C.V. %	7.66	10.39	7.44	10.65	10.15	3.72	9.69	8.23	3.37	14.75	4.29	9.25

DAS = Days after sowing NS=Non-significant

widest spacing S_3 as compared to closer spacings S_1 and S_2. In case of dry weight of root, it was maximum (3.11 g) under wider spacing S_3 (30 x 15 cm), which was higher over S_1 and S_2 spacings. Among the different treatments, S_2 was found to be at par with S_3 for moisture (%) and dry weight of root.

Influence of fertilizers on growth characters:

The growth characters were significantly influenced by the different combination of the fertilizers (Table 1).

In the present investigation, it was observed significant increase in source of organic fertilizers with chemical fertilizers, corresponding increased the number of leaves per plant (14.56) at 60 DAS with F_5 treatment (50 : 50 : 50 kg N:P:K+5 t FYM +1.25 t vermicompost+0.5 t castorcake/ ha). The increase in number of leaves may be due to the vital macro and micronutrient availability in cattle manure along with vermicompost. The increase in number of leaves also helps to increase the leaf area (220.73 cm^2) and thereby leaf area index (0.72) at 60 DAS. Moreover, fertilizer not only slowly releases the nutrients from itself but also prevents losses of chemical fertilizers through denitrification, volatilization and leaching by binding the nutrients and releasing with the passage of time. The above findings are in consonance with the results of Cortez jaun *et al.* (2010) and Maurya and Muthoo (1986).

The plant stand was not significantly affected due to the different levels of fertilizers in combination with organic and inorganic at 15 DAS and at the time of last picking. However, the maximum number of plants per square meter (35.78 and 31.0) were recorded in treatment F_5 at 15 DAS and at the time of last picking, respectively.

Influence of fertilizers on yield characters:

The maximum length of root (20.00 cm) was observed under the treatment F_5. It was significantly higher over rest of the treatments as well as control except treatment F_4 (19.20 cm) The increase in length of root might be due to increase in nutrient use efficiency by the organic fertilizer along with chemical fertilizer. The organic fertilizers also improve the soil structure and soil quality which might have resulted in increase in length of root. This finding is in accordance with the results of Asghar *et al*. (2006); Velmurugan *et al.* (2005) and Ahmed *et al.* (2005). Similarly maximum volume of root (108.91 cm^3) and diameter of root (4.12 cm) were recorded by F_5 treatment except the treatment F_4 (101.87 cm^3). This could be due to decrease in bulk density as well as increase in porosity and water holding capacity of the soil.The results are in agreement with findings of Hailu *et al.* (2008).

As a result of maximum diameter and volume of root. The treatment combination of organic and inorganic fertilizers recorded the higher value for fresh weight of root (146.60 g) in comparison to other treatments and control. This might be due to more availability of nitrogen, released from organic and inorganic fertilizers. The nitrogen also synthesized in to amino acids, which built complex proteins and helps in promoting the luxurious growth of crop.

The maximum leaf : root ratio (1.03) was recorded under the treatment F_5, which was significantly higher than rest of the treatments except treatment F_4. The supply of nitrogen through the chemical and organic fertilizers, the proportion of carbohydrate used in upper portion increases while proportion of translocation to the root decreases. On the other hand, the increasing leaf : root ratio could be due to the auxin effect. The concentration of auxin released by organic fertilizers, might have influenced on plants. The concentration of auxin is much lower for roots than for tops, so that between these two critical values, an increasing concentration of auxin tends to inhibit root growth and promotes top growth. The findings are in accordance with the results obtained by Joshi and Patil (1992); Chatterjee and Som (1991) and Asghar *et al.* (2006).

The yield was significantly influenced by various fertilizers (Table 2). The highest yield of radish (33.74 t/ha) was obtained in the treatment F_5. It was significantly higher as compared to control and other fertilizer treatments except treatment F_4 (31.50 t/ha). The increase in yield might be due to sustained availability of nitrogen throughout the growing phase and also due to enhanced carbohydrate synthesis and effective translocation of this photosynthates to sink. *i.e.* tuber. The proportion and activity of beneficial microbes would have been at the higher rate during fermentation and thus helping in synthesis of growth substances, which might have resulted in better yield. This finding is in accordance with the results obtained by Velmurugan *et al.* (2005).

Influence of fertilizers on quality characters:

The T.S.S content of root significantly affected by different fertilizer combinations (Table 2).The total soluble solid of root increased as the source of organic fertilizers increased in combination with inorganic fertilizers. The treatment F_5 recorded the highest T.S.S (5.82 %), which was significantly the highest over other treatments and remained at par with the treatment F_4. The reason of higher T.S.S could be that the organic fertilizers carry almost all micro and macronutrients required for the plants growth. Similarly the maximum moisture content (97.16 %) was recorded in the treatment F_5 as compared to other treatments. Among the different fertilizer treatments, all the treatments were remained at par with F_5 except the treatment F_3. Likewise, maximum dry weight of root (4.0 g) was also obtained under treatment F_5, which was significantly superior over rest of the fertilizer treatments and control. The higher dry weight of root might be due to the higher fresh weight of root obtained. This results are in line with the findings of Desuki (2005) in radish.

Table 2 : Effect of spacing and fertilizers on yield and quality attributes in radish cv. PUSA CHETKI

Treatments	Length of root (cm)	Volume of root (cm^3)	Diameter of root (cm)	Fresh weight of root/ plant (g)	Leaf : root ratio	Fresh root yield (t/ha)	T.S.S (%)	Moisture (%)	Dry weight of root (g)
Spacing (S)									
S_1 - Broadcasting	15.40	79.19	3.13	117.32	0.87	28.98	5.39	94.86	2.55
S_2 - 20 x 15 (cm)	17.22	98.73	3.73	127.88	0.84	26.48	5.28	95.72	2.88
S_3 - 30 x 15 (cm)	19.22	105.38	4.00	134.27	0.78	22.45	5.19	97.16	3.11
S.E. ±	0.39	2.44	0.12	1.93	0.017	0.65	0.09	0.51	0.09
C. D. (P=0.05)	1.10	6.94	0.34	5.49	0.049	1.87	NS	1.45	0.24
Fertilizers (F)									
F_1- 100 : 50 : 100 kg N:P:K/ha	15.60	90.07	3.25	114.76	0.72	20.80	4.92	95.19	2.32
F_2 - 75 : 50 : 100 kg N:P:K + 10 t FYM/ha	17.00	93.00	3.63	124.78	0.84	25.91	5.41	96.06	2.68
F_3- 50 :50 : 50 kg N:P:K + 10 t FYM/ha (control)	15.42	81.24	3.15	112.64	0.67	19.41	4.84	94.02	2.13
F_4 - 50 : 50 : 100 kg N:P:K + 5 t FYM + 2.5 t Vermicompost/ha	19.20	101.87	4.03	137.89	0.96	31.50	5.60	97.04	3.40
F_5 - 50 : 50 : 50 kg N:P:K + 5 t FYM +1.25 t Vermi compost + 0.5 t Castorcake/ha	20.00	108.91	4.12	146.60	1.03	33.74	5.82	97.16	4.00
F_6 - 10 t FYM + 2.5 t Vermicompost + 0.5 t Castorcake/ha	16.45	91.51	3.52	122.27	0.78	24.43	5.12	96.01	2.53
S.E. ±	0.55	3.45	0.17	2.73	0.024	0.92	0.12	0.71	0.12
C. D. (P=0.05)	1.57	9.92	0.47	7.76	0.069	2.64	0.34	2.05	0.34
Interaction (S x F)									
S.E. ±	0.95	5.98	0.29	4.73	0.042	1.59	0.21	1.24	0.21
C. D. (P=0.05)	NS	Sig	NS	Sig	Sig	Sig	NS	NS	NS
C.V. %	9.57	10.97	13.84	6.48	8.74	10.62	6.82	2.23	12.70

NS=Non-significant

Conclusion:

From the above findings, it can be concluded that sowing of radish seed cv. "Pusa Chetki" with broadcasting method and fertilized with 50 : 50 : 50 kg N : P: K + 5.0 t FYM + 1.25 t vermicompost + 0.5 t castorcake/ha gave maximum fresh root yield (38.58 t/ha) with net realization (Rs. 1,63,342/ha) and highest CBR (1 : 6.52) when raised on sandy loam soils of middle Gujarat.

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