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Effect of Different Rates of Nitrogen on Growth, Yield and Yield Components of Cabbage (*Brassica oleracea*) at Jimma, south western, Ethiopia

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Abstract

Field experiment was conducted at Jimma University College of Agriculture and Veterinary Medicine (JUCAVM) Horticultural farm to evaluate the effect of different rate of nitrogen on the growth, yield and yield components of cabbage. Four nitrogen levels (0, 50, 100, and 150kg\ha) were used. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. Copenhagen market variety of cabbage was used for this experiment. Result indicated that growth, yield and yield components of cabbage were significantly affected by different rates of applied nitrogen. Shortest days to maturity (61 days), longer plant and head height, wider head diameter (17.03), more outer leaf number (14.16), heavier total plant fresh weight (2.5kg/plant) and head weight (1.5kg/plant) and higher total yield were recorded at higher nitrogen fertilizer rate (150kg/ha). The result of current study revealed that 150kg/ha nitrogen fertilizer rate can be used for cabbage production in the study area. However further investigations may be suggested to be carried out on different soil type, at different season, year and location so as comes up with precise and comprehensive recommendation.

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Keywords

Nitrogen rate, Growth, Yield, Cabbage, Copenhagen

Introduction

Cabbage (*Brassica oleraceavar.capitata* L.) belongs to the family cruciferae and it is biennial crop with a very short stem supporting a mass of overlapping leaves to from a compact head. It originated in Western Europe and northern shore of Mediterranean (Semuli, 2005). It has been domesticated and used for human consumption since the earliest antiquity. It is cool season crop that is popular with gardeners and commercial producers.

Cabbage is known for its nutritional importance and it is rich in mineral and vitamins. It is also known for it is cooling effect being an appetizer, it aides digestion thereby help preventing constipation. It also protects against cancers (Ruzawlah *et al.*, 2002). Optimum growth of cabbage occurs at a mean daily temperature of about 17^{o}c with daily mean maximum of 24^{o}c and minimum of 10 ^{o}c. Mean relative humidity should be in the range of 60 and 90 % (Rai and Asati, 2005).

Cabbage ranks fifth among the vegetable crops of the world. It is grown for its head in more than ninety countries throughout the world (Meena *et al*., 2010). The top ten cabbage growing countries of the world in 2017are China, India, Russian Federation, Republic of Korea, Ukraine, Indonesia, Japan, USA, Poland and Romania (FAOSTAT, 2017). The world cabbage

production in 2017 is estimated to be 71451138tonnes, while area coverage was2513707ha in the same year with productivity of 28.423t/ha. Area, production and yield of cabbage in Ethiopia in 2017 were 43463 hectares, 406148 tons and 9.34t/ha respectively (FAOSTAT, 2017).

The average cabbage yield of national as well as farmers around Jimmais very low when compare to the world average. The major factors for the low productivity of this crop in Ethiopia in general and around Jimma in particular are low fertility status of the soil, in appropriate use of fertilizer rate, in appropriate plant population per unit area, disease, pests and inappropriate agronomic practices.

Low soil fertility also considered as serious problems among several production limiting factors in the study area. Nitrogen in one of the critical plant nutrients in cabbage yield and it is significant to note that nitrogen response is directly associated to the soil type, emphasizing that soil varying in fertility status react differentially to the applied fertilizer (Frezer, 2007). Thus, it requires applying of appropriate rate of fertilizer for the enhanced cabbage productivity and sustainable yield. Many experiments show that nitrogen application increases the growth and total yield of cabbage (Westveld *et al*., 2003). But, this is possible as long as it is managed properly in terms of rate and time of application.

In Western highlands of Ethiopia, particularly around Jimma, there is a need by farmers to increase productivity of cash crops like cabbage to maximize their profit from small plot of farm they have. However, farmers of this area who grow cabbage frequently give less attention to nitrogen fertilizer rate. Moreover, information on cabbage nitrogen application rate for optimum yield and other agronomic practices are limited. Since most of the farmers in this area has small plot of land and the yield obtained from this is very low. So it is important to increase the yield of cabbage from this small plot of land to improve the income of farmers around this area. Therefore, this research is proposed with the following objectives:

- To evaluate the effect of nitrogen fertilizer on the growth and yield of cabbage
- To determine optimum nitrogen level for cabbage yield and growth.

Materials and Methods

Description of the study area

The experiment was conducted at Jimma University College of Agricultures and Veterinary Medicine (JUCAVM) research site which is found in Oromia region, South Wesermt part of Ethiopia. JUCAVM is geographically located at about 7^{o}, 33^{o}N Latitude and 36^{o}S, 57^{o}E longitude and at altitude of 1710(m.a.s.l) (Gezahegn, 2003). The mean maximum and minimum temperature are 26.8^{o}C and 11.4^{o}C respectively and the mean maximum and minimum humidity is 91.4% and 31.2% respectively. The annual rain fall of the area is estimated to be 1500mm and its soil is characteristically radish brown well drained clay to silty clay with PH ranging from 5.07 to 6.0 (Gezahegn, 2003).

The Experimental material

The experimental materials that were used in the experiment were cabbage seed (Copenhagen market variety) and fertilizer (Urea).

Experimental design and treatments

The experiment was laid out in RCBD with three replications. It is a single factor experiment having four levels of nitrogen rates (0kg/ha, 50kg/ha, 100kg/ha and 150kg/ha). The experimental area was 47,5m^2. The space between block was 1 m and between plots is 0.5 m. A 1 m length area was used for gang way. Both the spacing between rows and plant was 50 cm. The area of one plot was 2 mx1 m=2 m^2. There were two rows per plot and four seeds within one row. Therefore, eight seeds were planted per plot.

Experimental procedures

First of allthe experimental site was selected and cleaned. The total experimental area was set and demarked using pegs. The land was ploughed and prepared. After this the total experimental area was divided into three blocks and then blocks were sub-divided into plots/beds equal to the number of treatment (four different levels of nitrogen on cabbage). The beds/plots were prepared to the desired site. The four different levels of nitrogen were randomly allotted to each beds/plots and the treatment control was taken as a standard check. The experimental cabbage was sown on to the beds according to the four different levels of nitrogen selected. Accordingly one seed of cabbage per hole was sown with respect to the four level of

nitrogen selected of 50x50cm spacing. Application of fertilizer (Urea) was done two times, at sowing and three weeks after sowing according to their levels. Beds was watered twice per day once early in morning and afternoon before germination depending on the condition and watered once a day afternoon after germination of the seed. Weed management practice was applied twice per a week. Other agronomic practices were applied s per recommendation.

Data collected

Growth, yield and yield related data such as plant whole fresh weight, days to maturity, plant height, head diameter, head height, leaf number and total yield were collected.

Data analysis

The data were subjected to analysis of variance using SAS software program version 9.0 (SAS Institute, 2000). Least significant difference (LSD) was used for mean separation.

Results and Discussions

Growth parameters

Days to maturity

Days to maturity was very highly significantly ($p<0.001$) affected by nitrogen fertilizer rate. Increased nitrogen fertilizer from 0 to 150kg/ha resulted in significant decrease in days to maturity from 84 to 61 days. The earliest days to maturity (61days) was observed at higher nitrogen fertilizer rate (150kg/ha), whereas the longest days to maturity (84days) was recorded at nil application (Fig. 1). The higher nitrogen rate that shortened the days to maturity is probably due to higher nutrient presumed to have helped the cabbage plant for wrapped or head formation than lower nitrogen rate. The current finding agrees with that of Westervel *et al.*, (2003) who indicated that nitrogen rate and days to maturity was quadratic that cabbage received highest nitrogen rate (240kg/ha) reached maturity up to four weeks earlier than those received no or low nitrogen rates.

Plant height

Plant height varied significantly due to nitrogen. The tallest plants were found in plot with 150kg/ha of N, while the shortest one in control. This might be due to higher N uptake by plants possibly created favorable conditions for better growth than those of others. The present investigation is akin with the report of Prasad (2009) who reported significantly maximum plant height (32.14 cm) at the 140/kg/ha of nitrogen application. Similarly, Thapa and Prasad (2011) obtained the maximum plant height (32.57 cm) using the combined application of 120 kg nitrogen and 100 kg phosphorus ha-1.

Outer leaf number

Outer leaf number was significantly ($p<0.05$) affected by nitrogen fertilizer rate. Increasing fertilizer from 0 to 150kg/ha increased leaf number. The highest leaf number (14.16) was recorded at 150kg/ha of nitrogen fertilizer rate but statistically in par with 50 and 100kg/ha. The lowest leaf number (10.7) was recorded with no nitrogen fertilizer (Table 1).

The current finding is in-line with the finding of Yebirzaf (2015) who observed highest outer leaf number at 50kg/h of N and Ghanti *et al*., (1982) who reported that nitrogen devours more vegetative growth with more number of leaves. Mariyam (2007) also reported similar result that the leaf number of lettuce was affected by nitrogen fertilizer rate and the highest leaf number was recorded at higher rate of fertilizer. Additionally Prasad (2009) observed higher outer leaf number at 140kg/ha of nitrogen.

Head height

Head height was not significantly ($p>0.05$) affected by nitrogen fertilizer level. But the highest head height (16.82cm) was recorded at highest (150 kg/ha) nitrogen fertilizer level, while the lowest (12.9cm) was recorded at zero nitrogen fertilizer level (Table 1). The present investigation contradict with the finding of Semuli (2005) who reported that for trimmed head, nitrogen at 150 kg/ha recorded higher head height than 100 kg/ha and 50 kg /ha.

Head diameter

Head diameter was significantly ($p<0.05$) affected by nitrogen fertilizer rate. The largest (17.03 cm) head diameter was recorded at the highest (150 kg/ha) nitrogen fertilizer rate whereas the smallest (11.2 cm) head diameter was observed at control (Table 1). This shows that increasing fertilizer rate from zero to 150kg/ha increased head diameter. This finding is in

agreement with those of Keteseeman (2006) who reported, head diameter increased from 98 to 218 mm when the nitrogen level increased from 0 to 120 kg/ha, respectively and Prasad (2009) who reported highest head diameter at 140kg/ha of N application. This was possibly due to higher synthesis of carbohydrate and their translocation to the sink, that is; cabbage head which subsequently helped in the formation of larger and comparatively broader head of the cabbage. It is also because of the reason that the nitrogen favors more leaf number and leaf area which form the diameter.

Yield parameters

Whole plant fresh weight

Whole plant fresh weight was highly significantly ($p<0.01$) affected by nitrogen rate. The highest whole fresh weight (2.5kg) was recorded at the highest nitrogen fertilizer level (150kgN/ha) even though it is not statically different from 100kgN/ha of fertilizer level. The lowest plant fresh weight (1.3kg/plant) was recorded at zero fertilizer level (Table 2).

Table.1 Effect of nitrogen rates on cabbage days to maturity, head height, head diameter and outer leaf number

	Growth parameters			
Treatments	Days to maturity	Head height(cm)	Head diameters(cm)	Outer leaf number
0gm	84a	12.9a	11.2a	10.7a
10gm	78b	14.21a	12.56a	12.53b
20gm	67c	15.20a	14.68b	13.8b
30gm	61d	16.82a	17.03b	14.16b
LSD (5%)	1.91(***)	4.76(ns)	3.84(*)	2.75(*)
C.V %	1.32	16.11	13.9	10.76

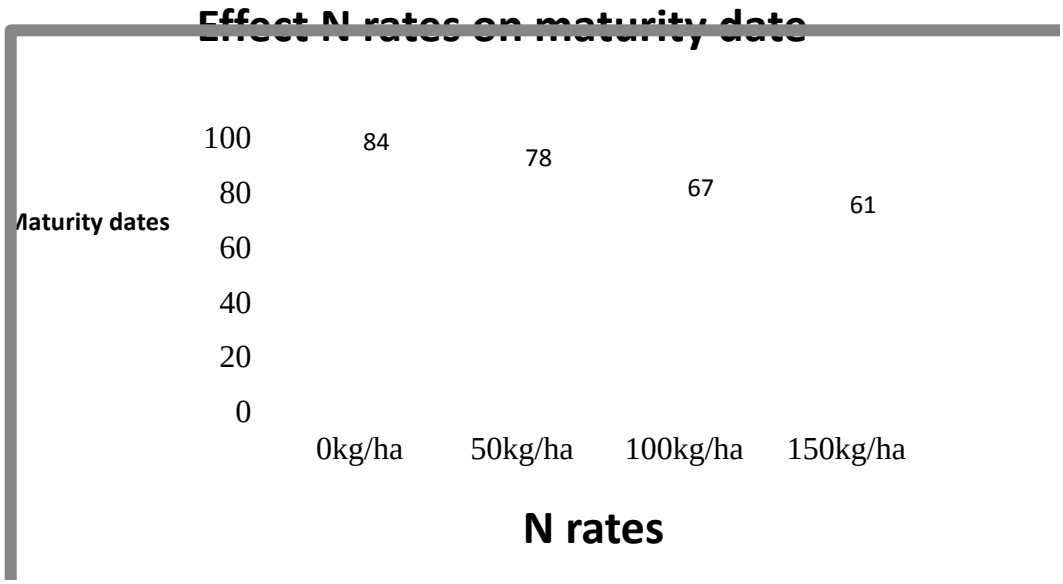
Means with the same letter are not significantly different.

Table.2 Effect of nitrogen fertilizer rate on whole plant fresh weight and head height

	Yield parameters	
Treatments	Whole plant fresh weight(kg/plant)	Head weight(kg/plant
0gm(control)	1.3a	0.46a
10gm	1.9b	0.95b
20gm	2.4c	1.0b
30gm	2.5c	1.5c
LSD (%)	0.597(*)	0.399(*)
C.V %	14.69	20.42

Means with the same letter are not significantly different.

Figure.1 Effect of nitrogen rates on cabbage days to maturity.



This shows increasing fertilizer level increased biomass of cabbage. The current finding is compatibles with that of Semuli (2005) who reported that plantfresh weight was recorded at higher nitrogen rate than lower nitrogen fertilizer rates.

Head weight

Cabbage head weight was highly significantly ($p<0.01$) affected by nitrogen fertilizer rate. The highest head weight (1.5 kg/plant) was obtained at the higher nitrogen fertilizer rate of 150kg/ha (Table 2). The lowest head weight (0.46kg/plant) was found at control. Similar results are observed by Prasad (2009) who reported that the combined application of 120 kg and 100 kg ha-1 of nitrogen and phosphorous, respectively, gave the maximum head weight (1.63 kg) of cabbages. This finding is also in line with that of Yebirzaf (2015) who indicated that increasing nitrogen level from 0 to 150 kg ha-1 resulted in progressive increase in head weight of cabbage. This is due to nitrogen that increases the vegetative growth and produces good quality foliage and promotes carbohydrate synthesis through photosynthesis and ultimately increased yield of plants.

Total yield

Different levels of nitrogen showed significant variation on yield per ha. Accordingly the highest yield was observed from nitrogen application at 150kg/ha and the lowest was from nil application. This finding is in line the finding of Prasad (2009), who have reported highest yield of cabbage application of N at 140kg/ha. Din *et al*., (2007) also reported that the maximum head yield was recorded in treatment receiving N level of 120kg/ha.

It is concluded that, growth characters yield and yield components were influenced greatly by different rates of applied nitrogen. Shortest days to maturity (61 days), longer plant and head height, wider head diameter (17.03), more outer leaf number (14.16), heavier total plant fresh weight (2.5kg/plant) and head weight (1.5kg/plant) and higher total yield were recorded at higher nitrogen fertilizer rate (150kg/ha).

The result of current study revealed that 150kg/ha nitrogen fertilizer rate can be used for cabbage production in the study area.

Recommendation

- Farmers around Jimma can use nitrogen fertilizer at rate of 150kg/ha for cabbage production.
- But further study is required regarding economic feasibility of this rate of application
- The current study should be repeated at different locations
- Awareness should be created among cabbage growing farmers regarding the use of right way, right amount and right time of nitrogen fertilizer application

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