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VD Kadam
PG Student, Department of Horticulture, College of Agriculture, Vasantrao Naik Marathwada Krishi Vidyapeeth Parbhani, Maharashtra, India

SJ Shinde
Associate Professor (Horticulture), Department of Horticulture, College of Agriculture, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharashtra, India

SJ Syed
PhD Scholar, Department of Horticulture, College of Agriculture, Parbhani, Vasantrao Naik Marathwada Krishi Vidyapeeth Parbhani, Maharashtra, India

Correspondence
VD Kadam
PG Student, Department of Horticulture, College of Agriculture, Vasantrao Naik Marathwada Krishi Vidyapeeth Parbhani, Maharashtra, India

Effect of different spacing and fertilizer levels on growth parameter and quality parameters of beetroot (*Beta vulgaris* L.)

VD Kadam, SJ Shinde and SJ Syed

Abstract
A field experiment was carried out at Department of Horticulture, College of Agriculture, V.N.M.K.V., Parbhani. The field experiment was carried out in Factorial Randomized Block Design (FRBD) with three replication during the *Rabi* season, 2017. Treatment consisted of three levels of spacing S_1 (15cm ×15cm), S_2 (20cm×15cm) and S_3 (30cm×15cm) and three levels of fertilizers F_1 (100% RDF), F_2 (125% RDF)and F_3 (150% RDF). The experiment was conducted in Factorial Randomized Block design with nine treatment combinations, replicated thrice. Variety "Ruby Queen" was selected for the study. Growth characters such as number of leaves per plant at harvest (15.64) were observed maximum with the treatments S_3 (30cm×15cm) and F_3 (150% RDF) with (15.88). The quality characters like TSS (11.63%), total sugar (8.50%), anthocyanin content (33.02 mg/100g) and iron content (1.14 mg/100g) were observed maximum with the treatment S_3 (30cm×15cm) and quality characters like TSS (11.62%), total sugar (8.45%), anthocyanin content (35.77 mg/100g) and iron content (1.18 mg/100g) were observed maximum with the treatment F_1 (100% RDF). The maximum physiological loss in weight (%) at 11th days (51.89%) was observed in the treatment S_1 (15cm×15cm) and at 11th days (54.00%) was observed in the treatment F_1 (100% RDF).

Keywords: Beetroot, PLW, Iron, Anthocyanin, FRBD, Growth

Introduction
Beetroot (*Beta vulgaris* L.) is a member of the *Chenopodiaceae* family which includes silver beet, sugar beet and fodder beet. Chromosome no. of beetroot is 2n=18. Beetroot is also known as 'garden beet' or 'table beet'. They are believed to have originated from Germany. They are biennials although they usually grow as annuals. Beetroot is essentially a modern vegetable and has become an important home-garden and market garden crop, cultivated for its fleshy roots. Beetroot produces green tops and swollen root during its first growing season. It is highly productive as it grows quickly and usually free from pests and diseases.
The total area under beetroot cultivation and production of beet root in India is about 2164 hectares and 36260 tones, respectively. The productivity of beetroot in India is 16.75 T/ha. (Anon 2017) [1]. Vegetables play an important role in human nutrition. During recent years, the interest in vegetable production has increased rapidly as a result of great appreciation of food value of vegetables and the place of vegetables in the nation's food requirements (Bansil, 2008).
Beetroot is an excellent source of iron, magnesium, sodium, potassium and betanin which are important for cardiovascular health. It is also abundant in vitamin C and antioxidants. Beets are also good for keeping cholesterol levels in body which protects the body against heart diseases. The plant also protects against birth defects and certain types of cancer. The herb is also a good general tonic that can be used by pregnant women, and is also good in purifying the liver, kidney and gall-bladder.
The climatic requirements of crop viz., temperature, humidity, light, CO_2 concentration and radiation should be in permissible range of the crop to obtain higher yield. The environmental factors can be controlled under protective cultivation and optimization of growing conditions enhances the production multifold, compared to open field conditions. In general, the main purpose of growing high value crops in protective environment is to obtain blemish free high quality produce.
Beetroot responds well to increasing nitrogen, phosphorus and potassium levels, as these nutrients are essential to produce higher yield along with good quality. It is necessary to optimize fertilizer rates for beetroot in varying environments.
Nitrogen is the most important element of those supplied to sugar beet in fertilization. Nitrogen fertilizer has a pronounced effect on the growth and physiological and chemical

characteristics of the crop. So that, nitrogen could cause desirable effect on sugar beet growth and yield characters. Decidedly, phosphorus play important role in root growth and potassium is a major plant nutrient needed for sugar beet, which plays an important role in plant nutrition association with the quality of the production and increases disease resistance in plant. In Maharashtra state very less work was done on this aspect.

In India beetroot is generally sown during March–July in hills and during September-November in the northern plains. In the southern plains the sowing is taken up from July to November. The optimum recommended spacing is adopted 45-60 cm x 8-10 cm. Thinning is practiced to maintain the intra-row spacing and optimum population. The seeds are sown at a depth of about 2.5 cm to ensure good germination.

The farmers apply spacing & fertilizers as a traditional method. Considering the demand of the farmers in Marathwada region, the present investigation on beetroot.

Materials and Methods

The detail of the materials used and techniques adopted during the course of the present study are described in this chapter under appropriate headings and sub headings. The meteorological data were collected from Agricultural Meteorological Observatory, Parbhani. The minimum and maximum temperatures recorded were 12 ^{0}C and 33 ^{0}C respectively. The average relative humidity ranges from 42.50 to 59.35%.

Details of experimental treatments

Factor A Spacing levels S_1- 15cm×15cm, S_2- 20cm×15cm and S_3- 30cm×15cm

Factor B Fertilizer levels F_1- 100% RDF, F_2 – 125% RDF and F_3 – 150% RDF

The experiment was conducted in Factorial Randomized Block Design with three replication and two factors, Factor A- S levels (spacing) and Factor B- F levels (fertilizer). There were 3 levels of S (spacing) and 3 levels of F (fertilizer) were being tried as given in treatment details.

A uniform dose of 60 kg K_2O/ha was applied to all the plots before sowing. Half dose of N and full dose of P_2O_5 as per treatments was applied as a basal dose before sowing. The beet root seeds are directly sown during *Rabi* season, 2017, with spacing 30 cm x 15 cm and the plot size 2.25 m x 1.5 m, and remaining half dose of N as per treatment was applied at 30 days after sowing. The doses of N, P and K are being applied through Urea, SSP & MOP respectively. The total treatment combinations were nine which are given in Table 1.

Table 1: Treatment combinations

S. No.	Treatment Combination	Spacing (cm)	Fertilizer RDF (%)
T_1	S_1F_1	15×15	100
T_2	S_1F_2	15×15	125
T_3	S_1F_3	15×15	150
T_4	S_2 F_1	20×15	100
T_5	S_2 F_2	20×15	125
T_6	S_2 F_3	20×15	150
T_7	S_3 F_1	30×15	100
T_8	S_3 F_2	30×15	125
T_9	S_3 F_3	30×15	150

Results and Discussion

Growth parameters

The effect of spacing at S_3 levels (30cm×15cm) on number of leaves per plant was found significantly maximum at 45 DAS (9.54), 60 DAS (12.38) and at end of harvest (15.64) over rest of the treatments and which was at par with treatment 45 DAS (9.43), 60 DAS (12.30) and at harvest (15.54) with observed in S_2 level (20cm×15cm). The minimum at number of leaves per plant 45 DAS (9.31), 60 DAS (12.18) and at harvest (15.44) with observed in S_1 level (15cm×15cm). While, the effect of spacing was found non-significant at 15 and 30 DAS for number of leaves per plant. Similar results were reported by Bilekudari *et al.* (2005) [4], Dod *et al.* (2010) [6], Pervez *et al.* (2004) in radish. The effect of fertilizer at F_3 levels (150% RDF) on number of leaves per plant was found significantly maximum at 45 DAS (10.89), 60 DAS (12.47) and at end of harvest (15.88) over rest of the treatments and which was at par with treatment 60 DAS (12.27) and at harvest (15.57) with observed in F_2 level (125% RDF). The minimum number of leaves per plant 45 DAS (8.14), 60 DAS (12.13) and at harvest (15.18) with observed in F_1 level (100% RDF). While, the effect of fertilizer was found non-significant at 15 and 30 DAS for number of leaves per plant. The variation in number of leaves between different fertilizer levels is attributed to more availability of nutrients to the crop. Similar results were reported by Jambukar and Wange (2006) [10] in beetroot. The interaction effect of different spacing and fertilizer levels was found non-significant for number of leaves per plant.

Table 2: Effect of different levels of spacing and fertilizer on number of leaves per plant in beetroot

Treatment No.	Treatments	15 DAS	30 DAS	45 DAS	60 DAS	At harvest
Factor S: Spacing Levels						
1	S_1	2.48	5.35	9.31	12.18	15.44
2	S_2	2.57	5.47	9.43	12.30	15.54
3	S_3	2.74	5.59	9.54	12.38	15.64
SE$\pm$		0.16	0.11	0.10	0.11	0.16
CD at 5%		NS	NS	0.31	0.34	0.49
Factor F: Fertilizer Levels						
1	F_1	2.53	5.35	8.14	12.13	15.18
2	F_2	2.56	5.47	9.25	12.27	15.57
3	F_3	2.70	5.56	10.89	12.47	15.88
SE$\pm$		0.16	0.11	0.10	0.11	0.16
CD at 5%		NS	NS	0.31	0.34	0.49
Interaction effect (S x F)						
SE$\pm$		0.28	0.20	0.18	0.25	0.28
CD at 5%		NS	NS	NS	NS	NS
G. M .		2.60	5.46	9.42	12.29	15.54

Spacing levels – S_1 (15cm×15cm), S_2 (20cm×15cm) and S_3 (30cm×15cm).

Fertilizer levels – F_1 (100% RDF), F_2 (125% RDF), and F_3 (150% RDF).

Quality parameters

The maximum TSS (11.63%) was observed in the treatments S_3 levels (30cm×15cm), which was statistically at par with the treatment S_2- 20cm×15cm (11.41%). The minimum TSS (11.17%) was recorded in the treatment S_1 levels (15cm×15cm). Similar results were reported by Desuki *et al.* (2005) [5] in radish, Alves *et al.* (2010) [2] in carrot. The maximum TSS (11.62%) was observed in the treatments F_1 levels (100% RDF), which was statistically at par with the treatment F_2- 125% RDF (11.37%). The minimum TSS (11.22%) was recorded under the treatment F_3 levels (150% RDF). Similar results were reported by Gehan *et al.* (2013) [7] and Abdelaal *et al.* (2015) in sugar beet. The interaction effect of different spacing and fertilizer levels was found non-significant for total soluble solids (%) content.

The treatment S_3 levels (30cm×15cm) recorded maximum reducing sugar (0.86%), which was at par with the treatment S_2-20cm×15cm (0.74%). The minimum reducing sugar (0.56%) was observed in the treatment S_1 levels (15cm×15cm). The maximum reducing sugar (0.83%) was observed in the treatment F_1 levels (100% RDF), while which was at par with the treatment F_2 125% RDF (0.72) and $F_3$150% RDF (0.62). The minimum reducing sugar (0.62%) was observed under the treatment F_3 levels (150% RDF). Similar results were reported by Ismail and El-Ghait (2004) [9] in sugar beet. The interaction effect of different spacing and fertilizer levels was found non-significant for reducing sugar content (%) of beetroot.

The maximum non reducing sugar (7.64%) was recorded in the treatment S_3 levels (30cm×15cm), which was at par with the treatment S_2-30cm×15cm (7.56%). The minimum non reducing sugar (7.52%) was recorded in the treatment S_1 levels (15cm ×15cm). The maximum non reducing sugar (7.62%) was noticed in the treatment F_1 levels (100% RDF), which was at par with the treatment F_2 -125% RDF (7.57%). The minimum non reducing sugar (7.51%) was noticed in the treatment F_3 levels (150%RDF). The interaction effect of spacing and fertilizer levels was found non-significant for non-reducing sugar content (%) of beetroot.

The maximum total sugar (8.50%) was obtained under the treatments S_3 levels (30cm×15cm), which was statistically at par with the S_2- 20cm×15cm (8.30%). The minimum total sugar (8.08%) was noticed under the treatment S_1 levels (15cm×15cm). Similar results were reported by Ismail and El-Ghait (2004) [9] in sugar beet. The maximum total sugar (8.45%) was obtained under the treatments F_1 levels (100% RDF), which was statistically at par with the F_2- 125% RDF (8.29%). The minimum total sugar (8.13%) was noticed under the treatment F_3 levels (150% RDF). Similar results were reported by Tarvydiene *et al*. (2004), Jambukar and Wange (2006) [10] in beetroot. The interaction effect of different spacing and fertilizer levels was found non-significant for total sugar content (%) of beetroot.

The maximum anthocyanin content (33.02) was recorded in the treatment S_3 levels (30cm×15cm), which was at par with the treatment S_3-20cm×15cm (32.82). The minimum anthocyanin content (32.72) was recorded in the treatment S_1 levels (15cm ×15cm). Similar results were reported by Silber *et al.* (2003) in bell pepper. The treatment F_1 levels (100% RDF) recorded maximum anthocyanin content (35.77), which was significantly superior over rest of the treatment. Significantly minimum anthocyanin content (30.34) was recorded in the treatment F_3 levels (150% RDF). Similar result were reported by Moor *et al.* (2009) and Attia *et.al.* (2013) [3]. The interaction effect of different spacing and fertilizer levels was found non-significant for anthocyanin content (mg/100g) of beetroot.

Table 3: Effect of different levels of spacing and fertilizer on quality parameters of beetroot

Treatment No.	Treatment	TSS (%)	Reducing sugar (%)	Non-reducing sugar (%)	Total Sugar (%)	Anthocyanin (mg/100g)	Iron (mg/100g)
Factor S: Spacing Levels							
1	S_1	11.17	0.56	7.52	8.08	32.72	1.09
2	S_2	11.41	0.74	7.56	8.30	32.82	1.11
3	S_3	11.63	0.86	7.64	8.50	33.02	1.14
SE±		0.12	0.73	0.87	0.09	0.52	0.01
CD at 5%		0.37	0.22	0.26	0.28	1.58	0.03
Factor F: Fertilizer Levels							
1	F_1	11.62	0.83	7.62	8.45	35.77	1.18
2	F_2	11.37	0.72	7.57	8.29	32.45	1.12
3	F_3	11.22	0.62	7.51	8.13	30.34	1.05
SE±		0.12	0.07	0.87	0.09	0.52	0.01
CD at 5%		0.37	0.22	0.26	0.28	1.58	0.03
Interaction effect (S x F)							
SE±		0.21	00.12	0.15	0.16	0.91	0.019
CD at 5%		NS	NS	NS	NS	NS	NS
G. M.		11.40	0.72	7.56	8.29	32.85	1.11

Spacing levels – S_1 (15cm×15cm), S_2 (20cm×15cm) and S_3 (30cm×15cm).
Fertilizer levels – F_1 (100% RDF), F_2 (125% RDF), and F_3 (150% RDF

The treatment S_3 levels (30cm×15cm) recorded maximum iron content (1.14), which was at par with treatment S_2-20cm×15cm (1.11). The minimum iron content (1.09) was recorded in the treatment S_1 levels (15cm×15cm). The maximum iron content (1.18) was obtained in the treatment F_1 levels (100% RDF), which was significantly superior over rest of the treatments. Significantly minimum iron content (1.05) was obtained in the treatment F_3 levels (150% RDF). Similar result were reported by Gopalan *et.al* (1989) [8]. The interaction effect of different spacing and fertilizer levels was found non-significant for iron content (mg/100g) of beetroot.

Table 4: Effect of different levels of spacing and fertilizer on Physiological loss in weight (PLW %) of beetroot

Treatment No.	Treatment	3rd day	5th day	7th day	9th day	11th day
Factor S: Spacing Level						
1	S_1	13.45 (21.51)*	26.69 (31.10)*	36.57 (37.20)*	44.54 (41.86)*	51.89 (46.08*)
2	S_2	11.05 (19.41)*	22.84 (28.54)*	32.27 (34.61)*	40.64 (36.60)*	47.14 (43.36)*
3	S_3	15.76 (23.39)*	24.49 (29.60)*	34.91 (36.21)*	42.84 (40.83)*	49.84 (44.90)*
SE±		0.93	0.83	1.19	0.60	0.72
CD at 5%		2.81	2.48	3.57	1.80	2.18
Factor F: Fertilizer Levels						
1	F_1	13.43 (21.49)*	27.24 (31.46)*	37.77 (37.92)*	46.08 (42.75)*	54.00 (47.29)*

2	F_2	10.99 (19.36)*	22.67 (28.43)*	32.51 (34.76)*	40.66 (36.61)*	46.42 (42.94)*
3	F_3	15.84 (23.45)*	24.11 (29.40)*	33.47 (35.34)*	41.17 (39.91)*	48.44 (44.10)*
SE$\pm$		0.93	0.83	1.19	0.60	0.72
CD at 5%		2.81	2.48	3.57	1.80	2.18
Interaction effect (S x F)						
SE$\pm$		1.62	1.43	2.06	1.04	1.26
CD at 5%		NS	NS	NS	NS	NS
G. M.		13.42	24.67	34.58	42.64	49.62

Spacing levels – S_1 (15cm×15cm), S_2 (20cm×15cm) and S_3 (30cm×15cm).
Fertilizer levels – F_1 (100% RDF), F_2 (125% RDF), and F_3 (150% RDF).
*Figures in parenthesis are arc sine value.

The maximum physiological loss in weight (15.76%) at 3rd day was recorded in the treatment S_3 levels (30cm×15cm), which was statistically at par with treatment S_1-15cm×15 cm (13.45%). The treatment S_1 levels (15cm×15cm) was found maximum physiological loss in weight at 5th day (26.69%), 7th day (36.57%), 9th day (44.54%), 11th day (51.89%) and which were statistically at par with the treatments S_3 levels (30cm×15cm) at 5th day (24.49%), 7th day (34.91%), 9th day (42.84%) and at 11th day (49.84%) respectively. The minimum physiological loss in weight was observed in the treatment S_2 levels (20cm×15cm) at 3rd day (11.05%), 5th day (22.84%) and at 7th day (32.27%). Significantly minimum physiological loss in weight was observed in the treatment S_2 levels (20cm×15cm) at 9th day (40.64%) and 11th day (47.14). Similar result were reported by Kumar and Nagpal (1996) [11].
The maximum physiological loss in weight (15.84%) at 3rd day was recorded in the treatment F_3 levels (150% RDF), which was statistically at par with treatment F_1- 100% RDF (13.43%). The treatment F_1 levels (100% RDF) was found maximum physiological loss in weight at 5th day (27.84%), 7th day (37.77%), 9th day (46.08%) and at 11th day (54.00%), which was significantly superior over rest of the treatments at 5th day, 7th day, 9th day and at 11th day respectively. The minimum physiological loss in weight was observed in the treatment F_2 levels (125% RDF) at 3rd day (10.99%), 5th day (22.67%), 7th day (32.51%), 9th (40.66%) and at 11th (46.42). Might be due to its anti-senescent action and also due to its role in the maintenance of fruit firmness, reduction of respiration, and delay in the senescence. Similar result was reported by Siddiqui and Gupta (1997) [12]. The interaction effect of different spacing and fertilizer levels was found non-significant for physiological loss in weight (%).

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