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Growth and Yield of Cabbage (*Brassica oleracea* L.) as Influenced by Different Rates of Nitrogen Fertilizer at Guder, West Shoa, Ethiopia

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Abstract: Cabbage (Brassisca oleracea L.) is biennial crop with a very short stem supporting a mass of overlapping leaves to from a compact head. It is grown for its head in more than ninety countries throughout the world. Cabbage is grown under irrigation and rain fed condition in Ethiopia. Ethiopia accounted for 12% of the total production in Africa (Nicolas *et al.,* 2012). The production of cabbage can be increased either by improving inherent genetic potential of the crop or through application of better agronomic management such as fertilizer rate which contribute to substantial amount of crop. A field experiment was conducted under irrigation in Guder, West Shoa Ethiopia to evaluate the effect of different rate of nitrogen fertilizer on the growth and yield of cabbage. Four nitrogen rates (0, 50, 100, and 150kg/ha) were used as a treatment. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. The study results revealed that plant height, leaf number per plant, leaf length, leaf width, head diameter, fresh head weight, dry weight and marketable yield were highly significantly ($p<0.01$) affected while spread of plant was significantly ($p<0.05$) affected by nitrogen fertilizer rates. The highest plant height (32.37cm), number of leaves plant^{-1} (11.45), leaf length (25.57 cm), leaf width (28.07cm), head diameter (11.83 cm), spread of plant (43.70 cm), fresh head weight (0.810 kg plant^{-1}), dry weight (0.0117 kg plant^{-1}), and the highest marketable head yield hectare^{-1} (79.83 ton ha^{-1}) were obtained at 150kg ha^{-1} of nitrogen rate. Therefore, application of 150kg nitrogen fertilizer per hectare was suitable for cabbage production to obtain higher head yield in the study area.

Keywords: Cabbage**,** Growth, Yield, Nitrogen, Fertilizer

1. Introduction

Cabbage (*Brassica oleracea* L.) is one of important leafy vegetables belonging to the family Cruciferae. Wide range of environmental condition is suitable for easy growth of cabbage. It can grow in temperate and tropical region though cool moist climate is suitable for better growth and yield [1].

Daily temperature of 17°C with mean maximum of 24°C and minimum of 10°C is required for optimum growth. Relative humidity ranging from 60 and 90% is also required for optimum growth and yield [2].

Cabbage is grown throughout the world in more than 90 countries for its head [3]. It is rich in its vitamin A and C content and can be used in slaw, salads or cooked dishes [4]. It has cooling effects helping as an appetizer, aids digestion and preventing constipation.

Cabbage is herbaceous biennial and grown under irrigation and rain fed condition in Ethiopia. Cabbage produced in Ethiopia accounted for 12% of the total production in Africa [5]. In 2016/17 cropping season, 6188.56 ha of land was coved by cabbage and about 38682 tons was produced in Ethiopia with national average yield per hectares of 6.3 which is below the world average yield [6]. Providing adequate fertilizer and maintaining optimum plant population are some factors that help to improve cabbage production and productivity [7]. Vigorous vegetative growth is promoted by

applying adequate nitrogen fertilizer. Nitrogen is essential in the formation of chlorophyll and it is an important component of proteins. Lack of nitrogen shows symptoms of pale foliage and results in slow and spindly growth and limited production [8]. Therefore, applying different rates of nitrogen may have positive effects on the growth and yield of cabbage. Thus, this study was conducted to evaluate effects of different rates of nitrogen on growth and yield of cabbage.

2. Materials and Methods

2.1. Description of the Study Area

The study was carried out at Ambo University, Guder Campus demonstration site in Toke kutaye district, Guder during the main cropping season in 2018/19. Guder is located at about 126km west of Addis Ababa and 12 km from Ambo town, capital of west Showa zone. It lies between 8°58'N 37°46E latitude and 8.967°N 37.767°E longitude. The average elevation of the area is 2101 m.a.s.l. receiving annual mean maximum and minimum rain fall of 1900mm and 600mm, respectively [9].

2.2. Experimental Materials

Copenhagen market cabbage seed (Heirloom Variety) and nitrogen fertilizer were used as experimental materials for the experiment. UREA was used as a source of nitrogen.

2.3. Experimental Design and Procedures

Randomized complete block design (RCBD) layout with three replications was used for the experiment. Seedlings were planted with spacing of 40 cm between rows and 30 cm between plants. There were four rows per plot and 6 seedlings were planted within one row. Four levels of nitrogen rates (0kg/ha, 50kg/ha, 100kg/ha, and 150kg/ha) were applied and UREA was used as a source of nitrogen. UREA was applied in two splits where the first application was done 15 days after transplanting and the second application was done one month after the first application.

2.4. Data Collection and Statistical Analysis

Data were collected on growth and yield parameters of cabbage and analyzed using GenStat software [10]. When the result of analysis of variance indicated the presence of significant treatment differences, least significant difference (LSD) was used for mean separation at probability level of 5%.

3. Results and Discussion

3.1. Plant Height (cm)

Nitrogen fertilizer rates highly significantly ($p<0.01$) affected plant height (Table 1). The highest plant height (32.37 cm) was recorded at 150kg nitrogen fertilizer rate ha^{-1} while the lowest plant height (27.97 cm) was recorded in control treatment (0kg nitrogen) (Table 1). Increase in plant height as rate of nitrogen rate increased might be due to the nature of nitrogen in promoting vegetative growth of plants. This finding corroborates with Semuli [11] who found that increased nitrogen fertilizer from 0 to 150 kg increased height of cabbage crop.

3.2. Number of Leaf Per Plant

The result indicated that mean leaf number per plant was highly significantly ($p<0.01$) affected by nitrogen rates (Table 1). The highest number of leaf per plant (11.45) was recorded with application of 150 kg of nitrogen per hectare as compared to that of control (9.39) treatment (0 kg of nitrogen per hectare) (Table 1). Increased rate of nitrogen from 0 to 100 kg resulted in numerical increment of leaf number though the difference was statistically at par. The result is in agreement with finding of Meena et al. [3].

3.3. Leaf Length (cm)

Application of nitrogen fertilizer highly significantly ($P<0.01$) influenced length of cabbage leaf (Table 1). The longest leaf (25.57 cm) was obtained from 150 kg ha^{-1} of nitrogen as compared to the control treatment (21.87 cm) (Table 1). The progressive effects of nitrogen (N) on leaf length of cabbage might be due to its key role in the synthesis of chlorophyll, enzymes and proteins. This is in line with the results of Souza et al. [12] who reported that adequate application of nitrogen promotes vigorous growth and dark green color of cabbage. Singh and Chaure [13] also reported that application of 150 kg ha^{-1} of nitrogen gave the best result on cabbage leaf length.

Table 1. *Effect of nitrogen fertilizer on leaf length, leaf width and plant height of cabbage.*

N ($Kgha^{-1}$)	Leaf Length (cm)	Leaf Width (cm)	Leaf Number/plant	Plant Height (cm)
0	21.87^{a}	22.63^{a}	9.39^{a}	27.97^{a}
50	25.13^{b}	25.70^{b}	9.71^{a}	30.33^{b}
100	25.53^{c}	25.87^{b}	9.82^{a}	31.03^{c}
150	25.57^{d}	28.07^{c}	11.45^{b}	32.37^{d}
Significance	**	**	**	**
CV%	1.5	2.2	5.2	1.5
LSD (0.05)	0.770	1.098	1.048	0.941

Means with the same superscript letter in the same column are not significantly different at 0.05 probability level; ** indicates 1% levels of significance.

3.4. Leaf Width (cm)

ANOVA results showed that nitrogen rates highly significantly ($p<0.01$) affected width of cabbage leaf (Table 1). The widest leaf width (28.07 cm) was obtained with application of 150 kg of nitrogen per hectare while the narrowest leaf width (22.63 cm) was gained from control treatment (0kg of nitrogen per hectare) (Table 1). Leaf width increment recorded might be due to nitrogen effects on growth parameters particularly the synthesis of more plant metabolites. This finding corroborates reports Pankaj (14) who indicated that increasing nitrogen level from 0 to 150 kg per hectare increased leaf width of cabbage.

3.5. Head Diameter (cm)

Analysis of variance result indicated that head diameter was highly significantly ($P<0.01$) affected by application of different rates of nitrogen fertilizer (Table 2). The highest head diameter (11.83 cm) was recorded at 150 kg ha^{-1} while the lowest head diameter (9.22 cm) was recorded at 0kg ha^{-1} nitrogen fertilizer application (Table 2). This is possibly due to higher carbohydrates synthesis and their translocation which subsequently helped in the formation of larger head of cabbage. This finding is in agreement with that of Hossain [15] who found that head diameter increased when the nitrogen levels increased from 0 to 250 kg ha^{-1}.

3.6. Spread of Plant (cm)

Spread of plant was significantly ($p<0.05$) affected by nitrogen fertilizer rates (Table 2). Application of 150 kg nitrogen ha^{-1} gave the highest spread of plant (43.2 cm) while control treatment (0 kg ha^{-1} of nitrogen) gave the lowest spread of plant (39.43 cm) (Table 2). As nitrogen fertilizer levels were increased from 50 to 150 kg ha^{-1}, there were consecutive numerical increments though the differences were statistically at par. The results showed that higher nitrogen uptake by plants increased the length of leaf creating favorable condition for better growth. This result is in conformity with the findings of Pramanik [14] who reported that maximum spread of plant was obtained from 260 kg N ha^{-1}.

3.7. Fresh Head Weight (kg/Plant)

Analysis of variances showed that application of different rates of nitrogen fertilizer highly significantly ($p<0.01$) affected fresh head weight per plant (Table 2). The highest fresh head weight (0.810 kg/plant) was recorded at nitrogen rate of 150kgha^{-1} while the lowest fresh head weight (0.492 kg $plant^{-1}$) was recorded at 0 kg ha^{-1} nitrogen rate (Table 2). Increasing nitrogen level form 0 to 150 kgha^{-1} resulted in progressive increase in fresh weight of cabbage. The optimum dose of nitrogen might ensure proper growth of plant resulting in the highest fresh head weight of cabbage too. In line with this finding, Pramanik [14] reported that higher yield in cabbage was associated with increased nitrogen rate.

3.8. Dry Weight (kg/Plant)

The dry weight per plant showed highly significant ($p<0.01$) difference due to different rates of nitrogen fertilizer application (Table 2). The highest dry weight (0.0117 kg $plant^{-1}$) was obtained with application of 150 kgha^{-1} of nitrogen while the lowest dry weight (0.0452 kg $plant^{-1}$) was recorded with control treatment (0kg ha^{-1} of nitrogen) (Table 2). Increasing levels of nitrogen fertilizer encouraged head with a significantlyhigher dry weight as compared to control treatment. There were no significant differences between plots that received 50 and 100 kg nitrogen ha^{-1}. Teiet al. *[*16] reported that increasing the rates of nitrogen fertilizer significantly increased dry weights of plant leaves. Similarly, Takebeet al. [17] reported that increments in leaf dry weight may be due to a combination of nitrogen with plant matter produced during photosynthesis such as glucose, ascorbic acid, amino acids, and protein.

Table 2. *Effects of nitrogen fertilizer on spread of plant, head diameter, fresh head weight, marketable yield and dry weight of cabbage.*

N (Kgha^{-1})	Spread of plant (cm)	Head diameter (cm)	Fresh head Weight (kg/plant)	Marketable yield (t ha^{-1})	Dry weight (kg/plant)
0	39.43^{a}	9.22^{a}	0.492^{a}	35.43^{a}	0.0452^{a}
50	42.33^{b}	9.80^{a}	0.680^{b}	63.83^{b}	0.087^{b}
100	42.70^{b}	10.67^{a}	0.743^{c}	78.70^{c}	0.0896^{b}
150	43.2^{b}	11.83^{b}	0.810^{d}	79.83^{c}	0.0117^{c}
Significance	*	**	**	**	**
CV%	2.4	3.8	2.6	5.4	2.0
LSD (0.05)	1.986	0.787	0.036	6.9062	0.0033

Means with the same superscript letter in the same column are not significantly different at 0.05 probability level; * and ** indicates 5% levels and 1% levels of significance respectively.

3.9. Marketable Yield of Cabbage Head Hectare^{-1}

The marketable yield of cabbage head showed highly significant ($p<0.01$) differences due to application of different levels of nitrogen fertilizer (Appendix Table 1). The maximum marketable yield (79.83 t ha^{-1}) was recorded at application of 150 kg nitrogen ha^{-1} but was no statistical difference between application of 100 and 150 kg ha-1 of nitrogen fertilizer (Table 2). The maximum dose of nitrogen ensured proper growth of plants, higher number of loose leaves and as a result the highest head yield $plant^{-1}$. The present finding agrees with that of Pramanik [14] who noted that the higher head yield in cabbage was associated with

increased rates of nitrogen. These findings are also in concurrent with the findings of Silva [18] who reported that increase in the rates of nitrogen from 15-30 kg ha^{-1} to 45 kg ha^{-1} results in increase of marketable yield. Similarly, Richard et al. [19] reported that higher nitrogen rate (375 kg ha^{-1}) gave maximum head yield.

4. Conclusion

The growth and yield of cabbage head was influenced by application of different rates of nitrogen fertilizer. Application of higher doses of nitrogen fertilizer increased number of loose leaves per plant, plant height, head diameter, leaf length, leaf width, and spread of plant, head diameter, fresh head weight per plant, and dry weight of cabbage. The significantly highest marketable head yield (79.83 t ha^{-1}) was also obtained at highest doses of nitrogen fertilizer (150 kg ha^{-1}). Thus, maximum cabbage head yield can be achieved with application of 150 kg of nitrogen $hectare^{-1}$ under condition of Guder and similar agro-ecology.

Authors' Contribution

This study was conducted in collaboration between two authors. Author Asfaw Shaka designed the study, led the field experiment design and data collection and wrote the first draft of the article. Author Bikila Olika contributed in designing, data collection, analysis and editorial aspects of the article. Both authors read and approved the final manuscript.

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