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DEPARTMENT OF HORTICULTURE

SENIOR RESEARCH PROJECT

EFFECT OF DIFFERENT RATES OF BLENDED NPSB FERTILIZER ON GROWTH AND YIELD ATTRIBUTES OF CARROT (*Daucus carota* L.) AT WOLKITE, SOUTH WESTERN ETHIOPIA

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ABSTRACT

Carrot is one of the most important vegetables in Ethiopia. Its production and productivity are mainly affected by biotic and abiotic factors. Among the abiotic factors, the lack of soil fertility is a critical issue. This study was designed to evaluate the effect of NPSB fertilizer levels on carrot growth and yield components in the study area. An experiment was conducted at Wolkite University, Department of Horticulture field experimental site during 2024 (March-May). The experiment had consisted total five treatments. The experiment was laid out in a randomized complete block design (RCBD) with three replications. The collected data were analyzed using SAS 9.4 software. The growth and yield components of carrot were significantly affected by NPSB fertilizer rate. Application of NPSB at 200 kg ha^{-1} gave the highest growth and yield-related components of carrot in the study area. The highest root diameter (1.6cm) and root length (23.03cm) were obtained from 200kg ha-1 NPSB, whereas lowest root diameter (0.4cm) and root length (5.87cm) were recorded from control treatment. The results showed that an increased fertilizer application had improved carrot growth performance both for vegetative and yield attributes. However, since the data was collected before crop maturity and missing yield performance, it needs further investigation having different location and cropping seasons by allocating appropriate time and resource.

Keywords: *Carrot, Fertilizer, Leaf length, Root diameter, Root length*

1. INTRODUCTION

1.1. Background and Justification

Carrot (*Daucus carota* L.) which belongs to the family Apiaceous is considered to be native to Mediterranean region (Shinohara, 2007). It consists of about 250 genera and approximately 2800 species of widely distributed herbaceous plant (Rubatzky *et al.,* 1999). Carrot is mainly a temperate crop grown during spring in temperate regions and during winter in tropical and subtropical regions of the world (Bose and Som, 2010).

Carrots are consumed all over the world fresh as a salad, crop, or cooked, processed alone or in mixtures with other vegetables by canning, freezing or dehydration. Its versatility makes it possible to be eaten as an accompanying vegetable with almost any meal or alone as a snack (Bertelsen *et al.,* 1994; Amjad *et al.*, 2005). Its root is used as a vegetable which is a rich source of carotene and is sometimes used for coloring butter and other food products (Vanangamudi *et al.,* 2006).

Fresh carrot root contain 86% moisture, 0.9g protein, 10.6g carbohydrate, 0.2g fat, 1.2g fiber, 48kilo calorie energy, 2.2mg iron, 1890mg carotene, 0.04mg thiamine, 0.02mg riboflavin, 0.5mg niacin, 3mg vitamin, 15mg folic acid, 80mg calcium and 30mg phosphorus per 100g of edible portion (Bose *et al.,* 2000). The worldwide consumption of carrot increased over the years and it is now one of the most popular vegetable crops in European countries, USA, China, Japan, Korea and Ethiopia. Its production has been expanding and the total production reached 17,333.427 tons from 4902.90 hectares of land and its productivity is 3.54 ton per hectare (CSA, 2022) in Ethiopia. The area under carrot is increasing from time to time mainly due to its ease of production, and the increases in small scale rain fed and irrigated based production by small holder households both for market and home based consumption.

The productivity of carrot is much lower than other African countries (Tadele and Solomon, 2011). That could be attributed to poor cultural practices including nutrient management and plant to plant spacing. Past research efforts in Ethiopia resulted in the development and release of a number of carrot varieties for different agro-ecologies of the country (Getachew and Mohammed, 2012). To avert the situation, the Ethiopian Ministry of Agriculture has recently introduced a new compound fertilizer (NPSB) that contains nitrogen, phosphorus, boron, and sulfur in the ratio of 19%N, 38% P_2O_5, 0.25% B, and 7% S that substituted DAP in Ethiopian crop production system as main source of phosphorous (MoANR, 2013).

National recommended fertilizer rate are currently used for all carrot varieties both under rain fed and irrigated cultivation. Except blanket recommendation of DAP and Urea, the effect of other fertilizers on yield components, overall performance and quality of carrot has not yet studied in the area. The agronomic practices of crops vary depending on the physical and chemical properties of the soil, the soil moisture status and varieties being under production. Thus, there is a need to investigate area specific recommendation of blended NPSB fertilizer rate and plant density in carrot production to achieve higher root yield for consumption and market. Thus, this study aimed to investigate how blended NPSB fertilizer rate affect growth and yield components of carrots.

1.2. Objectives

1.2.1. General objective

- To investigate the effect of different rates of NPSB fertilizer on the growth and yield attributes of carrot.

1.2.2. Specific objectives

- To evaluate the influence of blended NPSB rates on growth performance of carrot.
- To observe the yield attribute response of carrot to different rate of NPSB fertilizer.

2. LITERATURE REVIEW

2.1. Ecological and cultural requirements of Carrot

Carrots are moderately hardy and also tolerate high temperature but seedlings are more sensitive to both extremes of temperature. The crop grows best above 1000 m.a.s.l, where temperature is between 16 and 21 ^{0}C and rainfall is between 700 to 800mm (Rubatzky *et al*., 2012). In Ethiopia carrot is grown up to 2800 m.a.s.l in the central highlands. Mild freezing weather at maturity stage harms carrot leaves but not the roots. However, carrots grown at lower temperature produce seed stalks before roots attain off market size; such roots have bitter taste and undesirable flavor. High temperatures can cause burning of young seedlings and woody characteristic of the root (Madge *et al*., 2012). Prolonged hot weather later in development may cause an undesirable strong flavor and coarseness in the roots.

According to Getachew and Mohammed (2012) applications of 46 kg P_2O_5 and 41 kg N per hectare will be used by farmers in some parts of Ethiopia for the production of carrot. However, Wassu *et al.* (2014) recommended 46 kg P_2O_5, and 64 kg N after several years of genotypes trial at Harames. On the other hand 80.5 kg P_2O_5 and 31.5 kg N ha^{-1}will be recommended rate for root production for fresh market in Amhara of regional state of Ethiopia (ARARI, 2005).

The sources of plant nutrients for Ethiopian agriculture over the past five decades have been limited to urea, and Diammonium Phosphate (DAP) fertilizers which contain only nitrogen and phosphorus that may not satisfy the nutrient requirements of crops including carrot. However, Hailu (2014) reported that Ethiopian soils lack most of the macro and micronutrients that are required to sustain optimal growth and development of crops. This is exacerbated especially by Ethiopian fertilizer rates that are below international and regional standards (AGP, 2013). Consequently, the yield and productivity of crops including carrot in Ethiopia are much lower than other countries.

Conversely, if the air temperature during the early vegetative period falls below the optimum, long slender roots of much lighter color than typical and unwanted flower stalks (bolters) will appear (Bertelsen *et al.,* 2010). The pigment, carotene, accounts for a high percentage of color in carrots develops best between 15 and 20°C (Greenland, 2010).

Heavy clay soils do not allow smooth root growth and make cultivation, harvesting and washing of harvested roots difficult. Carrots grown on soils with high organic matter tend to become rough, course and hairy they grow in well drained alluvial and sandy loam soils with pH of 6.6 - 7.1 but not in heavy clay and water-logged soils Free-draining and deep sandy soils, with a low water-holding capacity are favored for production of carrot for their ease of cultivation and harvesting. However, because of their low water-holding capacity, irrigation is required for maximum production (Gibberd *et al.,* 2011; Drost and Bitner, 2011). On the other hand, poorly drained soils tend to increase the incidence of hairy roots (Bertelsen *et al.,* 2010).

2.2. Importance of Carrot and Its Production in Ethiopia

Carrot is an important vegetable crop in tropical and subtropical region. In Ethiopia, it is predominantly cultivated as a cash crop. It is mainly consumed in urban areas of the country which is about 15% of the population. However, it is used as source of vitamin A in human nutrition worldwide (www.seedalliance.org). In addition, the country obtains foreign currency by exporting fresh or chilled carrots and turnips. The export value increased from 581 USD in 1997 to 517,172 USD in 2011. Furthermore, a significant number of individuals derive their income from brokering and trading (wholesale or retail) (Getachew and Mohammed, 2012).

2.3. The Effect of Nitrogen on Growth, and Yield of Carrot

2.3.1. Effect of nitrogen on growth attributes of carrot

The availability of N in the soil positively and significantly affects the plant growth and development (Fageria and Baligar, 2011). In addition, several studies were reported that nitrogen is essentially needed for optimum growth, root development, crop canopy expansion and solar radiation interception in carrot (Don Eckert, 2010; Sisay *et al*., 2012; Fageria and Moreira, 2013; Moniruzzaman *et al*., 2013). Nitrogen supply also play an essential role in the balance between vegetative and reproductive growth for plant including carrot as stated by White *et al*. (2011). Nitrogen is very important nutrient in carrot production as the value of the other inputs cannot be fully realized unless N is applied to the crop in an optimum amount (Baniuniene and Zekaite, 2012). Carrot demand for additional nitrogen fertilizer varies between 0-110 kg/ha (Salo, 2010).

Great variation in nitrogen uptake may be related to different climatic conditions, soil type, nutrient concentration and well-developed root system which enable the plants to absorb nitrogen efficiently from the soil. About 85 - 90% of nitrogen is absorbed by carrot during the growth stage of plant; while in the first and last quarter of its growth only 10 - 15% of nitrogen is absorbed. All vegetative growth parameters in carrot gradually and significantly increased by increasing the rate of N fertilizer application up to optimum rate. N fertilization has been reported to increase the average fresh weight, plant height, leaf number, root length, root diameter and dry weight (El-Desuki *et al.,* 2005; Ali *et al.,* 2006; Kandil, 2011; Moniruzzaman *et al.,* 2013). However, inappropriate application of N showed adverse effects on root development of plants. Applications of N fertilizer can increase the yield and yield components of carrot (Moniruzzaman *et al*., 2013). According to Mehedi *et al.* (2012) the highest total (47.35 t ha^{-1}) and marketable yield (39.00 t ha^{-1}) were obtained from 150 kg N ha^{-1}.

2.3.2. Effect of nitrogen on carrot yield attributes

Nitrogen is necessary and important element for increasing the yield and quality of vegetables such as carrot (Gulser, 2011). However, in Samaru, Nigeria, the application of nitrogen significantly increased almost all growth and yield parameters of carrots, and the maximum yield of 15 ha^{-1} was recorded with an application rate of 90 kg N ha^{-1} (Babaji, 2010). Higher rate of N application (200 kg N ha^{-1}) significantly increased root diameter (Gaviola and Lipinski, 2011; Farooqui *et al*., 2012; Hore *et al*., 2011). A lower rate of nitrogen is also increase, carrot root yield and yield components and Tadila, (2011) also found that the highest mean clove weight (2.83 g) at 120 kg N ha^{-1} and highest fresh root weight of carrot at 100 kg N ha^{-1}. Furthermore, they explained that significantly higher carrot root weights and root yield are obtained from the Andosols in response to the application of 92 kg N ha^{-1}, while the highest root diameter was obtained from the application of 138 kg N ha^{-1}.

The total root yield of carrots increases with increasing nitrogen application up to a certain rate and then decreases. According to Gutezeit and Gemuse (2013), Shanmugasundaram and Savithri (2012), and Chen *et al*. (2013), the yield of carrots can be improved with the application of nitrogen fertilizers. Ali *et al.* (2012) studied the effect of different rates of nitrogen on yield and yield contributing characters of three varieties of carrot and having the nitrogen rates (0, 50, 100 and 150 kg N ha^{-1}).

According to the authors, the root yield was significantly influenced by applied nitrogen nutrition. The highest root yield (27.82 t ha^{-1}) was recorded with the application of 150 kg N ha^{-1}, while the lowest yield (18.04 t ha^{-1}) was obtained with zero nitrogen application. N application rate (0, 60, 120, 240 or 480 kg ha^{-1}) on yield, nutrient absorption and N utilization and it will be found that the soluble solids content of roots increased with N rate up to 120 kg ha^{-1} (Chen *et al*., 2003).

2.4. The Effect of Phosphorus on Growth and Yield of Carrot

2.4.1. Effect of Phosphorus on Growths attributes of carrot

Phosphorus is known to be involved in several physiological and biochemical processes of plants being components of membranes, chloroplasts, mitochondria and constituent of sugar phosphate. Phosphorus plays significant role in physiological and biochemical reactions such as photosynthesis and conversion of sugar into starch (Taheri *et al*., 2011).

Kumar *et al*. (2013) stated that Phosphorus increases photosynthesis and indicated that translocation of photosynthesis from source to sink has occurred up to maturity as a result of increased nutrient absorption (Biruk, 2011). In addition Phosphorus helps in nutrients uptake by promoting root growth and thereby increase in total dry matter (Sharma and Yadev, 2011; Rai, 2012). In many soils plant-available Phosphorus is deficient and has to be supplemented with fertilizer and organic amendments (Mikhailova *et al*., 2013; Firew *et al*., 2013; Osono and Takeda, 2010).

Phosphorus shortage restricted the plant growth and remains immature (Hossain, 2010) and results in poor root development and subsequently reduces yield (Jain *et al*., 2010) with a concomitant increase in dry matter, sugar and carotene contents of carrot root (Rao and Maurya, 2011). Phosphorus is a nutrient that should therefore be available in adequate quantities from the early growth stages to maintain a high photosynthetic rate during root development (Hu *et al*., 2010). Carrot is a heavy feeder of nutrients, which removes about 50 kg P_2O_5 per hectare. The crop is very sensitive to nutrient and soil moisture (Rani and MallaReddy, 2011). The phosphorus requirements vary depending upon the nutrient content of the soil (Bose and Som, 2012). Carrot growth and yield components like plant height, number of leaves, root length and root diameter, fresh weight of root, dry weight root and root yield, are greatly affected by phosphorus fertilization (McPharlin *et al.,* 2012; Nahar *et al*., 2012).

Nesa (2013) reported that the maximum marketable carrot yield will be recorded from application of P ha^{-1} whereas the lowest marketable yield will be found in the control treatment (no fertilizer applied). Sadia *et al.* (2013) reported statistically significant variation for yield per hectare of turnip due to the different rate of phosphorus application. Application of organic and inorganic fertilizers influenced the quality of carrot both at harvest. Ascorbic acid, reducing sugar, total sugar and titratable acidity of carrot were significantly affected by the different pre-harvest P fertilizer application (Sisay *et al*., 2011).

2.4.2. Effect of Phosphors on yield attributes of carrot

Phosphorus fertilization at the rate of 50 kg ha^{-1} in irrigated shallot and 25 kg P ha^{-1} in rain fed with supplemental irrigation of shallot showed increased root yield and mean root weight (Kebede, 2013). In contrast Kilgore *et al*. (2012b) reported that increase in P rates from 0 to 44 kg P ha^{-1} had no significant effect on yield of carrot. The effect of different rates of phosphorus application on carrot yield is reported by many researchers. For instance, Sims *et al*. (2013) stated that application of P from 29 to 48 kg P ha^{-1} would usually adequate for better carrot production while in the desert areas; however, rates of P up to 96 kg P ha^{-1} might be needed.

According to Alemu, (2011) increased application of P_2O_5 from 0 to 92 kg ha^{-1} also increased fresh biomass yield and total root yield by 16.52% and 20.61% over the control respectively. Similarly the study of Shege (2011) revealed that the highest root yield will be achieved at 122.6 kg ha^{-1} P_2O_5. The study by (Diriba, 2011) showed that phosphorus application on both Andosols and Vertisols at the rate of 40 kg P ha^{-1} led to the production of heavier cloves, highest root diameter, highest root weight and highest root yield.

2.5. The Effect of Sulfur on Growth, and Yield of Carrot

2.5.1. Effect of sulfur on growth attributes of carrot

Sulfur(S) is one of the essential nutrients for plant growth and it accumulates 0.2 to 0.5% in plant tissue on dry matter basis. Sulfur plays a vital role in improving vegetative structure for nutrient absorption; strong sink strength through development of reproductive structure and production of assimilates to fill economically important sink (Choudhary, 2011) has similar functions in plant growth and nutrition as N and plant requirements for S are comparable to P. Most crops remove 15 to 25 kg S ha^{-1}. Oil crops, legumes, forages, and some vegetables (onions) require more S than P for optimal yield and quality (Fan and Mesick, 2011).

Application of sulfur fertilizer is feasible technique to suppress the uptake of undesired toxic elements (Na and Cl) because of the antagonistic relationship, thus its application is useful not only for increasing crop production and quality of the procedure but also improves soil condition for healthy carrot crop growth. The rate of sulfur element in sol is depleting regularly and this condition has arisen due to the continuous use of sulfur free fertilizers and intensive cropping of high sulfur requiring crops. Leaching and erosion further aid to the melody and the condition has now become so severe that it is expected that 200 metric tons (MT) of negative balance of sulfur can arise by 2025. This condition could adversely affect the yield and quality of the crop (Choudhary, 2015).

Sulfur is the 4th major essential nutrient particularly in carrot. Its role in balanced fertilization and consequently in yield and quality enhancement of carrot is being increasingly appreciated (Choudhary, 2015). Particularly for Allium crops, adequate sulfur (S) supply is needed for the development of pungent flavors and for healthy growth of the plants (Randle, 2010). Sulfur uptake by plants accounts 9 to 15% of nitrogen uptake (Inal *et al*., 2013). Deficiency of S has long been recognized as limiting nutrient for crop production (Yasmin *et al*., 2011). Consequently, poor use efficiency of N by the plant is caused by insufficient S availability to convert N into biomass production, which in turn may increase N losses from cultivated soils (Ceccotti, 20911).

2.5.2. Effect of sulfur on carrot yield attributes

Many research results are indicating that the yield and yield components in seed crops including carrot are increased by the application of Sulfur. For instance, (Sharma *et al.,* 2010; Lancaster *et al.,* 2011; Hariyappa, 2013) reported a significant increase in growth and (Jaggi, 2011; Jaggi and Raina, 2011; Diriba, 2011) in carrot root yield and yield attributes following Sulfur application at 30 kgha^{-1}. As a report of Nasreen *et al*. (2011), the diameter and weight of roots are significantly increased with the application of Sulfur up to 40 kg ha^{-1} and then decreased. Increased average root weight, size and total root yields of carrot with sulfur fertilizer application. They also concluded that carrot recorded maximum dry matter production of leaves and root and root yield (5.75 t ha^{-1}) of carrot at 60 kg S ha^{-1}. Majumdar *et al*. (2013), Wani and Chatto, (2010), Losak and Wisniowska, (2009), Nagaich *et al*. (2003) and Farooqui *et al*. (2011) have also reported increased root and foliage yields and other yield attributes (number of cloves/root, yield/ plant and percent dry weight of root) in carrot under sulfur application ranging from 20 to 60 kg ha^{-1} over no Sulfur.

Verma *et al*. (2012) reported that application of only 90 kg ha^{-1} S produced neck thickness, number of cloves per root, weight of root, root diameter and root yield, whereas, the combined application of 5.0 t ha^{-1} VC along with 60 kg ha^{-1} S will be found to be significantly superior with respect to weight of root (34.55 g), root yield (199.18 q ha^{-1}) and net returns of Hore *et al*. (2014) studied the effect of S (0, 20, 40 and 60 kg S ha^{-1}) on the yield of carrot and found maximum polar diameter (3.67 cm), weight of root (33.68 g), yield per plot (3 kg plot^{-1} and projected yield (7.50 t ha^{-1}) with S 60 kg ha^{-1} and N 200 kg ha^{-1}. Similarly, Jain *et al*. (2011) noticed that combined effect of nitrogen and sulfur showed significant effect on fresh weight of shoot, fresh weight of root, horizontal diameter, vertical diameter, root yield and pyruvic acid content with maximum values at 120 kg N and 60 kg S ha^{-1}.

Study done in central Ethiopia by Diriba, (2011) displayed that significantly higher carrot root weights and highest root yield were obtained from both And sols and Vertisols in response to the application of 60 kg S ha^{-1} and 30 kg ha^{-1} S. Additionally they indicated that the highest root diameter will be obtained from 30 kg ha^{-1} Sulfur on and sols, and 60 kg S ha^{-1} on Vertisols.

2.6. The Effect of Boron on Growth, and Yield of Carrot

2.6.1. Effect of Boron on growth attributes of carrot

Boron is one of the essential nutrients for the optimum growths, development and quality of carrot or other crops. Boron can be applied directly to soil through fertilization or as a foliar spray. Increasing the application of Boron fertilizers from 1 kg to 3 kg ha^{-1} combining with Sulphur with different rates was increase the carrot treats like growth parameters like numbers of sprout per plants, stem diameters and plant height of carrot and the yield parameters like numbers of tuber per plants, marketable tuber and total yield of carrot and decrease unmarketable numbers of tubers per plants by increase the recovery of nutrients in the soil, increase the production of photosynthesis and chlorophyll of the carrot crops and due to application of boron in soil increase the uptake of NPK and Zn which improves the N: S and IAA: ABA and cytokinin: ABA ratio, which induces the formation and growth of stolen mainly due to increase in gibberellin content of plant (Mohammad *et al*., 2017)

2.6.2. Effect of Boron on yield attributes

Boron plays a key role in adverse range of plant function including cell wall formation, stability, maintain of structural and functional integrity of biological membranes. Combined application of NPK and B produced higher tuber yield with reduced cracking of tubers which may be ascribed to either direct or cumulative effect of supplied macro- and micro-nutrients on metabolic processes of potato. Greater tuber yield may further be attributed to increased availability of these nutrients for the actively growing plants, increasing RNA and DNA contents in reproductive tissues, and thereby increased translocation of photosynthetic from source to sink or tubers during entire tuber growth stage (Sarkar *et al*., 2018).

3. MATERIALS AND METHODS

3.1. Description of the study area

The experiment was conducted in Gurage Zone at Wolkite University College of Agriculture and Natural Resource, Department of horticulture demonstration site during 2024. Wolkite University which is found at158 km from Addis Ababa, to south west direction is also located at about 7.8°- 8.5^{0}N latitude, 37.5°- 38.7^{0}E longitudes and also an altitude of 1300m above sea level (GZAO, 2024; Adane and Bewuket, 2023). The annual temperature ranges from 14-24 ^{0}C with an average of 20.5 ^{0}C, and annual rainfall is 1294 mm. Based on the Ethiopian agro ecological classification, site is located in the *Woyna Dega* agro-ecological zones and soil has less capability to drain water (Teshome *et al*., 2018). Soil pH of the experimental site is 5.6 and soil type of the area is Haplic vertisols (Hypereutric) (Teshome *et al*., 2018; Adane and Bewuket, 2023).

3.2. Experimental Material

3.2.1. Planting material

Carrot seed of Nantes variety was used for this particular experiment. The roots are cylindrical with a slight shoulder and blunt tip. Its adaptation area is low to high altitudes (500 - 3000 m.a.s.l) and rainfall of 1244mm per annual. The seed was obtained from department of horticulture.

3.2.2. Fertilizer

NPSB fertilizer, which contains 19% nitrogen, 38% P_2O_5, 7% sulfur and 0.1% boron was used for the study. The fertilizer was bought by Horticulture Department of Wolkite University.

3.3. Treatments and Experimental design

The experiment had consisted of five rates of blended NPSB fertilizer (0, 50, 100, 150 and 200 kg ha^{-1}). The experimental design was arranged in a Randomized complete block design (RCBD) within three replications.

The treatment was assigned randomly to each plot consisting of 6 rows. The spacing between rows and plants was 20 cm and 10 cm, respectively. A distance of 0.5 m and 1 m was maintained between plots and replications, respectively. The single plot size was 2.04m^2 (1.2 m x 1.7 m). The gross area of the experiment was 58.8 m^2

3.5. Experimental procedures

A seed of "Nantes" carrot variety was soaked with water for 24 hours prior to sowing to facilitate germination. A seed was sown on March, 2024 on fine seed bed and slightly covered the seeds to protect from direct sun light. Full doze of blended NPSB fertilizer was applied at time of sowing as per the treatments. The fertilizers was placed in bands along the planting row and mixed with soil. Immediately after sowing, all seedbeds were mulched uniformly to regulate the existing low temperature during growing period. The seedling was thinned three weeks after emergence of seedlings to one plant keeping the distance between two carrot plants (Abiyot, 2010). All the cultural practice including weeding, irrigation, and others a production practice was done uniformly in all plots as per the recommended practices of the crop.

3.6. Data collected

Number of leaves per plant: was recorded by counting number of leafs from five randomly selected plants and the average value was taken.

Leave length per plant (cm): was measured from the base of the leave to the tips leave from five randomly selected plants and average value was taken.

Root length (cm): was recorded from five randomly selected plants and the average value was taken.

Root Diameter (mm): was recorded from five randomly selected plants and the average value was taken.

Leaf canopy diameter (cm): was recorded from five randomly selected plants and the average value was taken.

3.7. Data Analysis

Data was subjected to Analysis of variance (ANOVA) by using SAS software version 9.4, and when there is a mean difference among treatments, the significant differences among treatments was separated by using LSD at 5% significance level .

4. RESULT AND DISCUSSION

4.1. Leaf length (cm)

The analysis of variance showed that NPSB fertilizer application had a highly significant ($P<0.01$) effect on carrot leaf length (Appendix Table 1). The maximum (34.65cm) carrot leaf length was recorded from 200 kg ha^{-1}, while the shortest (11.47cm) leaf length from the control treatments (Table 2). The result indicated that application of NPSB fertilizer enhanced the vegetative growth of carrot. The increased leaf length with chemical fertilizer application could be due to improved chlorophyll content in carrot Yanti *et al.* (2020) that contributed for photosynthesis processes to produce maximum assimilate. Anjum and Amjad (2002) and Nesa (2007), had reported that increasing the rates of fertilizer, increased the leaf length of carrot plant. However, it is difficult to generalize the result for the experiment since the carrot plant was at active vegetative growth stage.

Table 2. Effect of NPSB fertilizer on carrot leaf length at 68 day after planting

Fertilizer level (kg ha^{-1})	**Leaf length (cm)**
0	11.47^{e}
50	16.18^{d}
100	20.41^{c}
150	25.69^{b}
200	34.65^{a}
LSD (0.05)	3.05
CV (%)	7.47

LSD= Least significant difference at 0.05 level of significant, CV= Coefficient of variation, Means with the same letter indicate not significant difference

4.2. Number of leave per plant

The analysis of variance showed that NPSB fertilizer had a highly significant ($P<0.01$) effect on carrot leaf number (Appendix Table 2) and maximum (23) leaf number was recorded from treatments received 200kg ha^{-1}, while the smallest leaf number of 3.93 was recorded from control treatments (Table 3). The result indicate the applications of inorganic fertilizer increased the soil fertility as well as the carrot number of leaf.

This result in agreed with the finding of Islam (2017) who reported that the increase leave number with respect to increased NPSB application rate indicates maximum growth of the plants under higher NPSB availability.

Table 3. Effect of NPSB fertilizer on carrot leaf number 68 day after planting

Fertilizer level (kg ha^{-1})	**Leaf number**
0	3.93^{e}
50	7.93^{d}
100	12.47^{c}
150	17.90^{b}
200	23.0^{a}
LSD (0.05)	3.3
CV (%)	13.39

LSD= Least significant difference at 0.05 level of significant, CV= Coefficient of variation, Means with the same letter indicate not significant difference

4.1. Root length

The ANOVA showed that NPSB fertilizer had positively influenced carrot root length (Appendix Table 3). The highest and lowest root length of carrot were recorded at 200 and 0kg ha^{-1} NPSB fertilizer treated plots respectively (Table 4). The study showed when increasing the level of NPSB fertilizer, correspondingly increase carrot root length. This result inline with work of John Smith (2023)) who reported that the increase root length with respect to increased NPSB application rate indicating maximum growth of the plants under higher NPSB due to availability of macro and micro nutrients.

Table 4. Effect of NPSB fertilizer on carrot root length 68 day after planting

Fertilizer level (kg ha^{-1})	**Root length (cm)**
0	5.87^{d}
50	9.77^{d}
100	14.53^{bc}
150	18.47^{ab}
200	23.03^{a}
LSD (0.05)	4.86
CV (%)	18.00

LSD= Least significant difference at 0.05 level of significant, CV= Coefficient of variation, Means with the same letter indicate not significant difference

4.2. Root diameter

The data analysis showed that NPSB fertilizer had significantly affected carrot root length (Appendix Table 4). The highest (15.62mm) carrot root diameter was recorded from pot with 200kg NPSB ha^{-1} that was statistically similar with mean value from 150kg NPSB ha^{-1} (Table 5), Similar with the current result, El-Desuki *et al*. (2005) reported that the root diameter of carrot had significantly increased with increase of NPSB fertilizer rates.

Table 5. Effect of NPSB fertilizer on root diameter 68 day after planting

Fertilizer level (kg ha^{-1})	**Root diameter (mm)**
0	1.18^{c}
50	3.67^{c}
100	6.96^{c}
150	11.93^{ab}
200	15.62^{a}
LSD (0.05)	4.81
CV (%)	13.45

LSD= Least significant difference at 0.05 level of significant, CV= Coefficient of variation, Means with the same letter indicate not significant difference

4.3. Canopy diameter

The experiment had shown a significant difference among the treatments on carrot canopy diameter (Appendix Table 5). The maximum canopy (34.7cm) size was recorded from plot received 200 kg NPSB ha^{-1}. Though statistically similar with that of 150 kg NPSB ha-1 and the smallest (10.83cm) canopy size was recorded from control treatment (Table 6), From the experiment, it was observed that application of chemical fertilizer at higher rate increased canopy size until some point. The result of this research work is concomitant with the findings reported by Pervez *et al.* (2004), who observed that the canopy diameter of carrot had significantly increased with increased application of chemical fertilizer rates

Table 6. Effect of NPSB fertilizer on carrot canopy 68 day after planting

Fertilizer level (kg ha^{-1})	**Carrot canopy (cm)**
0	10.83^{d}
50	20.10^{c}
100	21.70^{c}
150	28.21^{b}
200	34.70^{a}
LSD (0.05)	5.13
CV (%)	11.79

LSD= Least significant difference at 0.05 level of significant, CV= Coefficient of variation, Means with the same letter indicate not significant difference

5. CONCLUSION AND RECOMMENDATIONS

As per the result, it was observed that fertilizer rate had shown increasing trends for the growth and yield attributes considered for this particular experiment giving lowed values for control treatment and maximum mean values with 200 kg ha^{-1} NPSB fertilizer application. The maximum carrot leaf length (34.65cm), leaf number (23.0), root length (23.03cm), root diameter (15.62cm), and canopy diameter (34.70cm) were recorded from plot received 200kg/ha NPSB fertilizer. The data for the experiment was recorded at early growth stage making difficulty to observe the treatment effects that would be at maturity stage of the crop. From the experiment, it might not be the right time for generating concluding remark regarding the treatment effect. So, such research shall be repeated considering time of plantation for maturity of carrot and in different location and time by other researchers.

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7. APPENDIXES

Appendix Table 1. ANOVA table of leaf length

Source of variation	DF	SS	MS	F-Value	P-Value
Rep	2	47.55	23.78	9.06	0.0088
Trt	4	961.11	240.28	91.57	<.0001
Error	8	20.99	2.62		
Total	14	1029.66			

Rep= Replication, Trt= Treatments, DF= Degree of freedom, MS= Mean square, F= F-calculated, P-value= Probability value at 0.01 or 0.05

Appendix Table 2. ANOVA table of leaf number

Source of variation	DF	SS	MS	F-Value	P-Value
Rep	2	157.20	78.60	25.75	0.0003
Trt	4	696.48	174.12	57.04	<.0001
Error	8	24.42	3.05		
Total	14	878.097			

Rep= Replication, Trt= Treatments, DF= Degree of freedom, MS= Mean square, F= F-calculated, P-value= Probability value at 0.01 or 0.05

Appendix Table 3. ANOVA table of root length

Source of variation	DF	SS	MS	F-Value	P-Value
Rep	2	59.72	29.86	4.48	0.0495
Trt	4	556.06	139.02	20.87	0.0003
Error	8	53.30	6.66		
Total	14	669.07			

Rep= Replication, Trt= Treatments, DF= Degree of freedom, MS= Mean square, F= F-calculated, P-value= Probability value at 0.01 or 0.05

Appendix Table 4. ANOVA table of root diameter

Source of variation	DF	SS	MS	F-Value	P-Value
Rep	2	48.28	24.14	3.70	0.0729
Trt	4	419.22	104.80	16.05	0.0007
Error	8	52.23	6.53		
Total	14	519.73			

Rep= Replication, Trt= Treatments, DF= Degree of freedom, MS= Mean square, F= F-calculated, P-value= Probability value at 0.01 or 0.05

Appendix Table 5. ANOVA table of carrot canopy

Source of variation	DF	SS	MS	F-Value	P-Value
Rep	2	1.15	0.58	0.08	0.9260
Trt	4	966.41	241.60	32.53	<.0001
Error	8	59.42	7.43		
Total	14	1026.99			

Rep= Replication, Trt= Treatments, DF= Degree of freedom, MS= Mean square, F= F-calculated, P-value= Probability value at 0.01 or 0.05