Journal of Pharmacognosy and Phytochemistry
Available online at www.phytojournal.com

**E-ISSN:** 2278-4136
**P-ISSN:** 2349-8234
JPP 2018; 7(6): 31-35
Received: 19-09-2018
Accepted: 21-10-2018

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# Effect of different spacing and fertilizer levels on yield and economics of beetroot (*Beta vulgaris* L.)

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**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. The significant effect of the spacing and fertilizer levels were observed for number of leaves per plant, length of root (cm), weight of root per plant (g), weight of root per plot (kg), weight of root per hectare (q), yield per plot (kg), yield per ha (q) and B:C ratio. Yield characters like length of root (15.61 cm), weight of root per plant (152.80 g), weight of root per plot (10.55 kg) and weight of root per hectare (258.18q) were observed maximum with the treatments $S_3$ (30cm×15cm) and yield characters like length of root (16.57 cm), weight of root per plant (170.84 g), weight of root per plot (10.37 kg) and weight of root per hectare (289.26 q) were observed maximum with the treatments $F_3$ (150% RDF).The yield per plot (8.23 kg) and yield per ha (290.60 q) were observed maximum with the treatments $S_1$ (15cm×15cm) and yield per plot (7.72 kg) and yield per ha (280.77 q) were observed maximum with the treatments $F_3$ (150% RDF). The benefit cost ratio was found significantly superior over rest of the treatments $S_1$ (15cm×15cm) with (2.30) and (2.15) with $F_3$ (150% RDF) treatments.

**Keywords:** Beetroot, economics, FRBD, yield

## 1. Introduction
Attaining food security has been a major challenge for the nation since independence. The demand for food and processed commodities is increasing due to growing population and rising per capita income. There are projections that demand for food grains would increase from 192 mt in 2000 to 345 mt in 2030 (Anonymous, 2011).
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).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).
In fact, beetroot is very useful vegetable in a number of ways. The swollen roots are eaten boiled or as salad. They are also pickled and canned. The tops are used much like spinach, as leafy greens for salads or boiled. Beetroot is also used as sweet ingredient in cakes and puddings. Plants are also used as decorative bedding because of their attractive green leaves.
It is rich in vitamins and does not contain significant amount of nutritional factors like fat, hence it is an ideal vegetable for health conscious people. Beetroot is a rich source of protein (1.7 g/100 g), carbohydrate (8.8 g), calcium (200 mg), phosphorus (55 mg), minerals (0.8g), and vitamin C (88 mg). Green leaves are rich in iron (3.1mg), vitamin A (2100 I.U.), thiamine (110 µg) and ascorbic acid (50 mg/100 g) (Bhat, 2007).
Beetroot is an excellent source of folate, iron, magnesium, sodium, potassium and betamin 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.

In Maharashtra, most of the land lies in semi-arid tropics and facing problem of salt affected soils. Conventional cropping in these soils becomes uneconomical. Beetroot is one of the few vegetables, which can be successfully grown in saline soils. Therefore, cultivation of beetroot in such salt affected soils will help in efficient use of such wasteful land resources and can bring favorable social changes in farming community of the region.

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 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.

## 2. 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 was 3 levels of S (spacing) and 3 levels of F (fertilizer) were being tried as given in treatment details

A uniform dose 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 |

## 3. Results and Discussion

### 3.1 Yield characters

The maximum length of root (15.61 cm) was observed in the treatment $S_3$ levels (30cm×15cm), which was at par with the treatments $S_2$ (15.51 cm) i.e. 20cm×15cm and $S_1$ (15.01 cm) i.e. 15cm×15cm. Similar results were reported by Pervez *et al*. (2004) in radish. The fertilizer the treatment $F_3$ levels (150% RDF) was recorded maximum length of root (16.57 cm), which was at par with treatment $F_2$ (15.67 cm), while the treatment $F_1$ levels (100% RDF) recorded minimum length of root (15.09 cm). Similar results were reported by Aquino (2006) in beetroot. The interaction effect of different spacing and fertilizer levels was found non-significant length of root (cm).

The maximum weight of root per plant (152.80 g) was obtained under the treatment $S_3$ levels (30cm×15cm), which was at par with the treatments $S_2$ (151.78 g) i.e. 20cm×15cm and $S_1$ (150.76 g) i.e. 15cm×15cm. The minimum weight of root per plant (150.76 g) was obtained in the treatment $S_1$ levels (15mc×15cm). Among the levels of different fertilizer the maximum weight of root per plant (170.84 g) was obtained under treatment $F_3$ (150% RDF), which was significantly superior over rest of the treatments. Significantly minimum weight of root per plant (133.12 g) was obtained in the treatment $F_1$ (100% RDF). The interaction effect of different spacing and fertilizer levels was found non-significant for weight of root per plant (g).

The effect of spacing at $S_3$ levels (30cm×15cm) on weight of root per plot was found significantly maximum (10.55 kg) and it was at par with the treatments $S_2$ -20cm×15cm (9.53 kg). The minimum weight of root per plot (8.51 kg) was observed under the treatment $S_1$ levels (15cm×15cm). The maximum weight of root per plot (10.37 kg) was recorded in the treatment $F_3$ levels (150% RDF) which were significantly highest over rest of the treatments, which was at par with the treatment $F_2$ levels (9.74 kg) i.e.125% RDF. The minimum weight of root per plot (8.49 kg) was recorded in the treatment $F_1$ levels (100% RDF). The interaction effect of different spacing and fertilizer levels was found non-significant for weight of root per plot (kg).

The maximum weight of root per hectare (258.18 q) was found under the treatment $S_3$ levels(30cm×15cm), which was significantly superior over rest of the treatment, which was at par with $S_2$ (257.16 q)i.e.20cm×15cm.Significantly minimum weight of root per hectare (256.03 q) was recorded in the treatment $S_1$ levels (15cm×15cm). Similar results were reported by Badawi *et al.* (1995) and Kandil *et al.* (2002) in sugarbeet. The maximum weight of root per hectare (289.26 q) was observed in the treatment $F_3$ (150% RDF), which was significantly superior over rest of the treatments, which was at par with treatment $F_2$ (259.81 q) i.e. 150% RDF. Significantly minimum weight of root per hectare (222.30 q) was recorded under the treatment $F_1$ (100% RDF). Similar results were reported by Jambukar and Wange (2006), Aquino (2006) in beetroot. The interaction effect of different spacing and fertilizer levels was found non-significant for weight of root per hectare (q).

**Table 2:** Effect of different levels of spacing and fertilizer on yield parameters of beetroot

| Treatment No. | Treatment | Length of root (cm) | Weight of root plant$^{-1}$ (g) | Weight of root plot$^{-1}$ (kg) | | Weight of root ha$^{-1}$ (q) |
|---|---|---|---|---|---|---|
| **Factor S: Spacing Levels** | | | | | | |
| 1 | $S_1$ | | 15.01 | 150.76 | 8.51 | 256.03 |
| 2 | $S_2$ | | 15.51 | 151.78 | 9.53 | 257.16 |
| 3 | $S_3$ | | 15.61 | 152.80 | 10.55 | 258.18 |
| SE$\pm$ | | | 0.30 | 1.32 | 0.43 | 0.33 |
| CD at 5% | | | 0.92 | 3.76 | 1.29 | 1.06 |
| **Factor F: Fertilizer Levels** | | | | | | |
| 1 | $F_1$ | | 15.09 | 133.12 | 8.49 | 222.30 |
| 2 | $F_2$ | | 15.67 | 151.37 | 9.74 | 259.81 |
| 3 | $F_3$ | | 16.57 | 170.84 | 10.37 | 289.26 |
| SE$\pm$ | | | 0.30 | 1.32 | 0.43 | 0.33 |
| CD at 5% | | | 0.92 | 3.76 | 1.29 | 1.06 |
| **Interaction effect (S x F)** | | | | | | |
| SE$\pm$ | | | 0.53 | 3.33 | 0.74 | 0.61 |
| CD at 5% | | | NS | NS | NS | NS |
| G.M. | | | 16.04 | 151.78 | 9.53 | 257.12 |

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 $S_1$ levels (15cm×15cm) produced maximum yield per plot (8.23 kg), which was at par with the treatment $S_2$ (7.43 kg). The minimum yield per plot (6.48 kg) was obtained under the treatment $S_3$ levels (30cm×15cm). The optimum plant population in beet root is very necessary to have high root yields with good quality. Similar results were reported by Badawi *et al.* (1995) and Kandil *et al.* (2002) in sugar beet. The treatment $F_3$ levels (150% RDF) produced more yield per plot (7.72 kg), which were at par with the treatments $F_2$ (7.35 kg) and $F_1$ (7.08 kg). The minimum yield per plot (7.08 kg) was obtained under the treatment $F_1$ levels (100% RDF). This might be due to more available nutrients which increased all the growth and yield attributes of crop that finally lead to increased beetroot yield. Similar results were reported by Trani *et al*. (2005), Jambukar and Wange (2006) in beetroot and Balakrishnan *et al*. (2007) in radish.

The treatments $T_3$ i.e. $S_1F_3$ produced maximum yield per plot (8.50 kg), followed by $T_2$ (8.20 kg), $T_1$ (8.00 kg), $T_6$ (7.76 kg), $T_5$ (7.40 kg), $T_4$ (7.15 kg) and $T_7$ (6.10 kg) which were statistically at par with each other. The minimum yield per plot (6. 10kg) was observed in the treatment $T_7$ i.e. $S_3F_1$. Similar results were reported by Jambukar and Wange (2006), Aquino (2006) in beetroot.

The maximum yield per hectare (290.60 q) was recorded in the treatment $S_1$ levels (15cm×15cm), which was significantly superior over rest of the treatments. Significantly minimum yield per hectare (246.27 q) was observed under the treatment $S_3$ levels (30cm×15cm). Similar results were reported by Sirkar *et al*. (1998) and Desuki *et al*. (2005) in radish. The maximum yield per hectare (280.77 q) was recorded in the treatment $F_3$ levels (150% RDF), which was at par with the treatment $F_2$-125% RDF (267.40). The minimum yield per hectare (257.41 q) was observed under the treatment $F_1$ (100% RDF). Similar results were reported by Jambukar and Wange (2006), Aquino (2006) in beetroot, Shalaby *et al*. (2011) in sugar beet.

The treatment $T_3$ i.e. $S_1F_3$ produced maximum yield per hectare (299.82) followed by the treatments $T_2$ (289.82 q), $T_1$ (282.18 q) and $T_6$ (280.39 q), which were statistically at par with each other. The minimum yield per hectare (231.71 q) was recorded in the treatment $T_7$ i.e. $S_3F_1$ and it was at par with the treatment $T_8$ (245.01 q). Similar results were reported by Jambukar and Wange (2006), Aquino (2006) in beetroot.

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

| Treatment No. | Treatment | Yield plot$^{-1}$ (kg) | Yield ha$^{-1}$ (q) |
|---|---|---|---|
| **Factor S: Spacing Levels** | | | |
| 1 | $S_1$ | 8.23 | 290.60 |
| 2 | $S_2$ | 7.43 | 268.70 |
| 3 | $S_3$ | 6.48 | 246.27 |
| SE± | | 0.46 | 5.67 |
| CD at 5% | | 1.39 | 17.00 |
| **Factor F: Fertilizer Levels** | | | |
| 1 | $F_1$ | 7.08. | 257.41 |
| 2 | $F_2$ | 7.35 | 267.40 |
| 3 | $F_3$ | 7.72 | 280.77 |
| SE± | | 0.46 | 5.67 |
| CD at 5% | | 1.39 | 17.00 |
| **Interaction effect (S x F)** | | | |
| $T_1$ | $S_1F_1$ | 8.00 | 282.18 |
| $T_2$ | $S_1F_2$ | 8.20 | 289.82 |
| $T_3$ | $S_1F_3$ | 8.50 | 299.82 |
| $T_4$ | $S_2F_1$ | 7.15 | 258.35 |
| $T_5$ | $S_2F_2$ | 7.40 | 267.38 |
| $T_6$ | $S_2F_3$ | 7.76 | 280.39 |
| $T_7$ | $S_3F_1$ | 6.10 | 231.71 |
| $T_8$ | $S_3F_2$ | 6.45 | 245.01 |
| $T_9$ | $S_3F_3$ | 6.90 | 262.10 |
| SE± | | 0.80 | 9.82 |
| CD at 5% | | 2.42 | 29.45 |
| G.M. | | 7.38 | 268.52 |

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).

### Economic Characters

The treatment $S_1$ levels (15cm×15cm) was found significantly higher (2, 36, 427 Rs.ha$^{-1}$) gross monetary returns (GMR) per hectare, over rest of the treatments. The treatment $S_3$ levels (30cm×15cm) was found significantly lower (2, 05, 807 Rs.ha$^{-1}$) gross monetary returns per hectare. The treatment $F_3$ levels (150% RDF) was found significantly maximum (2, 33, 398 Rs.ha$^{-1}$) gross monetary returns (GMR) per hectare, over rest of the treatments. The minimum gross monetary returns per hectare (2, 03, 277 Rs.ha$^{-1}$) was recorded in $F_1$ levels (100% RDF). The interaction effect of different spacing and fertilizer levels was found non-significant for gross monetary returns (Rs. ha$^{-1}$).

The treatment $S_1$ levels (15cm×15cm) recorded higher (1, 02, 690 Rs. ha$^{-1}$) cost of cultivation per hectare, over rest of the treatments. While the treatment $S_3$ levels (30cm×15cm) recorded lower (1, 02, 450 Rs. ha$^{-1}$) cost of cultivation per hectare. The treatment $F_3$ levels (150% RDF) recorded higher (1, 08, 065 Rs. ha$^{-1}$) cost of cultivation per hectare, over rest of the treatments. While the treatment F levels $_1$ (100% RDF) recorded lower (1, 06, 255 Rs. ha$^{-1}$) cost of cultivation per hectare.

The treatment $S_1$ levels (15cm×15cm) was found significantly maximum (1, 33,737 Rs.ha$^{-1}$) net monetary returns (NMR) per hectare, over rest of the treatments. Significantly minimum net monetary returns per hectare (1,03,357 Rs. ha$^{-1}$) was found in $S_3$ levels (30cm×15cm) treatment.

**Table 4.** Effect of different levels of spacing and fertilizer on economic parameters of beetroot.

| Treatments | GMR (Rs. ha$^{-1}$) | Cost of cultivation (Rs. ha$^{-1}$) | NMR (Rs. ha$^{-1}$) | B: C ratio |
|---|---|---|---|---|
| **Spacing Levels (S)** | | | | |
| $S_1$: 15×15cm | 2,36,427 | 1,02,690 | 1,33,737 | 2.30 |
| $S_2$: 20×15cm | 2,22,712 | 1,02,570 | 1,20,142 | 2.17 |
| $S_3$: 30×15cm | 2,05,807 | 1,02,450 | 1,03,357 | 2.00 |
| SE (m) ± | 4082 | - | 4082 | - |
| CD at 5% | 12,259 | - | 12,259 | - |
| **Fertilizer Levels (F)** | | | | |
| $F_1$: 100% RDF | 2,03,277 | 1,06,255 | 97,022 | 1.91 |
| $F_2$: 125% RDF | 2,10,284 | 1,07,160 | 1,03,124 | 1.96 |
| $F_3$: 150% RDF | 2,33,398 | 1,08,065 | 1,25,333 | 2.15 |
| SE (m) ± | 4082 | - | 4082 | - |
| CD at 5% | 12,259 | - | 12,259 | - |
| **Interaction (S x F)** | | | | |
| SE (m) ± | 7085 | - | 7085 | - |
| CD at 5% | NS | - | NS | - |
| General Mean | 3,15,650 | 1,04,865 | 210785 | - |

The treatment $F_3$ levels (150% RDF) was found significantly maximum (1, 25, 333 Rs.ha$^{-1}$) net monetary returns (NMR) per hectare, over rest of the treatments. Significantly minimum net monetary returns per hectare (97,022 Rs. ha$^{-1}$) was found in $F_1$ levels (100% RDF) treatment. The interaction effect of different spacing and fertilizer levels was found non-significant for net monetary returns (Rs. $ha^{-1}$).

The treatment $S_1$ levels (15cm×15cm) was found maximum B:C ratio (2.30) than rest of the treatments and minimum (2.00) with $S_3$ levels(30cm×15cm) treatment. The higher B:C ratio (2.15) was observed in the treatment $F_3$ levels(150% RDF) and lower (1.91) in $F_1$ levels(100% RDF) treatment.

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