

STUDIES ON EFFECT OF DIFFERENT SPACING AND NITROGEN LEVELS ON QUALITY PARAMETERS OF BEETROOT (*Beta vulgaris* L.) cv. DETROIT DARK RED UNDER TELANGANA CONDITIONS

Comment [DSK1]: Can remove "Studies on"

Abstract

The present investigation entitled "Studies on effect of different spacing and nitrogen levels on quality parameters of beetroot (*Beta vulgaris* L.) cv. Detroit Dark Red under telangana conditions" was carried out during rabiseason 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 quality characters. Highest TSS (9.93⁰Brix), reducing sugars (1.64 %), total sugars (7.31 %) and chlorophyll content (45.50 SPAD value) were recorded in wider spacing S₁- 45 cm x 15 cm and highest ascorbic acid content (10.09 mg 100g⁻¹) were recorded in closer spacing S₄-15 cm x 15 cm, whereas pH and titrable acidity were found to be non-significant. Highest pH (6.20), reducing sugars (1.52 %), total sugars (7.29 %), ascorbic acid content 10.06 mg 100g⁻¹ were recorded in nitrogen level N₁-70 Kg N ha⁻¹, whereas highest TSS (9.79⁰Brix), chlorophyll content 45.70 (SPAD value) were observed in nitrogen level N₄-122.5 Kg N ha⁻¹. The interaction effect on quality parameters was found to be non-significant.

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Keywords: Beetroot, Spacing, Nitrogen, Detroit Dark Red

Introduction:

Beetroot (*Beta vulgaris* L.) is commonly 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).

Comment [DSK6]: remove

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Beetroot is famous for its juice value and medicinal properties and known by several common names like beet, chard, spinach beet, (Yashwant, 2015). 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).

Comment [DSK11]: remove full stop before reference

Comment [DSK12]: root

Comment [DSK13]: vitamin C

Comment [DSK14]: add has before 87.7

Comment [DSK15]: and

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). The betalains that are mainly found in beetroot are betacyanin's and betaxanthins (Gandia et al., 2010). 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).

Comment [DSK16]: remove

Comment [DSK17]: remove

Comment [DSK18]: instead of activities write properties

Comment [DSK19]: remove today

Optimum spacing avoids shading effect on plants and intraspace competition. 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.

Comment [DSK20]: add and after worldwide

Comment [DSK21]: remove as

Comment [DSK22]: which dual advantages?

Comment [DSK23]: It's the repeated statement

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.

Comment [DSK24]: What does term relative mean here?

Comment [DSK25]: production

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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".

Comment [DSK27]: reframe the whole sentence. Never use the title of article in introduction

Materials and Methods

The experiment was carried out at College of Horticulture, Rajendranagar, Hyderabad, Telangana during spring-summer season of 2020-21. The experiment was laid out in factorial randomized block design (FRBD) with three replications and sixteen treatments.

pH

The pH of the beetroot liquid fraction was determined using a pH meter (Model Hanna pH 210)

Comment [DSK28]: Give the detailed procedure of extracting liquid fraction

Total soluble solids (^oB)

Total soluble solids (TSS) in terms of percentage were obtained by using digital refractometer. Two to three drops of juice were placed on the prism of refractometer and reading was observed on scale and averages were expressed in ^oBrix.

Titration acidity (%)

10 ml of sample was pipette out in 250 ml beaker and added 90 ml distilled water and it was agitated using magnetic stirrer and electrode pH was immersed in solution and titrated with NaOH from burette to pH value 8.1. At this pH phenolphthalein turns colourless to pink.

Comment [DSK29]: Which sample?

Comment [DSK30]: Write the normality of NaOH used

Comment [DSK31]: Reframe the complete sentence

$$\frac{\text{Titre} \times \text{Normality of alkali} \times \text{Vol. made} \times \text{Eq. wt. of acid} \times 100}{\text{Wt. of sample} \times \text{Vol. of aliquot} \times 1000}$$

$$\text{Percentage acidity} = \frac{\text{Titre} \times \text{Normality of alkali} \times \text{Vol. made} \times \text{Eq. wt. of acid} \times 100}{\text{Wt. of sample} \times \text{Vol. of aliquot} \times 1000}$$

Reducing sugars (%)

The reducing sugars were estimated by the volumetric method as reported by the Ranganna (1986).

Comment [DSK32]: Remove the

Total sugars (%)

Total sugars were estimated by the volumetric method as reported by the Ranganna (1986).

Comment [DSK33]: Remove the

Ascorbic acid content (mg 100g⁻¹)

Take 2 ml of sample extract in a stoppered conical flask, add 2 ml of buffer, 1 ml of 40% formaldehyde and mix. Allow to stand for 10 min. then add 3 ml dye solution, stopper and shake for 10-15 sec. Follow the remaining steps as done in the case of standard curve preparation. From the standard curve note the ascorbic acid content (mg) in the 2 ml sample extract taken for the estimation.

Comment [DSK34]: Which buffer?

Comment [DSK35]: Which dye?

Comment [DSK36]: Please explain

Chlorophyll content (SPAD VALUE)

It was measured by Spad meter.

Results and Discussion

pH

The results revealed that there was no significant effect of spacing on pH of beetroot. Nitrogen shows significant effect on pH of beetroot. The maximum pH (6.20) was observed at nitrogen level N₁ (70 Kg N ha⁻¹) which is on par with nitrogen level N₂ (87.5 Kg N ha⁻¹) (6.13) and minimum pH (6.06) was recorded at nitrogen at level of N₄ (122.5 Kg N ha⁻¹). Similar results are reported by Abhiram and Kefale (2020) in tomato.

Comment [DSK37]: Where are the results?

Total Soluble Solids (°B)

The maximum TSS (9.93°B) was observed in the spacing S₁ level (45 cm X 15 cm) followed by spacing level S₂ (30 cm X 15 cm) (9.62°B). The minimum TSS (9.25°B) noticed in spacing level S₄ (15 cm X 15 cm). The maximum TSS (9.79°B) was observed with nitrogen level, N₄ (122.5 Kg N ha⁻¹) which is followed by nitrogen level N₃ (105 Kg N ha⁻¹) (9.61°B). The minimum TSS (9.33°B) was recorded in the nitrogen level N₁ (70 Kg N ha⁻¹). The interaction effect of different spacing and nitrogen levels was found to be non-significant for TSS. It may be due to the fact that, when there is less competition for light, moisture and nutrients, the plant accumulates large amount of carbohydrates in their root. Higher dose of nitrogen enhanced the growth of leaves which in turn results in increase of photosynthesis and ultimately an increase in storage of carbohydrates and is reflected by increased TSS. These findings are in agreement with the results of earlier workers like, Skrbic (19987) in carrot, Joshi and Patil (1988), Kadam *et al.* (2018) in beetroot.

Titration acidity (%)

Spacing Nitrogen levels did not exert any significant effect on titration acidity of beetroot. The interaction effect of different spacing and nitrogen levels was found to be non-significant for titration acidity. Similar results are reported by Abhiram and Kefale (2020), Rongaet *al.* (2020) in tomato and Alves *et al.* (2010) in carrot.

Comment [DSK38]: Reframe the sentence

Reducing sugars (%)

The maximum reducing sugars (1.64 %) were observed in spacing S₁ level (45 cm X 15 cm) which is followed by spacing level S₂ (30 cm X 15 cm) (1.42 %). The minimum reducing sugars (1.24 %) were noticed in spacing level S₄ (15 cm X 15 cm). The maximum reducing sugar (1.52 %) was observed in the nitrogen level N₁ (70 Kg N ha⁻¹) which is on par with nitrogen level N₂ (87.5 Kg N ha⁻¹) and N₃ (105 Kg N ha⁻¹) (1.44 % and 1.37 %). The minimum reducing sugar (1.27 %) was observed in the nitrogen level N₄ (122.5 Kg N ha⁻¹). The interaction effect of different spacing and nitrogen levels was found to be non-significant for reducing sugars. Similar results were reported by Sirkar *et al.* (1998) in radish, Kadam *et al.* (2018) in beetroot

Table 1. Effect of different spacing and nitrogen levels on pH, TSS (°brix) and titration acidity (mg 100 g fresh weight⁻¹) of beetroot cv. Detroit Dark Red

Comment [DSK39]: Table reference is not anywhere in the text.

Total sugars (%)

Spacing levels (S)	pH					TSS (°brix)					Titrable acidity (mg 100 g fresh weight ⁻¹)					
	Nitrogen levels (N)															
	N ₁	N ₂	N ₃	N ₄	Mean	N ₁	N ₂	N ₃	N ₄	Mean	N ₁	N ₂	N ₃	N ₄	Mean	
S ₁	6.31	6.14	6.11	6.08	6.16	9.62	9.78	10.00	10.30	9.93^a	0.19	0.21	0.21	0.15	0.19	
S ₂	6.20	6.17	6.13	6.05	6.14	9.42	9.55	9.70	9.80	9.62^b	0.28	0.15	0.22	0.21	0.21	
S ₃	6.14	6.12	6.11	6.08	6.11	9.20	9.27	9.41	9.66	9.39^c	0.24	0.21	0.21	0.17	0.21	
S ₄	6.17	6.10	6.08	6.05	6.10	9.10	9.20	9.32	9.40	9.25^d	0.23	0.24	0.18	0.23	0.22	
Mean	6.20 ^a	6.13 ^{ab}	6.11 ^{bc}	6.06 ^{cd}		9.33 ^d	9.45 ^c	9.61 ^b	9.79 ^a		0.24	0.20	0.20	0.19		
Factors	S.E.m±		CD at 5%		S.E.m±		CD at 5%		S.E.m±		CD at 5%		S.E.m±		CD at 5%	
S	0.02		NS		0.04		0.10		0.01		NS		0.01		NS	
N	0.02		0.08		0.04		0.10		0.01		NS		0.01		NS	
S X N	0.04		NS		0.08		NS		0.02		NS		0.02		NS	
S ₁ = 45 cm X 15 cm, S ₂ = 30 cm X 15 cm, S ₃ = 30 cm X 10 cm, S ₄ = 15 cm X 15 cm							N ₁ = 70 Kg ha ⁻¹ , N ₂ = 87.5 Kg ha ⁻¹ , N ₃ = 105 Kg ha ⁻¹ , N ₄ = 122.5 Kg ha ⁻¹									

Comment [DSK40]: Are these values the mean of triplicate values? Then must perform statistical analysis on them too.

Comment [DSK41]: Explain the alphabets on the numerals. Which statistical analysis is done on mean value?

Spacing showed significant effect among different treatments. The maximum total sugars (7.31 %) were observed in spacing S₁ level (45 cm X 15 cm) which is on par with spacing level S₂ (30 cm X 15 cm) and S₃ (30 cm X 10 cm) (7.15 % and 6.81 %). The minimum total sugars (6.12%) were noticed in spacing level S₄ (15 cm X 15 cm). The maximum total sugar (7.29 %) was observed in the nitrogen level N₁ (70 Kg N ha⁻¹) which is on par with nitrogen level N₂ (87.5 Kg N ha⁻¹) (7.05 %). The minimum total sugar (6.45 %) was observed in the nitrogen level N₄ (122.5 Kg N ha⁻¹). The interaction effect of different spacing and nitrogen levels was found to be non-significant for total sugars. Similar results were reported by Kadam *et al.* (2018) in beetroot.

Ascorbic acid content (mg 100g⁻¹)

Spacing showed significant effect among different treatments. The maximum ascorbic acid content (10.09 mg 100g⁻¹) was observed in spacing S₄ level (15 cm X 15 cm) which is on par with spacing level S₃ (30 cm X 10 cm) (9.87 mg 100g⁻¹). The minimum ascorbic acid content (9.63 mg 100g⁻¹) was noticed in spacing level S₁ (45 cm X 15 cm). The maximum ascorbic acid content (10.06 mg 100g⁻¹) was observed in the nitrogen level N₁ (70 Kg N ha⁻¹) which is on par with nitrogen level N₂ (87.5 Kg N ha⁻¹) (9.96 mg 100g⁻¹). The minimum ascorbic acid content (9.64 mg 100g⁻¹) was observed in the nitrogen level N₄ (122.5 Kg N ha⁻¹). The interaction effect of different spacing and nitrogen levels was found to be non-significant for ascorbic acid content. Similar results were noticed by Rakocevic *et al.* (2012) in carrot.

Chlorophyll content (SPAD value)

Spacing showed significant effect among different treatments. The maximum chlorophyll content (45.50 SPAD value) was observed in spacing S₁ level (45 cm X 15 cm) which is on par with spacing level S₂ (30 cm

Comment [DSK42]: Avoid repetition of the sentences in every paragraph

X 15 cm) (45.11 SPAD value). The minimum chlorophyll content (44.02 SPAD value) was noticed in spacing level S₄ (15 cm X 15 cm). Nitrogen shows significant effect on chlorophyll content. Maximum chlorophyll content (45.70 SPAD value) was recorded with nitrogen at level of N₄ (122.5 Kg N ha⁻¹) which is on par with nitrogen level N₃ (105 Kg N ha⁻¹) (45.17 SPAD value). The minimum chlorophyll content (43.61 SPAD value) was recorded in the nitrogen level N₁ (70 Kg N ha⁻¹). The interaction effect of different spacing and nitrogen levels was found to be non-significant for chlorophyll content. Similar results were reported by Singh *et al.* (2004) in onion.

Conclusion

Highest TSS (9.93⁰Brix), reducing sugars (1.64 %), total sugars (7.31 %) and chlorophyll content (45.50 SPAD value) were recorded in wider spacing S₁- 45 cm x 15 cm and highest ascorbic acid content (10.09 mg 100g⁻¹) were recorded in closer spacing S₄-15 cm x 15 cm, whereas pH and titrable acidity were found to be non-significant. Highest pH (6.20), reducing sugars (1.52 %), total sugars (7.29 %), ascorbic acid content 10.06 mg 100g⁻¹ were recorded in nitrogen level N₁-70 Kg N ha⁻¹, whereas highest TSS (9.79 ⁰Brix), chlorophyll content 45.70 (SPAD value) were observed in nitrogen level N₄-122.5 Kg N ha⁻¹. The interaction effect on quality parameters was found to be non-significant.

Table 2. Effect of different spacing and nitrogen levels on reducing sugars (%) and total sugars (%) of beetroot cv. Detroit Dark Red

Comment [DSK43]: Are values, 45.5 and 44 are significantly different?

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Spacing levels (S)	Reducing sugars (%)					Total sugars (%)				
	Nitrogen levels (N)									
	N ₁	N ₂	N ₃	N ₄	Mean	N ₁	N ₂	N ₃	N ₄	Mean
S ₁	1.72	1.66	1.60	1.57	1.64^a	7.68	7.45	7.20	6.90	7.31^a
S ₂	1.61	1.50	1.33	1.22	1.42^b	7.59	7.43	6.85	6.75	7.15^{ab}
S ₃	1.46	1.33	1.30	1.13	1.31^{bc}	7.30	6.88	6.59	6.47	6.81^{abc}
S ₄	1.30	1.27	1.23	1.16	1.24^{cd}	6.59	6.42	5.81	5.66	6.12^d
Mean	1.52^a	1.44^{ab}	1.37^{abc}	1.27^{cd}		7.29^a	7.05^{ab}	6.61^{bc}	6.45^{cd}	
Factors	S.E.m±		CD at 5%		S.E.m±		CD at 5%			
S	0.07		0.16		0.23		0.50			
N	0.07		0.16		0.23		0.50			
S X N	0.12		NS		0.40		NS			
S ₁ = 45 cm X 15 cm, S ₂ = 30 cm X 15 cm, S ₃ = 30 cm X 10 cm, S ₄ = 15 cm X 15 cm					N ₁ = 70 Kg ha ⁻¹ , N ₂ = 87.5 Kg ha ⁻¹ , N ₃ = 105 Kg ha ⁻¹ , N ₄ = 122.5 Kg ha ⁻¹					

Table 3. Effect of different spacing and nitrogen levels on Ascorbic acid content(mg 100g⁻¹) and Chlorophyll content (SPAD value) of beetroot cv. Detroit Dark Red

Spacing levels (S)	Ascorbic acid content (mg 100g ⁻¹)					Chlorophyll content (SPAD value)				
	Nitrogen levels (N)									
	N ₁	N ₂	N ₃	N ₄	Mean	N ₁	N ₂	N ₃	N ₄	Mean
S ₁	9.80	9.72	9.51	9.50	9.63^{bcd}	44.63	45.55	45.80	46.01	45.50^a
S ₂	10.00	9.85	9.70	9.63	9.80^{bc}	44.81	45.42	45.53	44.69	45.11^{ab}
S ₃	10.17	10.10	9.70	9.50	9.87^{ab}	43.17	43.65	44.40	46.31	44.38^{bc}
S ₄	10.28	10.17	10.00	9.93	10.09^a	41.83	43.53	44.93	45.80	44.02^{cd}
Mean	10.06^a	9.96^b	9.73^{bc}	9.64^{cd}		43.61^d	44.54^{bc}	45.17^{ab}	45.70^a	
Factors	S.E.m±		CD at 5%		S.E.m±		CD at 5%			
S	0.11		0.24		0.42		0.92			
N	0.11		0.24		0.42		0.92			
S X N	0.19		NS		0.73		NS			
S ₁ = 45 cm X 15 cm, S ₂ = 30 cm X 15 cm, S ₃ = 30 cm X 10 cm, S ₄ = 15 cm X 15 cm					N ₁ = 70 Kg ha ⁻¹ , N ₂ = 87.5 Kg ha ⁻¹ , N ₃ = 105 Kg ha ⁻¹ , N ₄ = 122.5 Kg ha ⁻¹					

COMPETING INTERESTS DISCLAIMER:

Authors have declared that no competing interests exist. The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

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