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Effect of Plant Spacing and Urea Fertilizer on Yield and Yield Components of Beetroot (*Beta Vulgaris L.*)

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Abstract

Beetroot is one of horticultural crop which need intensive cultural practice. It is important throughout the world by being a source of food as well as income for consumers, processors and producers. But there is a gap of research output and information for its cultural practice especially on optimum recommended fertilizers and spacing to improve its yield in Ethiopia. A field experiment was conducted in the 2012 to study the effects of plant spacing and urea fertilization on yield and yield components of Deteroit dark red beetroot cultivars. The experiment was a randomized complete block design (RCBD) arrangement. Plant spacing (16, 20 and 25 cm within plant) were combined with three Nitrogen rates (45, 52.5 and 60 gm/plot). The general objectives that was to know the effect of spacing and urea on yield and yield component of beetroot with specific objectives that were to determine appropriate spacing and urea fertilizer rate on Beetroot for optimum yield production by keeping other agronomic practices constant, to determine appropriate interaction effect of spacing and urea for optimum yield and yield components of beetroot, and to compile information for producers, researchers and students for further improvement of the crop with regard to spacing, urea fertilizer rate and other agronomic practice. As a result of finding significant influence ($p<0.05$) of spacing on leaf width, leaf area and underground dry weight of beetroot at the lowest spacing over the control was observed while it did not show significant effect for the other parameters of yield and yield component of beetroot. Significant effect ($p<0.05$) of Urea was observed on leaf area and underground dry weight but not on other parameters. The interaction effect of both factors significantly encouraged ($p<0.05$) only underground dry weight. This is due to low competition that reduces dry matter of produce. Though there was no statistical difference, the highest yield was recorded with interaction effect of S1U1. This was due to high density of plant population per given area when compared with other treatment. Therefore it is summarized from the studied result that spacing at highest level (30*25cm) with lowest level of urea (45gm/plot) was found to be optimum for maximizing yield of beetroot by providing high underground dry weight that directly related to its yield.

Keywords: Beet roo, Spacing, Urea, Yield.

1. Introduction

Beetroot (*Beta vulgaris* .L) belongs to family Chenopodiaceae. It is indigenous to Asia Minor and Europe. They were first used for food about before the third century although they had been grown for thousands of years for medicinal purposes. It is grown widely in Germany and France and in lesser amounts in other European countries, Africa and South America. Beetroot is now a popular salad vegetable. Beetroot has been used as root vegetables, leafy vegetables, health benefits, source of dyes and traditional remedy [1].

Beetroot is biennial crop growth as annual for its root. It produces green tops and a flesh swollen taproot during its first growing season. The nutrients stored in the taproot are used to produce flowers and seeds in the second season. The extensive root system developed from tap root is used to penetrate to a great depth indicates drought resistant property of beetroot. Leaves are often ovate dark green or reddish. The rosette leaves develop in a close spiral with the oldest ones the outside. The inflorescence is botanically a large spike [2]. There are many good beet varieties through seed catalogs. Most grow well in different area. It includes Detroit Dark Red, Red Ace, Early Wonder, Green Leaf, and Golden [2].

Beets root prefer fertile, well-drained, deep, sandy soils rich in organic matter for best growth. Most light soil is well suited for beet production. Heavy soils need to be amended with plenty of compost to allow good root development; however, hairiness and thick root development from tap root in the compost. Prepare soil before planting; incorporate up to 2-4 inches of well composted organic matter. Work this into the top 6 inches of soil. Soil PH should be 6-8 [3].

Beetroot can be planted from August to February in temperate and subtropical regions and from May to September in tropical. Beet plants are always grown from seed. Beets can be sown after soils reach 40°F. Seeds germinate best at 55-75°F and require 7-14 days to emerge. Temperatures above 80°F reduce seed germination. During plantingSeeds should be planted 1.5-3cm deep. Crusting soils will limit seedling emergence and affect plant stands. Maintain a uniform and moist soil surface to ensure good plant stands. Seeded beets should be spaced 20cm between plants in the row with rows 30cm apart. After sowing water it regularly. Water requirements depend on soil type and climatic condition. Mulching around the plants helps to conserve soil moisture. Moisture fluctuations cause root cracking, slow leaf development, and contribute to low yields. Water stress during the first 6 weeks of growth often leads to premature flowering and low yields. Apply nitrogen-based fertilizer 6 weeks after emergence to encourage rapid plant growth. Place the fertilizer to the side of the plants and irrigate it into the soil. Beets require adequate amounts of boron to develop properly. Black, sunken spots on or in the root generally indicate low boron levels in the soil. Weed control is particularly important during germination and early establishment when plant growth is slow because it does not compete well with weeds. Most beets grow rapidly and are not susceptible to many production problems like insect and disease. Rotate planting locations in the garden from year to year to help control many diseases. Boron deficient plants are more susceptible to many of the more common root diseases [3].

Good yields beetroots are produced if they gain good nitrogen amount and spacing with in row. Any cessation in growth of beetroot produces tough, woody roots with uneven color and inferior flavor, since excessive nitrogen results in lush disease prone at the expense of the root development [4].

There is no satisfactory research conducted on the production of beet root in our country as well as in African counties. As many research reports indicated that, there is a research gap in cultivation practices of beet root such as recommended spacing, fertilizer rate and other practices. Because of this the production and productivity of beet root is low throughout the world. This problem is caused by absence of sufficient information on the crop and this constraint on the crop still has not been solved.

Therefore the focus of this research is to investigate optimum spacing and Urea fertilizer rate on beet root practice that would bring optimum yield and yield component and to contribute to the information profile for absence of scientific information on the crop.

1.1. Objectives

1.1.1. General Objectives

- To know effect of spacing and urea on yield and yield component of beetroot.
- 1.1.2 Specific objectives
- To determine appropriate spacing and urea fertilizer rate on Beetroot for optimum yield production by keeping other agronomic practices constant.
- To determine appropriate interaction effect of spacing and urea for optimum yield and yield components of beetroot.
- To compile information for producers, researchers and students for further improvement of the crop with regard to spacing, urea fertilizer rate and other agronomic practice.

2. Literature Review

2.1. The effect of Plant Population

Beetroot (*Beta vulgaris* L) grows best under cool conditions almost all year round. If drainage is satisfactory, almost any soil is suitable and somewhat tolerate alkaline soil except acidic. Acid soils are likely to create nutrient deficiency problems and should be avoided [4].

Beet root contain numerous fibrous and storage root. Soon it germinates rapidly from the seed it bear; fibrous roots that are extended roots rapidly into the soil for accumulation of water and nutrients and forms large root for storing sucrose at high concentration at the suit condition and also it bear quickly large leaves for the efficient capture of sunlight. Storage root growth starts only when sugar needs for basic metabolism, top growth and fibrous root development has been met. This commonly occurs during early leaf development, when the tops have nearly reached maximum size for a given environment. Once storage root growth has started, the growth rate of the storage root is determined primarily by the amount of surplus sugar produced by the tops and water as well as nutrient absorbed by fibrous root. For these processes enough spacing is needed for both root and leaves to reduce competition within and between root or leaf as well as other different cultural practices like fertilizer application like nitrogen. Root dry weight of beet root is significantly ($p<0.05$) increased at the wider the spacing. Its yields significantly ($p<0.05$) increased under closer spacing. Spacing had no significant effects on root fresh weight, shoot fresh weight, and shoot dry weight. Shoot dry weight was significantly greater under higher nitrogen levels and wider spacing. Beet root sown at wider apart significantly ($p<0.05$) attained the greatest root dry weight [5].

The effects of population density were primarily noted on percent harvestable beetroot but not on yield and harvest weight. Trends toward reduced length and width with increasing density were also noted, suggesting that certain aspects of beet shape may be manipulated by controlling population density. Shape and size of globe-shaped red beet genotypes is determined largely by population density and within-row spacing. Results from these experiments suggest that the highest yield of desirable small size grades (25 to 50 mm in diameter) of globe-shaped beets for processing is obtained with high population densities. Furthermore Yield of small size grades of beetroots (<25 mm in diameter) increased more than 2-fold with reduced row spacing from 30 cm to 15cm. The percentage of harvestable beets was significantly higher in the low density planting, followed by the medium density and the high density planting. It is expected that medium- and high density plantings will yield beets of favored processing size at later harvest dates. Harvest weight also decreased with increasing density, revealing an increase of > 15% at low density compared to medium density. No significant difference was measured between medium and high density for harvest weight. Length, middle width, and length × width decreased with increasing density. Lengths x width values were 22% lower at high than low densities. Length decreased significantly from low to medium densities but not from medium to high densities. These data suggest that beets with greater length and width result from lower-density plantings [6].

2.2. The Effect of Urea

The most important plant nutrients required by beetroot is nitrogen, phosphorus, potassium and boron. Beetroot requires a great deal of nitrogen, phosphorus and potassium, but only small quantity of boron. Nitrogen being "the motor of plant growth, unbalanced, excess in crops will decrease quality and yield of crops particularly storage ability [7] cited by Mirvat, et al. [8]. Nitrogen fertilizer has a pronounced effect on the growth, physiological and chemical characteristics of the yield and quality of beet root. So that, nitrogen fertilization should be managed to produce high root tonnage with high yield and yield component levels. In this respect, increasing nitrogen application as soil fertilizer recorded significantly increase length, diameter and weight of roots as well as root, top and root yield ton/ha. On the other hand, root quality determination of beet i.e. sucrose%, juice purity and recoverable sugar percentages were significantly decreased by increasing nitrogen rates. Moreover, impurities in terms of potassium, sodium and α-amino nitrogen were significantly increases by increasing nitrogen levels [8].

Nitrogen is often the most limiting factor in crop production and there is no single characteristic symptom that identifies nitrogen deficiency of beetroot. However, then foliage typically becomes light green in appearance, then yellow, due to the disappearance of chlorophyll from the leaves. This reduces photosynthesis and subsequently crop yield though application of fertilizer nitrogen results in higher biomass yield. Nitrogen is a key factor in sucrose utilization and sugar concentration in the storage root of beetroot. When the plant is abundantly supplied with nitrogen, top growth is favored over root growth, perhaps because the raw materials for sugar utilization, nitrogen and sugar meet in the young leaves; however, limited nitrogen supply is, sugar using processes decreases and sugar tends to accumulate throughout the plant. Under these conditions, sugar utilization appears to be located primarily in the root, where sugar from the tops first meets the nitrate front the soil. This favors storage root growth [2].

Nitrogen application increased root fresh weight; dry weights of shoot, root; green and dry beet root yields significantly. Raising nitrogen fertilization levels from 40, 80 to 120 kg N/ha has resulted in a significantly higher shoot dry weight. This increment could be due to the increase in the amount of metabolites synthesized by plants due to the effect of nitrogen in enhancing photosynthesis and hence dry matter accumulation. This leads to more growth and consequently accumulation of more photosynthesis assimilates. Nitrogen resulted in significant ($p<0.05$) increase in root dry weight under 80 kg/N/ha. Supplying beetroot plants with nitrogen fertilizer up to 100 kg N/ha increase root fresh weight [5].

Research results of different authors reported that increasing nitrogen fertilizer increased dry matter yield and yield components of beet root. The effects of five nitrogen rates (0, 50, 100, 200 and 300kg/ha) on root yield and yield components of fodder beets were evaluated under Sparta conditions in the 2007 and 2008 growing seasons. But 300kg/ha nitrogen rates significantly affected most of the yield components determined in fodder beet. Nitrogen applications increased root yield, dry matter yield, root diameter, and root length. Based on these results, 150kg/ha nitrogen treatments can be recommended under similar managements [9].

If the soil does not always have enough of nitrogen for beetroot; therefore, farmers must supplement it. Nitrogen 300 to 400kg/ha is applied during the growing season of beetroot. About 150kg/ha of nitrogen is usually applied at planting and the rest when the plants are about 10-15cm high. Some research reports indicated that nitrogen side-dressings using urea at 100kg/ha can be applied when beetroot are 10cm tall. Further side-dressings may be required, particularly if leaching rains occur. Good quality roots are produced if they are grown quickly. Any cessation in growth produces tough, woody roots with uneven color and inferior flavor [4].

3. Materials and Methods

3.1. Description of the Study Area

The experiment was conducted in Oromia Region south west of Ethiopia under field condition at Jimma University College of Agriculture and Veterinary Medicine (JUCAVM) from February to end of April at specific place horticultural garden. JUCAVM is geographically located at about 7°, 33° North latitude and 36°, 57° East longitude at an altitude of 1710meter above sea level. The mean maximum and minimum temperature were 26.8°C and 11.4°C respectively and the mean maximum and minimum relative humidity were 91.4% and 31.2% respectively. The annual rain fall of the area was 1500 mm. The soil of the experiment site was characterized by well drained clay to silty clay with PH of 4.51 [10].

3.2. Experimental Materials

Beetroot seed of the Deteroit dark red variety, equipments such as watering can, digging hoe, shovel, fork, rake, rope, meter, stakes, mulching materials, shading materials, cutting materials and writing materials like recording book, pen, fixer, computer paper, note book, rulers, and weighing equipment (beam balance) were used for research work. The seed of beet root was obtained from Jimma market. Experimental conditions that were applied to the experimental plots were two factors. These were: spacing at three levels and urea fertilizer as one factor at three levels were investigated on Beet root crop. Accordingly the two factors at three levels were indicated below.

Factor One: Spacing at Three Levels

S1: Treatment one (spacing) at = 30 × 16 cm
S0: Treatment two (spacing) at = 30 × 20 cm
S2: Treatment three (spacing) at =30 × 25cm

- S0: Treatment two (spacing) at = 30 × 20 cm was considered as standard checks

Factor Two: Urea Fertilizer Rate at Three Levels

U1: Treatment one (urea fertilizer at = 45 gm/plot)

U0: Treatment two (urea fertilizer at= 52.5gm/plot)
U2: Treatment two (urea fertilizer at = 60gm/plot)

- U0: Treatment two (urea fertilizer at= 52.5gm/plot) was considered as standard checks

There were Nine Treatment Combinations:

S1U1=30 × 16 cm X45 gm/plot	S1U0=30 × 16 cmX52.5gm/plot
S1U2=30 × 16 cmX60gm/plot	S0U1=30 × 20 cmX45 gm/plot
S0U0=30 × 20 cmX 52.5gm/plot	S2U1=30 × 25cmX45gm/plot
S2U0=30 × 25cmX 52.5gm/plot	S2U2=30 × 25cmX 60gm/plot

S0U0=30 × 20 cm X 52.5gm/plot was considered as standard checks

3.3. Experimental Design

Completely block design (RCBD) with three replications was used.This design was aimed at removing variability in experimental plots & reduces experimental error to precisely saw the difference between treatments. Depending on the number of factor involved those experiment was classified as two factor experiment and therefore the design RCBD was selected with factorial arrangements. The total experimental area was been having a total area of 92.5m^2 which was divided in to three small homogenous blocks/replications and each block contains complete set of the treatment combinations which was allotted to the plots within each block at random. Plots/beds in a block were equal to the number of treatment combinations (three different spacing and three different urea fertilizer were combined on Beetroot) and one treatment combination was replicated three times and was appeared only once in one block. Accordingly the total experimental area was divided in to three replications perpendicular to the soil fertility gradient. The area for single plot was been (1m X 1.5m) or (1.5m^2), and total plot area (40.5m^2) and the path between plots/beds were 0.5m. One meter path between blocks was maintained to facilitate agronomic practice.

3.4. Procedure of Investigation

1. Suitable site (Horticultural garden of JUCAVM) was selected for research purpose.
2. At selected site land was cleared
3. The total experimental area was set.
4. The experimental area was divided into blocks.
5. Blocks were divided into plots.
6. Soils of an experimental area were made fine and loosen.
7. The well prepared beds/plots were watered to facilitate uniform germination.
8. The seeds were soaked for 24 hours in water to fasten the uniform germination.
9. One seed per hole at depth of 3 cm was directly sown using hand on each experimental unit for respective treatment combinations (30*16, 30*20, and 30*25) cm. For each treatment 30 cm was found to be a row distance while 16cm, 20cm, and 25cm respectively were distance between plants.
10. After seeds were sown, the beds/plots were covered with mulch material until seed emergence. Mulching was removed as soon as seed emergence and over head shade was constructed that allows 50% light entrance.
11. One third of each urea level was applied with each of the above spacing after the seeds were germinated.
12. Important crop managements practice was applied like (thinning, weeding, and insect pest and disease control, hoeing, watering, and keeping from wild animals).
13. Water was applied twice per day during in the morning and in the afternoon at 5-6 PM depending on the condition.

3.5. Data Collected

Data collected was leaf length in cm (LL), leaf width in cm (LW), leaf area (cm^2) (LA), leaf number (LNo.), Plant height in (cm) (PHt), Root diameter (cm) (RD), root length (cm) (RL), above ground fresh weight (gm) (AGFW), underground fresh weight (gm) (UGDW), above ground dry weight (gm) (AGDW), (BGDW) below ground dry weight (gm) and yield in grams or kg (quintals).

3.6. Methods Used for Data Collection

Ten plants samples per plot were taken at random with respect to replicated treatments and border effects were eliminated. Data on parameters was taken at the maturity of the crop. Data was taken starting from 75 days after planting or sowing. Parameters like leaf length, leaf width, plant height, root diameter, and root length were measured using ruler in centimeter or meter base. Dry weight was calculated after the above ground and below ground was dried in oven for 24 to 36 hrs depending on the temperature of the condition and accordingly all data were taken and recorded.

3.7. Data Analysis Method

All parameters under investigation were subjected to ANOVA for statistical analysis and LSD at 5% was used to compare mean difference and interaction effect between treatments.

4. Results and Discussion

4.1. Effect of Spacing

The significant influence of spacing on leaf width, leaf area and underground dry weight of beetroot at the lowest (16cm) spacing over the control (20cm) was observed (Table 1). But for the other parameters of yield and yield component of beetroot spacing did not show significant effect (Table 1 and 2). As it can be observed from the (Table 1 and 2) yield and yield component parameters statistically were not significant. The highest leaf area

(60.56cm²/plant), leaves width (5.41cm/plant) and highest underground dry weight were recorded with 16cm spacing statistically different over spacing control (20cm). The current research conducted indicated that root dry weight of beetroot is significantly ($p<0.05$) increased at wider spacing. Beetroot sown at wider apart significantly ($p<0.05$) attained the greatest root dry weight [5]. Except leaf area, leaf width and underground dry weight spacing did not have significant influence on other parameters like yield, leaf length, leaf number, plant height, above ground fresh weight, underground fresh weight, above ground dry weight, root length and root diameter of beet root (Table 1 and 2). The finding indicated that spacing had no significant effects on root fresh weight, shoot fresh weight, and shoot dry weight. Shoot dry weight was significantly greater under higher nitrogen levels and wider spacing, but this finding disagree with the findings of Khogali, et al. [5]reported that its yields significantly ($p<0.05$) increased under closer spacing. It was observed that the lowest leaf area (28.45cm²), leaf width (2.48 cm) and underground dry weight (0.44gm/plant) were recorded at the control spacing 20cm (Table 1 and 2).

Table-1. Yield and yield components of Beet root as influenced by spacing

Levels of spacing	LA(cm²)	LL(cm)	LW(cm)	LNo.	PHt (cm)	UGFW(gm)
So	31.43b	7.02	2.84	6	11.93	4.28
S1	60.56a	8.75	5.46	6	14.37	8.02
S2	35.42b	7.5	3.62	6	12.75	4.55
LSD(at α=0.05)	8.98	Ns	0.81	Ns	Ns	Ns
CV	37.6%	24%	35.68%	26%	24.8%	7.13%

Means with the same letter are not significantly different.ns: non significant

Table-2. Yield and yield components of Beetroot as influenced by spacing

Levels of Spacing	UGDW (gm)	AGFW (gm)	AGDW (gm)	RL (cm)	RD (cm)	Yield (ton/ha)
So	0.44b	13.42	0.99	5.16	1.44	7.91
S1	1.01a	17.30	1.88	6.79	1.21	12.16
S2	0.85a	4.02	1.12	6.29	0.73	4.62
LSD (at α=0.05)	0.19	Ns	Ns	Ns	Ns	Ns
CV	44.2%	73%	63%	21%	134%	75%

Means with the same letter are not significantly different. ns: non significant

4.2. Effect of Urea

As it was observed in (Table 3 and 4) as urea levels was increased leaf area parameter significantly increased in linear trend. But the rest parameters did not show significant at different levels of urea. According to this finding increment of urea rate application significantly influence leaf area of beetroot and the leaf become large and provide the plant to prepare more photo assimilate that supports the growth and development of the beetroot. Under these conditions, sugar utilization appears to be located primarily in the root, where sugar from the tops first meets the nitrate from the soil. This favors storage root growth [2]. As different research finding indicated that more roots of the beetroot crop is to be favored to have high storage for growth; similarly this finding reported the same result for underground dry weight of beetroot. The highest amount underground dry weight (1.28gm/plant) was recorded at the lowest level application of urea 45gm/plot (Table 3 and 4). Urea at the highest rate (60 gm/plot) and lowest level rate (45gm/plot) significantly affected the leaf area. The high leaf area (52.20cm² and 46.77cm) and the lowest leaf area recorded were 28.45 gm/plant (Table 3 and 4). The medium the leaf area the largest the underground dry weight of beet root that resulted from the lowest application levels of urea (45.5gm/plot). For the others parameter like yield, leaf length, leaf number, plant height, above ground fresh weight, underground fresh weight, above ground dry weight, root length and root diameter, urea did not showed significant effect on beet root like that of spacing (Table 3 and 4).

Table-3. Yield and yield components of Beet root as influenced by urea

Levels of Urea	LA(cm²)	LL(cm)	LW(cm)	LNo	PHt(cm)	UGFW(gm)
U0	28.45b	6.61	3.29	6	11.38	3.11
U1	46.77a	8.23	4.44	5	13.79	7.66
U2	52.20a	8.47	4.41	7	13.88	6.13
LSD(at α=0.05)	8.98	Ns	Ns	ns	Ns	Ns
CV	37.6%	24%	35.69%	26%	24.8%	7.13%

Means with the same letter are not significantly different. ns: non significant

Table-4. Yield and yield components of Beetroot as influenced by urea

Levels of urea	UGDW (gm)	AGFW (gm)	AGDW (gm)	RL (cm)	RD (cm)	Yield (ton/ha)
U0	0.32c	7.96	0.73	5.28	1.35	0.33
U1	1.28a	15.68	1.62	6.37	1.00	0.81
U2	0.71b	18.07	1.64	6.61	1.01	0.72
LSD (at α=0.05)	0.19	Ns	Ns	Ns	Ns	Ns
CV	44.2%	73%	65%	21%	134%	75%

Means with the same letter are not significantly different. ns: non significant

4.3. The Interaction Effect of Spacing and Urea

As it was observed in (Table 5 and 6) yield and yield component were not increased with the subsequent addition of spacing and urea except underground dry weight. This finding indicated that individual application of spacing and urea showed significant effect on underground dry weight of beetroot as their interaction showed significant effect. But the interaction between spacing and urea did not show influence on the leaf area. Urea alone and its interaction with spacing did not showed significant effect on leaf width of beet root, but only spacing showed significant effect on leaf width of beet root. Individual spacing, urea and their interaction did not show significant on several parameters like of yield and other yield component of beet root (Table 1, 2, 3 and 4). The highest underground dry weight (1.92gm/plant) were noticed at the highest level of spacing combined with lowest level of urea 25cm and 45gm/plot urea respectively. Similarly the lowest amount of underground dry weight was recorded at the highest spacing with highest urea 25cm and 60gm/plot respectively. This finding as well indicated that lowest spacing with control urea 16cm and 52.5gm/plot respectively showed significant effect (Table 5 and 6). Other yield and yield like components (leaf length, leaf number, plant height, above ground fresh weight, underground fresh weight, above ground dry weight, root length and root diameter) parameters were responded non significant to the interaction of spacing and urea (Table 5 and 6).

Table-5. Yield and yield component of beetroot as influenced by the interaction of spacing and urea fertilizer

Levels Spacing	Levels Urea	L.A(cm²)	LL(cm)	LW(cm)	LNo.	P.Ht(cm)	UGFW(gm)
So	Uo	24.67	6.43	2.82	5	10.9	2.37
	U1	34.59	8.23	3.21	6	14.18	5.27
	U2	35.29	6.4	6.48	6	10.7	4.85
S1	Uo	38.01	6.32	4.67	6	11.32	2.37
	U1	65.31	8.87	5.86	4	13.8	11.40
	U2	78.30	11.05	5.85	8	17.99	10.29
S2	Uo	22.56	7.08	2.36	6	11.91	4.07
	U1	40.41	7.59	4.26	7	13.40	6.32
	U2	43.28	7.96	4.24	6	12.94	3.13
LSD(at α=0.05)		Ns	Ns	ns	Ns	Ns	Ns
CV%		37.6	24	35.6	26	24.83	7.13

Means with the same letter are not significantly different.ns: non significant

Table-6. yield and yield component of beetroot as influenced by the interaction between spacing and urea fertilizer

Levels of spacing	Levels of Urea	UGDW (gm)	AGFW (gm)	AGDW (gm)	RL(cm)	RD(cm)	Yield (ton/ha)
S0	Uo	0.31d	6.69	0.59	4.87	2.77	5.56
	U1	0.52c	13.30	1.31	5.72	0.85	9.34
	U2	0.50c	20.26	1.09	4.9	0.75	8.62
S1	Uo	0.24d	6.56	0.59	5.03	0.52	3.28
	U1	1.39b	21.67	2.22	7.02	1.48	17.50
	U2	1.39b	23.68	2.84	8.32	1.61	15.64
S2	Uo	0.41cd	10.63	1.03	5.94	0.22	4.66
	U1	1.92a	12.14	1.33	6.33	0.69	5.54
	U2	0.23d	10.27	0.83	6.61	0.68	3.65
LSD(at α=0.05)		0.19	Ns	Ns	Ns	Ns	*Ns*
CV%		44.04	73	65	25	134	75

Means with the same letter are not significantly different. ns: non significant

5. Summary and Conclusion

Beetroot is one of horticultural crop which need intensive cultural practice. It is important throughout the world by being a source of food as well as income for consumers, processors and producers. But there is no much research output and information for its cultural practice especially on optimum recommended fertilizers and spacing to encourage its yield in Ethiopia. Therefore to mitigate this gap different finding clued from the available research for those concerned. To reduce this gap this finding was conducted as it is concluded below.

As this finding indicated the significant influence of spacing on leaf width, leaf area and underground dry weight of beetroot at the lowest spacing over the control was observed while it did not show significant effect for the other parameters of yield and yield component of beetroot like yield, leaf length, leaf number, plant height, above ground fresh weight, underground fresh weight, above ground dry weight, root length and root diameter. Significant effect of urea indicated on leaf area and underground dry weight while it did not revealed significant effect on yield, leaf length, leaf number, plant height, above ground fresh weight, underground fresh weight, above ground dry weight, root length and root diameter, urea did not showed significant effect on beetroot like that of spacing. The interaction effect of both factors significantly encouraged only underground dry weight. This is due to low competition that reduces dry matter of produce. Though there was no statistical difference, the highest yield was recorded with interaction effect of S1U1. This was due to high density of plant population per given area when compared with other treatment. Therefore it is summarized from the studied result that spacing at highest level (30*25cm) with lowest level of urea (45gm/plot) was found to be optimum for maximizing yield of beetroot by providing high underground dry weight that directly related to its yield.

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List of Appendixes

Appendix-1. analysis of variance of leaf area

Sv	Df	Ss	ms	Fcal
Block	2	5812.77	2906.39	11.42
Trt	8	7976.7	997.34	3.92*
S	2	4490.5	2245.3	8.82*
U	2	2786.9	1393.45	5.47*
SxU	4	699.3	175	0.69
Error	16	4073.43	254.6	
Total	26	17762.9	687.04	

CV=37.6 ss=sum square ms=mean square sv=source of variance df=degree freedomFcal=F calculated Ftab= F table*= significant

Appendix-2. analysis of variance of leaf number

SV	Df	Ss	ms	Fcal
Block	2	80.47		
Trt	8	13.38	6.69	2.9
U	2	29.7	3.72	6.69*
S	2	9.93	4.97	2.12
SxU	4	1.5	0.75	0.32
Error	16	18.3	4.58	1.96
Total	26	37.39	2.34	

CV= 26% ss=sum square ms=mean square sv=source of variance df=degree freedom Fcal=F calculated Ftab= F table

Appendix-3. analysis of variance of leaf length

SV	Df	Ss	ms	Fcal
Block	2	89.58	44.78	12.87
Trt	8	55.507	6.938	1.99
U	2	18.7719	9.385	2.696
S	2	14.118	7.039	2.03
SxU	4	22.6172	5.654	1.62
Error	16	55.7029	3.48	
Total	26	200.4	37.721	

CV= 24% ss=sum square ms=mean square sv=source of variance df=degree freedom Fcal=F calculated Ftab= F table

Appendix-4. analysis of variance above ground fresh weight

SV	Df	Ss	Ms	Fcal
Block	2	1612.36		
Trt	8	87.63	806.18	7.84
U	2	503.89	123.45	1.2
S	2	179.15	251.94	2.44
SxU	4	304.59	89.58	0.87
Error	16	1650.66	76.15	0.74
Total	26	4250.65	103.16	

CV= 73% ss=sum square ms=mean square sv=source of variance df=degree freedom Fcal=F calculated Ftab= F table

Appendix-5. analysis of variance yield

SV	Df	Ss	Ms	Fcal
Block	2	168.14	84.07	6.89
Trt	8	221.36	27.67	2.07
U	2	67.84	33.92	2.53
S	2	80.67	40.34	3.01
SxU	4	72.85	18.21	1.36
Error	16	214.13	13.38	
Total	26	603.63	22.23	

CV= 75% ss=sum squarems=mean square sv=source of variance df=degree freedom Fcal=F calculated Ftab= F table

Appendix-6. analysis of variance plant height

SV	Df	Ss	ms	Fcal
Block	2	271.6	135.8	12.96
Trt	8	126.3	15.75	1.50
U	2	36.32	18.16	1.73
S	2	27.8	13.9	1.33
SxU	4	62.2	15. 55	1.48
Error	16	167.7	10.48	
Total	26	565.6	21.75	2.08

CV= 24.8% ss=sum squarems=mean square sv=source of variance df=degree freedomFcal=F calculated Ftab= F table*= significant

Appendix-7. analysis of variance root length

SV	Df	Ss	ms	Fcal
Block	2	68.04	34.02	14.42
Trt	8	29.65	3.71	1.57
U	2	7.55	3.61	1.53
S	2	11.15	5.58	2.36
SxU	4	10.95	2.51	1.06
Error	16		2.36	
Total	26	135.47	5.21	

CV= 25% ss=sum square ms=mean square sv=source of variance df=degree freedom Fcal=F calculated Ftab= F table*= significant

Appendix-8. analysis of variance leaf width

SV	Df	ss	ms	Fcal
Block	2	14.26	7.13	3.43
Trt	8	40.2	5.03	2.41
U	2	7.2	3.6	1.73
S	2	27.77	13.89	6.68*
SxU	4	5.23	1.31	0.63
Error	16	33.29	2.08	
Total	26	87.75		

CV= 35.69% ss=sum squarems=mean square sv=source of variance df=degree freedom Fcal=F calculated Ftab= F table *= significant

Appendix-9. analysis of variance above ground dry

SV	Df	ss	ms	Fcal
Block	2	14.75	1.23	0.63
Trt	8	13.34	1.11	0.14
U	2	4.83	0.4	0.2
S	2	4.2	0,35	0.18
SxU	4	4.31	0.36	0.36
Error	16	12.02	0.75	
Total	26	40.11		

CV = 65% ss=sum square ms=mean square sv=source of variance df=degree freedom Fcal=F calculated Ftab= F table

Appendix-10. analysis of variance root diameter

SV	Df	Ss	ms	Fcal
Block	2	4.3	2.04	0.94
Trt	8	11.89	1.49	0.65
U	2	0.76	0.38	0.17
S	2	2.56	1.28	0.56
SxU	4	8.57	4.29	1.9
Error	16	36.7	2.29	
Total	26	53.89	2.04	

CV = 134% ss=sum square ms=mean square sv=source of variance df=degree freedomFcal=F calculated Ftab= F table *= significant

Appendix-11. analysis of variance underground dry weight

s.v	Df	Ss	ms	Fcal
Block	2	0.223		
Trt	8	9.417	1.17	10.234
U	2	4.165	2.08	18.104*
S	2	1.52	0.76	6.608*
SxU	4	3.73	0.9	7.826*
Error	16	1.85	0.115	
Total	26	11.49	1.04	

Cv= 44% ss=sum squarems=mean square sv=source of variance df=degree freedomFcal=F calculated Ftab= F table *= significant

Appendix-12. analysis of variance underground fresh weight

s.v	Df	Ss	ms	Fcal
Block	2	169.50	84.75	5.24
Trt	8	245.63	30.70	1.90
U	2	96.49	48.24	2.988
S	2	72.70	36.35	2.25
SxU	4	76.435	19.109	1.18
Error	16	258	16.14	
Total	26	673.52	25.90	

C v%=7.13 ss=sum square ms=mean square sv=source of variance df=degree freedomFcal=F calculated Ftab= F table * significant

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