

## Research Article

# Influence of Plant Density and Nitrogen Fertilizer Rates on Yield and Yield Components of Beetroot (*Beta vulgaris* L.)

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Ethiopia is endowed with diverse agroecologies suitable for the production of tropical, subtropical, and temperate vegetables. Agronomic practices such as plant density and fertilizer management are known to affect the crop environment, which influences the growth and ultimately the yield. So far limited research has been done on plant density determination and rate of nitrogen fertilizer in Ethiopia in general and the study area in particular. Thus, this experiment was carried out to evaluate the influence of plant density and nitrogen fertilizer rates on the yield and yield components of beetroot (*Beta vulgaris* L.). Four plant densities (133 333, 100 000, 80 000, and 66 666 plants per hectare) and four nitrogen (N) fertilizer rates (0, 46, 92, and 138 kg N ha<sup>-1</sup>) were arranged in a factorial combination in a randomized complete block design with three replications. The results revealed that the main and interaction effects of plant density and nitrogen fertilizer rates on total root yield, root length, root fresh weight, root diameter, and total soluble solute of beetroot were significant. The highest root yield of beetroot was achieved from the combination of 66 666, 80 000, and 10 0000 plant ha<sup>-1</sup> with 92 kg N ha<sup>-1</sup>, whereas the lowest root yield of beet was obtained from the combination of 0 kg N ha<sup>-1</sup> with a planting density of 133 333 plants ha<sup>-1</sup>. The economic analysis showed that higher net benefit and marginal rate of return were obtained from the application of 92 kg N ha<sup>-1</sup> with plant densities of 66 666 plants ha<sup>-1</sup>. In order to prevent excessive production costs, the use of 66 666 plants ha<sup>-1</sup> combined with the application of 92 kg N ha<sup>-1</sup> is recommended.

## 1. Introduction

Beetroot (*Beta vulgaris* L.) is a member of the Chenopodiaceous family which has silver beet, sugar beet, and fodder beet [1]. Beetroot has three basic varieties: chard, grown specifically for its leaves; beets, grown for their bulbous root and leaves (with varieties in white, yellow, and red roots); and sugar beets, grown for producing sugar from the long thick roots. Beetroot produces green tops and a swollen root during its first growing season. It is highly productive and usually free of pests and diseases [2]. Most types of beet plants are tolerant to heat but thrive in environments with temperatures between 15 and 18°C in full sun and can also withstand cold temperatures [3]. It attains the best color, texture, and quality in cool weather conditions. Red beets are also widely used in the food industry [4] and are rich in several vitamins; hence, they are ideal vegetables for health-conscious people [1].

Agronomic practices such as plant density and fertilizer management are known to affect the crop environment, which influences the growth and ultimately the yield [5, 6]. Optimum population and nitrogen levels should be maintained to exploit maximum natural resources, such as nutrients, sunlight, and soil moisture, to ensure satisfactory growth and yield. The plant density of cultivated land is a major factor in determining the quality and quantity of the beetroots. Optimum plant density provides a larger area which allows the plant a sufficient quantity of water and light and thus raises the efficiency of photosynthesis thereby increasing the productivity of beetroot [7]. Research evidence suggests that planting density affects the growth and yield of beetroot. According to Ramazan [8], a higher root yield was obtained at a planting density of 111 111 plants ha<sup>-1</sup> compared to a population per hectare of 55 555 plants. In addition, Sogut and Arioglu [9] reported that plant

density at 148 148, 111 111, and 88 889 produced higher root yields than 74 074 and 63 492 plants per hectare. Nemeat-Alla [10] reported that planting sugar at a population of 100 000 plants ha<sup>-1</sup> caused significant increases in root diameter but did not affect root length and total soluble solids. On the other hand, Bhullar et al. [11] stated that the plant population of 100 000 plants ha<sup>-1</sup> produced the lowest beetroot diameter and highest root length and root yields.

Nitrogen (N) is one of the most important nutrients in determining plant growth and crop yield [12]. It is a component of proteins, enzymes, and vitamins in plants as well as many structural, genetic, and metabolic compounds (chlorophyll) in plant cells and is required for biomass production [13]. Most farmers apply N fertilizer to increase crop yields. Insufficient supply of N can reduce plant N content and rate of photosynthesis [14] and concomitantly reduce plant growth and quality of harvestable materials [15]. The optimal application of N fertilizers positively impacts production. However, oversupply of N does not always lead to increased yield, and it might actually result in reduced growth and yield. Excessive applications of N fertilizers result in delayed maturity and competition between sink (tubers) and supply (leaves) and may lower yields [16]. Excessive N application does not only delay plant maturity but limits the formation of storage organs, especially for crops where roots and tubers are harvested. This leads to lower yields and may reduce the postharvest root quality in terms of flavor and sugar content, pH, and firmness [17]. Different scholars recommended different rates of N fertilizer for beetroot. El-Hosary et al. [18, 19] found that increasing N fertilizer levels caused significant differences in yield, yield components, and quality of sugar beet. Seadh [20] stated that growth characters, yields, and its components significantly increased as the N fertilizer level increased. Khalil [21] found that increasing N levels significantly increased root length, root diameter, root fresh weight, and root yield plant<sup>-1</sup>. Abdou et al. [22] indicated that increasing N fertilizer level significantly increased root fresh weight, root length, and diameter as well as total soluble solutes (TSS) and root yield. Ouda [23] found that root diameter, root length, root fresh weights as well as root yield, and TSS percentage were increased by raising N levels. Similarly, Abdou [24] reported increasing N levels significantly reduced TSS percentages. In contrast, other studies showed that TSS was significantly reduced when N rates were increased [25, 26].

Ethiopia is endowed with diverse agroecologies appropriate for the production of tropical, subtropical, and temperate vegetables within the lowlands, midlands, and highlands [27]. The warm-season vegetables are produced in hot semiarid areas under both dryland and irrigation, while the highland offers favorable growing conditions for the production of cool-season vegetables such as kale (*Brassica oleracea* L. var. *acephala*), cabbage (*Brassica oleracea* L. var. *capitata*), garlic (*Allium sativum* L.), shallot (*Allium cepa* L. var. *aggregatum*), carrot (*Daucus carota* L.), and beetroot [27, 28]. In Ethiopia in general and in the study area in particular, beetroot is relatively new and a lot of people do not know how to grow it while it is increasingly gaining a high level of economic importance in both generation of

income and provision of good nutrition. The major constraints in the production of beetroot in Ethiopia are poor agronomic practices including the use of inappropriate planting density and N fertilizer rates due to lack of adequate information on its cultivation which reduces the yield and quality of the crop. Therefore, it is necessary to establish the optimum plant density and N application rates for the increased weight and quality of beetroot. The objectives of this study were to evaluate the influence of plant density and N fertilizer rates on the yield and quality of beetroot.

## 2. Materials and Methods

**2.1. Description of the Experimental Site.** The experiment was conducted at Arba Minch University Gircha Highland Fruit and Vegetable Research Center, Ethiopia. It is located at 37° 60' E and 6°13' N with an altitude ranging from 3005 masl and a mean annual rainfall of 1800 mm. The mean annual temperature of the area is 22.5°C. The soil used in the study is clay loam with pH 4.8, 0.308% N, 3.2 mg L<sup>-1</sup> P, 11.2 mg L<sup>-1</sup> K, and 2.4% OC [29, 30].

**2.2. Experimental Treatments, Design, and Management.** The experiment was laid out as a randomized complete block design (RCBD) with factorial arrangements of 4 × 4 = 16 treatment combinations and three replications for two consecutive years (2018 and 2019). The treatments consisted of four plant densities, namely, 133 333, 100 000, 80 000, and 66 666 plants ha<sup>-1</sup> and four rates of N fertilizer, namely, 0, 46, 92, and 138 kg N ha<sup>-1</sup>. Each plot was 3 m × 3 m in size consisting of six rows. The distances between plots and replications were 0.5 and 1.0 m, respectively. Ground lime (CaCO<sub>3</sub>) at the rate of 2.25 t ha<sup>-1</sup> was added one month before planting to reduce soil acidity, and phosphorus (P) fertilizer was applied uniformly to all experimental plots at the rate of 46 kg ha<sup>-1</sup>. Half of N for the respective treatments and all P were applied at the time of seed sowing, and the remaining N was applied 45 days after sowing. Urea and Triple Super Phosphate (TSP) were used as the sources of N and P fertilizer, respectively, and a beetroot variety called Detroit red was planted. All other agronomic practices were kept uniform for all experimental units.

**2.3. Data Collection.** Data on all parameters were taken after 97 days after seeding. Data were collected on total root yield (t ha<sup>-1</sup>) by weighing the below-ground beetroot parts after washing. Total fresh mass (t ha<sup>-1</sup>) was determined by weighing the mass of the entire plant (above- and below-ground portion) after washing. Root length (cm) and root diameter (cm) were determined by measuring at right angles to the vertical and horizontal axis, respectively, using a caliper, model CD 8. Total soluble solids of roots were measured using a hand refractometer, model REF-113ATC.

**2.4. Data Analysis.** Analysis of variance (ANOVA) was carried out for all data using SAS version 9.1 software [31]. Homogeneity of error variance was tested using the F test as

described by Gomez and Gomez [32], and the F test was not significant. Thus, a combined analysis of the two-year data was performed. The least Significant Difference (LSD) at the 5% probability level was carried out for mean separation.

**2.5. Partial Budget Analysis.** The partial budget analysis was carried out by using the methodology described in CIMMYT [33] in which prevailing market prices for inputs at sowing and outputs at harvesting were used. All costs and benefits were calculated on a hectare basis in Ethiopian Birr (ETB). The mean grain yields were adjusted down by subtracting 10% to approach the real production conditions. Total variable costs were calculated as cost of inputs (100 kg Urea/1390 ETB + one kg beetroot seed/880 ETB) plus fertilizer application and seed sowing costs (75 birrs/person/day). The current open market price of 100 kg root yield was 700 ETB, and the mean root yield of each treatment was calculated. The net benefit (NB) was obtained by subtracting total variable costs from the gross benefit. In addition, the marginal rate of return was also calculated as a change in net benefit/change in total variable cost  $\times 100$ . For a treatment to be considered as worthwhile to farmers, with the highest net benefit and marginal rate of return,  $>100\%$  was considered for the recommendation [34].

### 3. Results and Discussion

**3.1. Summary of ANOVA.** A summary of ANOVA for the attributes measured in this study is shown in Table 1. According to the analysis variance, there were highly significant ( $P < 0.01$ ) differences between levels of experimental factors for all studied traits. Interaction of plant density and nitrogen fertilizer was highly significant ( $P < 0.01$ ) on root yield and root length, but root fresh weight, root diameter, and TSS were not significant ( $P > 0.05$ ).

**3.2. Root Yield.** The higher root yield of beet was achieved from the combination of 92 kg N ha<sup>-1</sup> with a plant density of 66666 80 000 and 10 0000 plant ha<sup>-1</sup> whereas the lowest root yield of beet was obtained from the combination of 0 kg N ha<sup>-1</sup> with a planting density of 133333 plants ha<sup>-1</sup> (Figure 1). Increasing the nitrogen level of the fertilizers up to 92 kg N ha<sup>-1</sup> increased the total yield of beetroot and the trend decreased at the highest level (138 kg N ha<sup>-1</sup>). This might be due to more available nutrients which increased all the growth and yield attributes of the crop that finally led to increased beetroot yield [35]. Leilah et al. [36] reported that root yield increase is caused by high N levels due to N playing an important role in enhancing growth, chlorophyll formation, the photosynthesis process, and other variables contributing to yield improvement. Hamidia et al. [37] stated that biomass yield decreases progressively as the number of plants increases in a given area because the production of the individual plant is reduced. Moreover, Khaiti [38] mentioned that the use of a high population increases interplant competition for light, water, and nutrients, which can be detrimental to final yield. El-Hosary et al. [18–20] stated that root yields of sugar beet are significantly increased as nitrogen fertilizer levels increased.

**3.3. Root Length.** Root length was significantly higher where N fertilizer was applied at 92 kg N ha<sup>-1</sup> combined with a plant density of 80000 plants ha<sup>-1</sup> than other treatment combinations used, except where 138 kg N ha<sup>-1</sup> and 80000 plants ha<sup>-1</sup> were used (Figure 2). On the other hand, the lowest root length was recorded where N fertilizer was applied at 0 kg N ha<sup>-1</sup> with a plant density of 133333 plants ha<sup>-1</sup>. This is because at a wide spacing there will be more empty space and no competition for nutrients, water, and light that affect photosynthesis. Sadre et al. [39] mentioned that the increase in root length can be explained through the fact that the higher biomass in treatments having comparatively less plant density was possibly due to optimum utilization of soil and other environmental resources with lower competition by the crop. Mustafa [40] suggested that the nitrogen element may be playing an important role in increasing cell elongation and cell division. Abdou et al. [21, 22] stated that increasing nitrogen levels significantly increased root length. Amin [41] reported that the application of N fertilizer at high rates increases root length.

**3.4. Root Fresh Weight per Plant.** The data in Table 2 indicate that the plant density of 66 666 plants ha<sup>-1</sup> had a significantly higher root fresh weight of beetroot than the other plant density treatments while 133 333 plants ha<sup>-1</sup> resulted in the lowest root fresh weight of beetroot. The plant densities of 80 000 plants ha<sup>-1</sup> increased yields significantly over the crop that was sown at 133333 and 100 000 plants ha<sup>-1</sup>. The root fresh weight per plant at a wide spacing was greater than the fresh weight at narrow plant spacing. This is because the nutrients, water, and sunlight can be received optimally and the competition between plants can be minimized in widely spaced rows, thereby increasing the yield of plants in the form of arrowroot tubers [42]. Root fresh weight increased with increasing levels of N (Table 2). The highest root fresh weight was obtained from the application of 92 and 138 kg N ha<sup>-1</sup>, while the lowest root fresh weight was obtained from 0 kg N ha<sup>-1</sup>. At 138 kg N ha<sup>-1</sup>, the root fresh weight was not significantly different from that obtained at the 46 kg N ha<sup>-1</sup> application rates. In addition, no significant differences in root fresh weight were found between 46 kg N ha<sup>-1</sup> and control (0 kg N ha<sup>-1</sup>). The increase in root fresh weight per plant was accompanied by the increase in root dimensions (i.e., length and diameter). This is maybe the effective role of nitrogen fertilizer on cell division and elongation which consequently reflected on root fresh weight [22]. Supplying beetroot plants with N fertilizer up to 100 kg N ha<sup>-1</sup> increased root fresh weight [43]. Turk [44] found that the application of N fertilizer had a significant effect on beetroot fresh weight.

**3.5. Root Diameter.** The plant density of 66 666 plants ha<sup>-1</sup> had a significantly higher root diameter of beetroot than the other plant densities while 100 000 plants ha<sup>-1</sup> resulted in the lowest root diameter of beetroot (Table 2). The data also indicate that crops sown at 80 000 plants ha<sup>-1</sup> resulted in higher root diameter compared with the crop sown at 133 333 and 100 000 plants ha<sup>-1</sup>. However, nonsignificant differences were observed

TABLE 1: Combined analysis of variance showing mean squares for root yield and other parameters of beetroot influenced by plant density and nitrogen fertilizer rates.

Source variation	Mean square				
	Root yield	Root fresh weight	Root length	Root diameter	Total soluble solute
Plant density (PD)	10.956**	3318.92**	193.08**	3.813**	18.271**
Nitrogen (N)	35.806**	237.28**	218.75**	9.220**	1.646**
PD * N	0.786**	5.21 <sup>ns</sup>	10.49**	0.331 <sup>ns</sup>	0.048 <sup>ns</sup>
Error	0.258	39.37	3.59	0.173	0.062
CV %	7.49	11.33	4.3	7.18	3.61

Where, CV stand for Coefficient of Variation; \*\* stand for significance at  $P < 0.01$ , respectively; NS stands for non-significant at  $P < 0.05$ .

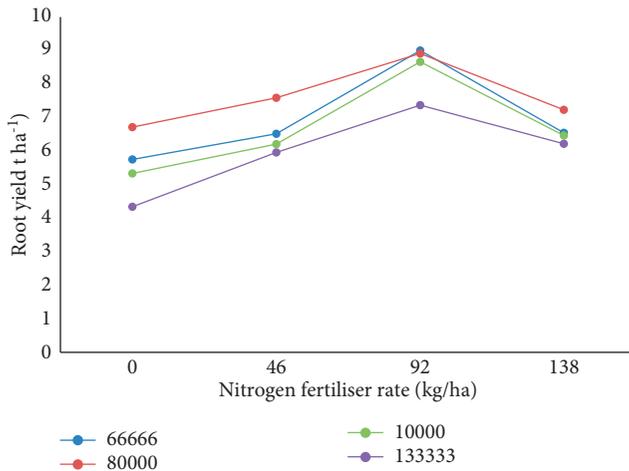


FIGURE 1: Interaction effects of plant density and nitrogen fertilizer rates on root yield ( $t\ ha^{-1}$ ) of beetroot.

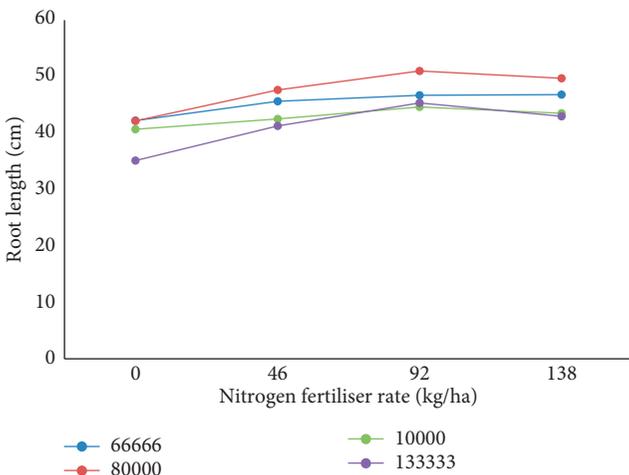


FIGURE 2: Interaction effects of plant density and nitrogen fertilizer rates on root length (cm) of beetroot.

in root diameter where the crop was sown at 133 333 and 100 000 plants  $ha^{-1}$ . These results are confirmed with the findings of [45] which stated that wider row spacing gave more space to roots to grow horizontally and root diameter was wider. Kogali et al. [46] stated that wider row spacing resulted in wider root diameter. Heitholt and Sassenrath-Cole [47] reported that spacing affects the root diameter of beetroot. Beetroot diameter

increased with increasing rates of N (Table 2). Diameter of plants receiving 92 and 138  $kg\ N\ ha^{-1}$  was significantly wider than those that did not receive N applications and those that received 46  $kg\ N\ ha^{-1}$ . Nitrogen at 46  $kg\ N\ ha^{-1}$  resulted in a significantly wider beetroot diameter than the control. Application of N at 92 and 138  $kg\ ha^{-1}$  did not differ significantly in influencing the beet diameter. The reason for maximum beet diameter in plants receiving more N may be due to the fact that these plants were more healthy and vigorous than others [48]. These results are confirmed by [44] who found that increasing the N fertilizer rates increased beetroot diameter.

3.6. Total Soluble Solute (TSS). Plant density of 66 666 plants  $ha^{-1}$  had a significantly higher TSS concentration while 133 333 plants  $ha^{-1}$  resulted in the lowest TSS concentration (Table 2). Plant densities of 80 000 plants  $ha^{-1}$  resulted significantly in higher TSS compared to those of 133 333 and 100 000 plants  $ha^{-1}$ . The data also indicate that crops that were sown at 100 000 plants  $ha^{-1}$  resulted in more TSS than those plants at a density of 133 333 plants  $ha^{-1}$ . The gradual increase in TSS that was accompanied with the decrease in plant populations may be due to the fact that the increase in plant population results in the decrease of sucrose content in beetroots [49]. Kirimi et al. [50] reported that higher TSS obtained at wider spacing might be due to translocation of assimilates (a major constituent of TSS) affected by growing conditions through the rate of assimilating export from the leaves. Nitrogen level significantly influenced TSS of beetroot (Table 2). The application of N at 138  $kg\ N\ ha^{-1}$  resulted in significantly more TSS than the control level (0  $kg\ N\ ha^{-1}$ ). Total soluble solids of plants receiving 138  $kg\ N\ ha^{-1}$  were significantly larger than those that received 0, 46, and 92  $kg\ N\ ha^{-1}$ . Nitrogen at 92  $kg\ N\ ha^{-1}$  levels resulted in more TSS than the control level and 46  $kg\ N\ ha^{-1}$ . Also, the application of N at 46  $kg\ ha^{-1}$  resulted in more TSS than the control. Nitrogen being a constituent of protein and amino acids directly affects TSS (Kirimi et al. 2011). The paper [23] found that TSS concentration was increased by raising N levels. The present findings contradicted those of [51] who found that the TSS of carrots was not significantly affected by N fertilizer treatments. The results also contradicted those of [52] who found that there were no significant differences in the TSS of sugar beet when different levels of N were applied. Leilah et al. [36] also stated that high N levels increase the moisture content in root tissue, resulting in lower TSS. Abdou [24] found that increasing N levels significantly reduced TSS percentages.

TABLE 2: Mean root fresh weight, root diameter, and total soluble solute of beetroot influenced by plant density and N fertilizer rates.

	Root fresh weight	Root diameter	Total soluble solute
Plant density (plants ha <sup>-1</sup> )			
133 333	42.06 <sup>d</sup>	5.54 <sup>c</sup>	5.83 <sup>d</sup>
100 000	50.16 <sup>c</sup>	5.45 <sup>c</sup>	6.57 <sup>c</sup>
80 000	60.39 <sup>b</sup>	5.88 <sup>b</sup>	7.23 <sup>b</sup>
66 666	68.99 <sup>a</sup>	6.33 <sup>a</sup>	7.86 <sup>a</sup>
LSD ≤ 0.05	3.62	0.24	
Nitrogen (kg ha <sup>-1</sup> )			
0	51.39 <sup>c</sup>	4.93 <sup>c</sup>	6.57 <sup>d</sup>
46	54.56 <sup>bc</sup>	5.83 <sup>b</sup>	6.78 <sup>c</sup>
92	58.56 <sup>a</sup>	6.11 <sup>a</sup>	6.97 <sup>b</sup>
138	57.10 <sup>ab</sup>	6.34 <sup>a</sup>	7.18 <sup>a</sup>
LSD < 0.05	3.62	0.24	0.14
CV %	11.33	7.18	3.61

Means followed by the same letter (s) within a column are not statistically different at  $P < 0.05$ .

TABLE 3: Economic analysis for the effect of plant density and nitrogen fertilizer rates on beetroot.

Treatments	Root yield adjusted by 10% (kg ha <sup>-1</sup> )	Gross income (@ 7 ETB kg <sup>-1</sup> )	Total variable cost (ETB ha <sup>-1</sup> )	Net benefit (ETB ha <sup>-1</sup> )	Marginal rate of return (MRR %)
PD <sub>4</sub> NF <sub>1</sub>	5159.70	36117.90	4519.96	31597.94	
PD <sub>3</sub> NF <sub>1</sub>	6018.30	42128.10	5424.00	36704.10	564.82
PD <sub>4</sub> NF <sub>2</sub>	5840.10	40880.70	6059.96	34820.74	D
PD <sub>2</sub> NF <sub>1</sub>	4781.70	33471.90	6780.00	26691.90	D
PD <sub>3</sub> NF <sub>2</sub>	6799.50	47596.50	6964.00	40632.50	255.09
PD <sub>4</sub> NF <sub>3</sub>	8062.20	56435.40	7599.96	48835.44	1289.85
PD <sub>2</sub> NF <sub>2</sub>	5562.00	38934.00	8320.00	30614.00	D
PD <sub>3</sub> NF <sub>3</sub>	7985.70	55899.90	8504.00	47395.90	D
PD <sub>1</sub> NF <sub>1</sub>	3895.20	27266.40	9039.98	18226.42	D
PD <sub>4</sub> NF <sub>4</sub>	5869.80	41088.60	9139.96	31948.64	D
PD <sub>2</sub> NF <sub>3</sub>	7760.70	54324.90	9860.00	44464.90	D
PD <sub>3</sub> NF <sub>4</sub>	6482.70	45378.90	10044.00	35334.90	D
PD <sub>1</sub> NF <sub>2</sub>	5344.20	37409.40	10579.98	26829.42	D
PD <sub>2</sub> NF <sub>4</sub>	5798.70	40590.90	11400.00	29190.90	D
PD <sub>1</sub> NF <sub>3</sub>	6604.20	46229.40	12119.98	34109.42	D
PD <sub>1</sub> NF <sub>4</sub>	5573.70	39015.90	13659.98	25355.92	D

**3.7. Partial Budget Analysis.** Partial budget analysis on plant density with N fertilizer is shown in Table 3. The highest net benefits of ETB 48835.44 ha<sup>-1</sup> and marginal rate of return 1289.85% were obtained from plant density of 66 666 plants ha<sup>-1</sup> with application rates of 92 kg N ha<sup>-1</sup>. The marginal rate of returns of 255.09 and 564.80% was obtained from a plant density of 80 000 plants ha<sup>-1</sup> with application rates of 46 and 0 kg N ha<sup>-1</sup>, respectively. The economic net benefit of ETB 44464.9 and 47395.9 ha<sup>-1</sup> was achieved from plant density of 100 000 and 80 000 plants ha<sup>-1</sup>, respectively, with application rates of 92 kg N ha<sup>-1</sup>. This indicates that N fertilizer at 92 kg ha<sup>-1</sup> with different plant densities was given higher economic benefits. Generally, the application of 92 kg N ha<sup>-1</sup> with 66,666 plants ha<sup>-1</sup> resulted in optimum and profitable root yield. With higher N prices, it becomes more important to fertilize at the most economic rate, which may differ from the agronomic rate. Kiprono et al. [53] found that the economic optimum nitrogen rate changes as market costs and returns change.

## 4. Conclusions

The current investigation showed that the interaction effects of plant density and nitrogen fertilizer rates significantly influence root yield and root length whereas root fresh mass, root diameter, and total soluble solute were influenced by the main effects. The highest root yield of beetroot was achieved from the combination of 66 666, 80 000, and 100 000 plant ha<sup>-1</sup> with 92 kg N ha<sup>-1</sup> whereas the lowest root yield of beet was obtained from the combination of 0 kg N ha<sup>-1</sup> with a planting density of 133 333 plants ha<sup>-1</sup>. The economic analysis showed that higher net benefit and marginal rate of return were obtained from the application of 92 kg N ha<sup>-1</sup> with plant densities of 66 666 plants ha<sup>-1</sup>. So, in order to prevent excessive production costs, the use of 66 666 plants ha<sup>-1</sup> combined with the application of 92 kg N ha<sup>-1</sup> is recommended because it is economic. Further experiments should be conducted considering different combinations of nutrients to fully exploit the yield performance of beetroot under our study area conditions.

## Data Availability

The datasets used to support the findings of this study are available at the hands of corresponding author upon request.

## Conflicts of Interest

The authors declare that they have no conflicts of interest.

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