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Studies on effect of different spacing and nitrogen levels on growth and yield of beetroot (*Beta vulgaris* L.) Cv. Detroit dark red under Telangana conditions

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Abstract
The present investigation entitled "Studies on effect of different spacing and nitrogen levels on growth and yield of beetroot (*Beta vulgaris* L.) cv. Detroit Dark Red under Telangana conditions" was carried out during *rabi* season of 2020-21 at SKLTSHU, College of Horticulture, Rajendranagar, Hyderabad. The experiment was laid out in Factorial Randomized Block Design (FRBD) with sixteen treatments replicated thrice. Treatment consisted of four levels of spacing S1 (45cm ×15cm), S2 (30cm×15cm), S3 (30cm×10cm) and S4 (15cm ×15cm) and four levels of nitrogen N1 (70 Kg ha-1), N2 (87.5 Kg ha-1), N3 (105 Kg ha-1) and N4 (122.5 Kg ha-1). The significant effect of the spacing and nitrogen levels were observed for growth and yield characters. Growth characters like plant height recorded highest in spacing level S4 (15cm ×15cm) and number of leaves per plant was found maximum in spacing level S1 (45cm ×15cm) and plant height and number of leaves per plant at 25, 50 and 75 DAS were recorded maximum in nitrogen level N4 (122.5 Kg ha-1). Yield characters like root length, root girth and weight of root per plant were observed maximum with spacing level S1 (45cm×15cm) and yield characters like length of root, girth of root and weight of root per plant were observed maximum with nitrogen level N4 (122.5 Kg ha-1). The yield per plot and yield per ha (45.89 t) were observed maximum with spacing level S4 (15cm×15cm) and yield per plot and yield per ha (40.44 t) were observed maximum with nitrogen level N4 (122.5 Kg ha-1).

Keywords: Beetroot, spacing, nitrogen, Detroit dark red

Introduction
Beetroot (*Beta vulgaris* L.) is commonly is known as Chukandar and is one of the important root vegetable crops, belongs to the family Chenopodiaceae along with spinach, palak, Swiss chard, parsley and celery, having chromosome no (2n=18). A plant with origin throughout the coast of Western Europe and North Africa where they were grown to feed both humans and livestock. It produces green tops and swollen root used both as vegetable and salad. Beetroot is grown for food uses (pickles, salad, juice) rather than for sugar production.

Beetroot is famous for its juice value and medicinal properties and known by several common names like beet, chard, spinach beet. (Yashwant, 2015) [19]. Roots of beetroot is a rich source of proteins (1.7 g), carbohydrates (8.8 g), calcium (18 mg), phosphorous (55 mg) and vit-C (10 mg) and 87.7 percent of water per 100 g of fresh weight (Aykroyd, 1963) [2].

Beetroot is a rich source of folic acid which was useful for pregnant women. It makes an excellent dietary supplement being not only rich in minerals, nutrients and vitamins but also unique phyto constituents, which have several medicinal properties. Several parts of this plant are used in medicinal system such as anti-oxidant, anti-depressant, anti-microbial, antifungal, anti-inflammatory, diuretic, expectorant and carminative. It is one of the natural foods which boosts the energy in athletes as it has one of the highest nitrates and sugar containing plant (Yadav *et al*., 2016) [18].

The intense red colour of beetroot derives from high concentration of betalains. Betalains are used as natural colorants by the food industry, but have also received increasing attention due to possible health benefits in humans, especially their antioxidant and anti-inflammatory activities (Georgiev *et al*., 2010, Zielinska *et al*., 2009) [10, 20]. The betalains that are mainly found in beetroot are betacyanin's and betaxanthins (Gandia *et al*., 2010) [9].

Today, beetroot is grown in many countries worldwide is regularly consumed as part of the normal diet, and commonly used in manufacturing as food colouring agent known as E 162 (Clifford *et al*., 2015) [7]. Effects of a commercially available beetroot juice on inflammation is strongly involved in the development and progression of several clinical conditions including coronary heart disease and cancer. Beneficial effect of beetroot extract may relate to this anti-inflammatory capacity (Jurgen *et al*., 2015) [12].

Optimum spacing avoids shading effect on plants and intraspace competition. Higher yield per unit area can be obtained by proper plant geometry. Proper plant geometry minimizes competition for nutrition, light, radiation, water etc. Optimum use of spacing or plant population has dual advantages. It avoids strong competition between plants for growth factors 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.

Nitrogen has a great importance as a constituent of numerous organic molecules in plants such as proteins, nucleic acids and alkaloids and its content is associated with the leaf relative chlorophyll content which affects photosynthesis. Nitrogen is the plant nutrient that is most limiting to efficient and profitable crop production. Inadequate supply of available nitrogen frequently results in plants that have slow growth, depressed protein levels, poor yield, low quality produce and inefficient water use.

Keeping in view of the above information, the research programme entitled "studies on effect of different spacing and nitrogen levels on growth, yield and quality of beetroot (*Beta vulgaris* L.) cv. Detroit Dark Red under Telangana conditions is planned".

Materials and Methods

The experiment was carried out at College of Horticulture, Rajendranagar, Hyderabad, Telangana during spring-summer season of 2020-21. The experimental site is situated at the altitude of the 542.3 m above the mean sea level on 17º 191 North latitude and 79º 231 East longitude. The experiment was laid out in factorial randomized block design (FRBD) with three replications and sixteen treatments. The meteorological data were collected from ARI, Rajendranagar. The minimum and maximum temperatures recorded were 12.5 ^{0}C and 36.3 ^{0}C respectively. The average relative humidity ranges from 41 to 95%.

Details of experimental treatments

Factor A Spacing levels S1- 45cm×15cm, S2- 30cm×15cm and S3- 30cm×10cm and S4- 15cm×15cm Factor B Nitrogen levels N1-70 Kg ha-1, N2-87.5 Kg ha-1, N3-105 Kg ha-1 and N4 -122.5 Kg ha-1.

The experiment was conducted in Factorial Randomized Block Design with three replication and two factors, Factor A-S levels (spacing) and Factor B-N levels (nitrogen). There were 4 levels of S (spacing) and 4 levels of N (nitrogen) were being tried as given in treatment details.

The observations were recorded on growth characters (Plant height and number of leaves) and yield characters (Root length, Root girth, Weight of root per plant, Yield per plot and Yield per ha).

Results and Discussion Growth Parameters Plant height (cm)

The data pertaining to plant height at 25, 50, 75 days after sowing (DAS) as influenced by the spacing and nitrogen levels are presented in the table 1.

The maximum plant height (15.02, 32.83 and 39.48 cm) was observed in spacing level S4 (15cmX15cm) and minimum plant height (12.33, 28.50 and 35.11 cm) was recorded in spacing level S1 (45cmX15cm) at 25, 50 and 75 DAS. Among different nitrogen levels, highest plant height (14.11, 32.98 and 38.47 cm) was registered in nitrogen level N4 (122.5 Kg ha-1) and lowest plant height (13.10, 28.84 and 35.38 cm) was recorded in nitrogen level N1 (70 Kg ha-1) at 25, 50 and 75 DAS. The interaction effect was found to be non-significant at 25 DAS but the treatment combination S4N4 (15 cm x 15 cm, 122.5 Kg N ha-1) showed significant effect on plant height at 50 DAS (35.07 cm) and at 75 DAS (42.13 cm). It may be due to the fact that increased plant density limits the availability of space for lateral growth, resulted in increased plant height. Height of plant can be considered as one of the indices of plant vigour ordinarily and it depends upon vigour and growth habit of the plant. Soil nutrients are also very important for the height of plants. So, higher dose of nitrogen increased plant height. The above findings were in accordance with the results of Bathkal *et al*. (1971) [4], Cho *et al*. (2000) [6], Basavaraju *et al*. (2002) [3] in radish, Moniruzzaman *et al*. (2013) [13] in carrot.

Table 1: Effect of different spacing and nitrogen levels on plant height (cm), of beetroot cv. Detroit Dark Red

Plant height (cm)															
Spacing levels (S)	**Nitrogen levels (N)**														
	25 DAS					**50 DAS**					**75 DAS**				
	N1	**N2**	**N3**	**N4**	**Mean**	**N1**	**N2**	**N3**	**N4**	**Mean**	**N1**	**N2**	**N3**	**N4**	**Mean**
S1	12.10	12.23	12.43	12.53	12.33d	28.07	28.23	28.67	29.03	28.50d	33.78	34.93	35.20	36.53	35.11d
S2	12.91	13.20	13.40	13.66	13.29c	27.77	29.37	30.87	34.53	30.63c	34.79	35.43	36.43	37.18	35.96c
S3	12.80	13.33	13.66	14.77	13.64b	28.62	29.30	32.47	33.30	30.92b	35.63	35.97	37.23	38.01	36.71b
S4	14.60	14.87	15.10	15.50	15.02a	30.90	32.04	33.42	35.07	32.83a	37.33	38.63	39.80	42.13	39.48a
Mean	13.10cd	13.41bc	13.65b	14.11a		28.84d	29.73c	31.36b	32.98a		35.38d	36.24c	37.17b	38.47a	
Factors	S.E.m±		CD at 5%			S.E.m±		CD at 5%			S.E.m±		CD at 5%		
S	0.14		0.31			0.20		0.43			0.19		0.42		
N	0.14		0.31			0.20		0.43			0.19		0.42		
S X N	0.24		NS			0.34		0.99			0.33		0.96		
S1 = 45 cm X 15 cm, S2 = 30 cm X 15 cm, S3 = 30 cm X 10 cm, S4 = 15 cm X 15 cm						N1 = 70 Kg ha-1, N2 = 87.5 Kg ha-1, N3 = 105 Kg ha-1, N4 = 122.5 Kg ha-1									

Number of leaves

The data pertaining to plant height at 25, 50, 75 days after sowing (DAS) as influenced by the spacing and nitrogen levels are presented in the table 2.

The highest number of leaves (7.15, 17.74 and 18.36) was observed in spacing level S1 (45cmX15cm) and lowest number of leaves (5.07, 14.48 and 14.77) was recorded in spacing level S4 (15cmX15cm) at 25, 50 and 75 DAS. Among different nitrogen levels, greater number of leaves (6.61, 16.66 and 17.43) was registered in nitrogen level N4 (122.5 Kg ha-1) and lesser number of leaves (5.74, 15.81and 14.77) was recorded in nitrogen level N1 (70 Kg ha-1) at 25, 50 and 75 DAS. The interaction effect was found to be non-significant. Maximum number of leaves were recorded with the lower plant density, might be due to lesser competition for nutrients and light amongst the plants. The variation in number of leaves between different nitrogen levels is due to more availability of nutrients to the crop. It may be due to the fact that nitrogenous fertilizers increase the vegetative growth. Similar results were reported by Patil *et al.* (1986) [14], Basavaraju *et al.* (2002) [3], Thapa *et al.* (2003) [16], Bilekudari *et al.* (2010) [5], Jilani *et al.* (2010) [11] in radish, Ali *et al.* (2006) [1] in carrot.

Table 2: Effect of different spacing and nitrogen levels on number of leaves of beetroot cv. Detroit Dark Red

Number of leaves															
Spacing levels (S)	**Nitrogen levels (N)**														
	25 DAS					**50 DAS**					**75 DAS**				
	N1	**N2**	**N3**	**N4**	**Mean**	**N1**	**N2**	**N3**	**N4**	**Mean**	**N1**	**N2**	**N3**	**N4**	**Mean**
S1	6.87	7.00	7.17	7.57	7.15a	17.17	17.87	17.96	17.95	17.74a	17.70	17.90	18.77	19.07	18.36a
S2	5.83	6.17	6.47	6.83	6.33b	15.93	16.27	17.53	17.38	16.78b	17.63	17.83	17.53	17.87	17.72b
S3	5.47	5.87	6.63	6.70	6.17bc	15.75	16.23	16.31	16.74	16.26c	17.13	17.23	17.33	17.37	17.27c
S4	4.80	4.85	5.30	5.35	5.07d	14.40	14.40	14.57	14.57	14.48d	14.07	14.53	15.07	15.40	14.77d
Mean	5.74cd	5.97c	6.39ab	6.61a		15.81cd	16.19abc	16.59ab	16.66a		16.63cd	16.88bc	17.18ab	17.43a	
Factors	S.E.m±		CD at 5%			S.E.m±		CD at 5%			S.E.m±		CD at 5%		
S	0.13		0.28			0.22		0.47			0.20		0.43		
N	0.13		0.28			0.22		0.47			0.20		0.43		
S X N	0.22		NS			0.37		NS			0.35		NS		
S1 = 45 cm X 15 cm, S2 = 30 cm X 15 cm, S3 = 30 cm X 10 cm, S4 = 15 cm X 15 cm						N1 = 70 Kg ha-1, N2 = 87.5 Kg ha-1, N3 = 105 Kg ha-1, N4 = 122.5 Kg ha-1									

Yield parameters Root length (cm)

The maximum length of root (17.25 cm) was observed in the spacing level S1 (45cm×15cm) and minimum (15.50 cm) root length was observed in spacing level S4 (15cm×15cm). Among different nitrogen levels, maximum length of root (16.99 cm) recorded in nitrogen level N4 (122.5 Kg N ha-1) and minimum length of root (15.47 cm) observed in nitrogen level N1 (70 Kg N ha-1). The interaction effect of different spacing and nitrogen levels was found significant for root length. The highest root length (18.10 cm) was recorded in treatment combination S1N4 (45 cm X 15 cm, 122.5 Kg N ha-1) and the lowest root length (14.90 cm) was recorded in S4N1 (15 cm X 15 cm, 70 Kg N ha-1). This might be due to the fact that nitrogen is a part of chlorophyll molecules, which plays major role in in the process of photosynthesis, a powerful set of carbohydrates, which occurs in the leaves and is translocated to the storage organs of roots. The results were in accordance with the results of Pervez *et al.* (2004) [15], Desuki *et al.* (2005) [8], Tripathi *et al.* (2017) [17] in radish.

Root girth (cm)

The maximum root girth (8.66 cm) was observed in the spacing S1 level (45 cm X 15 cm) and minimum root girth (7.68 cm) was observed in spacing level S4 (15 cm X 15 cm). The nitrogen at level of N4 (122.5 Kg N ha-1) was recorded maximum root girth (8.48 cm) and minimum root girth (7.82 cm) was recorded in the nitrogen level N1 (70 Kg N ha-1). This might be due to the fact that nitrogen is a 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 girth of root. The findings were in agreement with the results of Pervez *et al.* (2004) [15], Desuki *et al.* (2005) [8] in radish.

Root weight per plant

The maximum root weight (183.18 g) was observed in the spacing S1 level (45 cm X 15 cm) and the minimum root weight (102.39 g) was observed in spacing level S4 (15 cm X 15 cm). The nitrogen level N4 (122.5 Kg N ha-1) was recorded maximum root weight (154.52 g) and the minimum root weight (139.33 g) was recorded in the nitrogen level N1 (70 Kg N ha-1). Among all the treatment combinations, S1N4 (45 cm X 15 cm, 122.5 Kg ha-1) recorded maximum root weight (188.96 g) and the minimum root weight (96.00 g) was observed in treatment S4N1 (15 cm X 15 cm, 70 Kg N ha-1). Similar results were reported by Pervez *et al.* (2004) [15] in radish.

Root yield (Kg plot-1)

The maximum yield per plot (18.35 Kg) was observed in spacing level S4 (15 cm X 15 cm) and the minimum yield per plot (10.92 Kg) was observed in spacing level S1 (45 cm X 15 cm). The maximum yield per plot (16.18 Kg) was recorded in the nitrogen level N4 (122.5 Kg N ha-1) and the minimum yield per plot (14.62 Kg) was recorded in the nitrogen level N1 (70 Kg N ha-1) which is on par with nitrogen level N2 (87.5 Kg N ha-1) (14.99 Kg). The interaction effect of spacing and nitrogen had significant influence on yield of beetroot. The highest yield (18.76 Kg plot-1) was observed in treatment combination S4N3 (15 cm X 15 cm, 105 Kg N ha-1) which is on par with S4N4 (15 cm X 15 cm, 122.5 Kg N ha-1) (18.73 Kg plot-1) while the lowest yield (10.56 Kg plot-1) was obtained from S1N1 (45 cm X 15 cm, 70 Kg N ha- 1). Similar results were reported by Pervez *et al.* (2004) [15], Desuki *et al.* (2005) [8], Tripathi *et al.* (2017) [17] in radish

Root yield (t ha-1)

The maximum yield per hectare (45.89 t) was observed in the spacing S4 level (15 cm X 15 cm) and the minimum yield per

hectare (27.31 t) was observed in spacing level S1 (45 cm X 15 cm). The maximum yield per hectare (40.44 t) was recorded in the nitrogen level N4 (122.5 Kg N ha-1), which was at par with nitrogen level N3 (105 Kg N ha-1) (40.26 t). The minimum yield per hectare (36.54 t) was recorded in the nitrogen level N1 (70 Kg N ha-1) which is on par with nitrogen level N2 (87.5 Kg ha-1) (37.48 t). The interaction effect of spacing and nitrogen had significant influence on yield of beetroot. The highest yield (46.89 t) was observed in treatment combination S4N3 (15 cm X 15 cm, 105 Kg N ha-1) which is on par with S4N4 (15 cm X 15 cm, 122.5 Kg N ha-1) (46.81 t) while the lowest yield (26.41 t) was obtained from S1N1 (45 cm X 15 cm, 70 Kg N ha-1). Increase in nitrogen level had significant positive effect on increased plant stand i.e., closer spacing, resulted in significant increase in yield. Similar results were reported by Pervez *et al.* (2004) [15], Desuki *et al*. (2005) [8], Tripathi *et al.* (2017) [17] in radish.

B:C ratio

The highest B:C ratio was found in treatment combination S4N3 (15 cm X 15 cm and105 Kg N ha- 1) is 4.17 which is followed by S4N4 (15 cm X 15 cm and 122.5 Kg N ha-1) is 4.15 while the lowest B:C ratio was found in S1N1 (45 cm X 15 cm and 70 Kg N ha-1) is 2.46.

Table 3: Effect of different spacing and nitrogen levels on root length (cm), root girth (cm) and root weight plant-1 (g)) of beetroot cv. Detroit Dark Red

Spacing levels (S)	Root length (cm)					Root girth (cm)					Weight of root per plant (g)				
	Nitrogen levels (N)														
	N1	N2	N3	N4	Mean	N1	N2	N3	N4	Mean	N1	N2	N3	N4	Mean
S1	16.27	16.94	17.70	18.10	17.25a	8.39	8.48	8.69	9.07	8.66a	172.00	183.00	188.75	188.96	183.18a
S2	15.52	15.99	16.72	17.12	16.34b	8.00	8.21	8.49	8.53	8.31b	165.68	171.72	178.87	181.70	174.49b
S3	15.20	15.92	16.55	16.82	16.13c	7.77	8.03	8.17	8.35	8.08c	123.63	126.60	133.22	141.59	131.26c
S4	14.90	15.88	15.28	15.93	15.50d	7.10	7.73	7.90	7.97	7.68d	96.00	102.75	105.00	105.82	102.39d
Mean	15.47d	16.18c	16.56b	16.99a		7.82d	8.11c	8.31b	8.48a		139.33d	146.02c	151.46b	154.52a	
Factors	S.E.m ±		CD at 5%			S.E.m ±		CD at 5%			S.E.m ±		CD at 5%		
S	0.08		0.18			0.05		0.10			0.70		1.51		
N	0.08		0.18			0.05		0.10			0.70		1.51		
S X N	0.14		0.41			0.08		0.24			1.21		3.50		
S1 = 45 cm X 15 cm, S2 = 30 cm X 15 cm, S3 = 30 cm X 10 cm, S4 = 15 cm X 15 cm						N1 = 70 Kg ha-1, N2 = 87.5 Kg ha-1, N3 = 105 Kg ha-1, N4 = 122.5 Kg ha-1									

Table 4: Effect of different spacing and nitrogen levels on root yield (Kg plot-1) and Root yield (t ha-1) of beetroot cv. Detroit Dark Red

Spacing levels (S)	Root yield (Kg plot-1)					Root yield (t ha-1)				
	Nitrogen levels (N)									
	N1	N2	N3	N4	Mean	N1	N2	N3	N4	Mean
S1	10.56	10.84	11.19	11.11	10.92d	26.41	27.11	27.96	27.77	27.31d
S2	15.44	15.60	16.42	16.49	15.99c	38.59	39.00	41.06	41.22	39.97c
S3	14.80	15.25	18.05	18.39	16.62b	36.99	38.12	45.14	45.97	41.56b
S4	17.67	18.27	18.76	18.73	18.35a	44.17	45.67	46.89	46.81	45.89a
Mean	14.62cd	14.99c	16.10ab	16.18a		36.54cd	37.48c	40.26ab	40.44a	
Factors	S.E.m ±		CD at 5%			S.E.m ±		CD at 5%		
S	0.18		0.38			0.43		0.95		
N	0.18		0.38			0.43		0.95		
S X N	0.30		0.88			0.76		2.19		
S1= 45X15 cm, S2= 30X15 cm, S3= 30X10 cm, S4 =15X15 cm						N1 =70 Kg ha-1, N2=87.5 Kg ha-1, N3=105 Kg ha-1, N4= 122.5 Kg ha-1				

Conclusion

Based on the results, it can be concluded that the treatment combination S4N3 (15 cm X 15 cm, 105 Kg N ha-1) produced higher root yield per hectare and economic returns. So, it was concluded that a spacing level S4 (15 cm X 15 cm) and nitrogen level N3 (105 Kg N ha-1) is most profitable for the cultivation.

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