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Research Article
Effect of Nitrogen Fertilizer and Farmyard Manure on Growth and Yield of Lettuce (*Lactuca sativa* L.)

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Abstract

Background and Objective: Lettuce is one of the very important cash and food vegetable crops. Lettuce is more susceptible to nutrient deficiencies than most crop plants because of their shallow root system. Therefore, this study was initiated to assess the response of lettuce to farm yard manure and nitrogen fertilizer application rate on its growth and yield. **Materials and Methods:** The current study was conducted at Debre Markos, North West Ethiopia, during 2018, under irrigation the study consists of three levels of Farm Yard Manure (0, 15 and 30 t ha^{-1}) and three levels of nitrogen (0, 75 and 150 kg Nitrogen ha^{-1}). The experiment was conducted in 3×3 factorial arrangements in a randomized complete block design with three replications. Data on growth and yield, parameters were recorded and analyzed using SAS Computer Software version 9.2. Results revealed that interaction of FYM and N fertilizer significantly ($p<0.05$) influenced. **Results:** The results showed significant variation was obtained from fertilizers tested with regard to plant height (cm), leaf number, root length (cm) Leaf Width (cm) and Total Yield (t ha^{-1}). The highest plant height 25.79 cm and 25.08 cm was obtained from application of 75 kg N h^{-1} and 30 t ha^{-1} Farm yard manure, respectively lowest plant height was obtained from application of 0 kg N ha^{-1} and 0 t h^{-1} farm Yard Manure. Maximum (32.66) number of leaves per plant was noticed from application of 75 kg Nitrogen ha^{-1} with 30 t ha^{-1} farm yard, which was on par with application of 150 kg ha^{-1} Nitrogen with 30 t ha^{-1} farm yard (29.55). The lowest number of leaves (21) per plant was obtained from application of 0 kg Nitrogen with 0 t farm yard manure. the tallest root length of lettuce (13.44 cm) was obtained from 15 kg ha^{-1} farm yard manure and 75 kg ha^{-1} Nitrogen. **Conclusion:** The highest yield of lettuce (31.34 t ha^{-1}) was obtained when the plots received combined application of 75 kg ha^{-1} of N and 30 t ha^{-1} of FYM. Therefore, the present study suggested that lettuce grown with 30 t ha^{-1} farm yard manure and 75 kg ha^{-1} nitrogen showed better growth and yield.

Key words: Nitrogen fertilizer, nutrient deficiencies, farm yard manure, plant height, lettuce

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Lettuce (*Lactuca sativa* L.) is the most widely grown of all green leaf salad vegetables[1] and it is important vegetable according to the highest consumption rate and economic importance through the world[2]. It is an important leafy vegetable crop and it is considered as an excellent nutritive source of minerals and vitamins since it is consumed as fresh green salad[3]. It is usually used as salad with tomato, carrot, cucumber or other salad vegetable and often served alone or with dressing. It is the most popular vegetable according to the highest consumption rate and economic importance through the world[2].

In Ethiopia, lettuce is one of the very important cash and food vegetable crops[4]. Area covered by lettuce and chicory, in the 2016 cropping season was 117 ha, with average yield[5] of 649.6 kg ha^{-1}, which is below the world average[6]. This is due to poor agronomic practices like irrigation, fertilizer, spacing, weeding and disease. Among many contributing farmers which causes low yields is lack of proper knowledge on optimum amount of nitrogen and farm yard manure fertilization rate.

Lettuce requires a soil that is high in organic matter and has adequate nutrient[6]. Nitrogen and farm yard manure are one of the most important mineral nutrients determining growth and yield of lettuce because it is heavy feeder of nutrients[7,8].

Integrated use of bio fertilizer, organic manure and chemical fertilizers resulted in crop yield increase in comparison with the exclusive application of chemical fertilizers. Moreover, higher yields were reported when a combination of chemical and organic fertilizer was applied, compared with the use of chemical fertilizer alone. But increased cost and uncertain availability and reliability of chemical fertilizer made the growers look towards renewable and organic sources of nutrients for their crops[9]. Regular and unbalanced use of chemical fertilizers in the long run leads to decreasing base saturation and acidification of soil[10]. Chemical fertilizers alone generate several deleterious effects to the environment and human health and they should be replenished in every cultivation season because, the synthetic N, P and K fertilizer are rapidly lost by either lettuce is more susceptible to nutrient deficiencies than most crop plants because of their shallow root system.

Therefore, this study was initiated to evaluate the effect of Nitrogen fertilizer and Farm Yard Manure on growth and yield of lettuce and to determine optimum Nitrogen fertilizers rate and Farm Yard Manure application on yield and yield component on lettuce.

MATERIALS AND METHODS

Experimental site description: The experiment was conducted at Debre Markos University College of Agriculture and Natural Resources in 2018 North West of Addis Ababa at about 10°18′10″ North latitude and 37°44′53″ East longitude at an altitude of about 2450 m above sea level (m.a.s.l). The minimum and maximum temperature were 10.6 and 22.30°C, respectively. The mean annual rain fall of the area was about[11] 1100 mm.

Experimental materials: Cos type lettuce (Variety Paris Island) obtained from known vegetable seed suppliers was used. Nitrogen fertilizer and farm yard manure was used as experimental material during the study. There were three levels of nitrogen rates (0, 75 and 150 kg ha^{-1}) and three level of Farm Yard Manure (0, 15 and 30 t ha^{-1}). Urea was used as a source of nitrogen fertilizer.

Experimental design and treatments: The experiment was laid out in 3×3 factorial combinations, treatments involving three levels of nitrogen rates and three level of Farm Yard Manure in Randomized Complete Block Design (RCBD) with three replications. The treatments were three levels of nitrogen rates (0, 75 and 150 kg ha^{-1}) and three level of Farm Yard Manure (0, 15 and 30 t ha^{-1}). There were 9 treatment combinations and 27 plots in three replications. Treatments were assigned to the experimental plot randomly. The spacing between rows were 0.4 m and between plants were 0.3 m (40×30 cm). There were 4 rows per plot and 10 plants per row. There were 40 plants per row. The space between plots and between blocks were 0.5 cm and 1 m, respectively.

Cultural practices: Lettuce seedlings were raised in nursery bed in rows of 15 cm between rows. Seedlings at four-week stage were transplanted at permeant field at spacing 40×30 cm between rows and plants, respectively. After transplanting important cultural practices were applied per recommended. Nitrogen were applied in the form of urea (46% N) in two split doses of equal amounts, 50% of urea at time of transplanting and the other 50% at two weeks after transplanting. Well decomposed manure was carefully weighed and thoroughly applied into the experimental plot.

Data collection: Data on growth, yield and yield component parameters were collected from the central two rows.

Plant height (cm): It was measured using ruler from the soil surface to the tip of the longest mature leaves at maturity.

Number of leaves/plant: Number of leaves per plant was counted from six plants at maturity.

Leaf width (cm): It was measured by recorded the width at the middle part of the leaves (at widest part of the leaves).

Root length: The depth of the main root from the border of the soil to the tip of the main plant root was measured with ruler.

Root weight: It was measured during harvesting by removing soil with digital sensitive balance.

Total fresh yield: The total fresh leaf weight was measured after uprooted from the base of petiole and washed off any loose soil, remove surface moisture and weight it immediately.

Data analysis: The data collected on different growth and yield parameters were subjected to the Analysis of Variance (ANOVA) (two-way ANOVA) by using SAS version 9.2. computer software[12]. Mean separation was carried out using least significance difference (LSD) at 5% probability level statistically.

RESULTS AND DISCUSSION

Plant height (cm): Separate application of Nitrogen (N) and Farm Yard Manure (FYM) significantly ($p<0.005$) influenced plant height (Table 1). However, their interaction was not significant. The highest plant height (25.79 cm) was obtained from application of 75 kg N ha^{-1}, which was on par with that of 150 kg ha^{-1}. While lowest plant height (23.13 cm) was obtained from application of 0 kg N ha^{-1} (control). Increment of plant highest at application of Nitrogen fertilizer was, they provide major elements at the early stage of plant growth and development. Chemical fertilizer offers nutrients which are readily soluble in soil solution and thereby instantly available to plants. The result is in line with the findings of Boroujerdnia and Ansari[13]. Additionally, the investigation carried out by Tittonell *et al.*[14] on lettuce showed that increasing nitrogen fertilizer from 0-150 kg ha^{-1} increased the plant height, leaf number, fresh weight and dry weight of the crop[15] also reported that increasing nitrogen up to 100 kg ha^{-1} increased the plant height.

Table 1: Effect of farm yard manure and nitrogen fertilizer on plant height of lettuce

N (kg ha^{-1})	Plant height (cm)
0	23.13^{b}
75	25.79^{a}
150	23.79^{ab}
LSD (5%)	2.02
FYM (t ha^{-1})	
0	22.52^{b}
15	25.12^{a}
30	25.08^{a}
LSD (5%)	
CV%	8.34

N: Nitrogen, FYM: Farm yard manure. Means followed by the same letter(s) within the same column are not significantly different

Regarding Farm Yard Manure, the lowest plant height (22.52 cm) was obtained from control plots. Increasing the level of FYM application from 15-30 t ha^{-1}, did not increase the mean plant height (Table 1). This might be because of it slow release of nutrients from organic manures like farm yard manure specially at early stage of plant growth. Nutrient availability from organic sources is due to microbial action and improved physical condition of soil[16]. Nutrients in inorganic fertilizers are directly available to plant roots, whereas the nutrients of organic materials are of low availability.

The variation in plant height due to nutrient sources was considered to be due to variation in the availability of major nutrients. The available nutrients might have helped in enhancing leaf area, which thereby resulted in higher photo-assimilates and more dry matter accumulation[16].

Leaf number: The interaction of nitrogen and farm yard manure significantly influenced leaf number of lettuce (Table 2). Maximum (33.06) number of leaves per plant was noticed from application of 75 kg Nitrogen ha^{-1} with 15 t ha^{-1} Farm yard, which was on par with application of 75 kg Nitrogen ha^{-1} with 30 t ha^{-1} Farm yard (33.05) and 150 kg ha^{-1} Nitrogen with 30 t ha^{-1} Farm yard (29.55). The lowest number of leaves (21) per plant was obtained from application of 0 kg Nitrogen with 0 t Farm yard manure. Maximum number of leaves/plants was recorded for highest level of nitrogen and farm yard manure, because they ensure favorable condition for the growth of lettuce[15,14,17].

Kokobe *et al.*[18] also reported the highest number of leaves per plant was obtained at the application of higher Nitrogen in onion. The increase in number of leaves per plant with increase in N level can be due to nitrogen that might have contributed in producing new shoots and vigor in vegetative growth which is directly responsible in increasing the leaf number.

Leaf width (cm): The interaction of Nitrogen and Farm yard manure significantly ($p<0.05$) influenced leaf width of lettuce (Table 2). Application of 75 kg N ha^{-1} and 30 t FYM ha^{-1} increased plant leaf width compared to the control treatment

Table 2: Interaction effect of farm yard manure and nitrogen fertilizer on leaf number, leaf width and root length of lettuce

FYM t ha^{-1}	N kg ha^{-1}	No. of Leaf	Leaf width (cm)	Root length (cm)
0	0	21.00^{b}	8.83^{c}	10.80^{cd}
	75	25.88^{ab}	12.86^{ab}	10.58^{d}
	150	27.83^{ab}	12.16^{ab}	10.83^{cd}
15	0	30.44^{a}	11.47^{b}	12.8^{ab}
	75	32.22^{a}	13.66^{a}	13.44^{a}
	150	33.05^{a}	12.80^{ab}	12.58^{abc}
30	0	27.94^{ab}	12.08^{ab}	11.36^{bcd}
	75	32.66^{a}	13.91^{a}	12.00^{abcd}
	150	29.55^{a}	11.13^{b}	11.16^{bcd}
LSD (5%)		8.24	1.89	1.90
CV (%)		3.07	9.0	9.30

N: Nitrogen, FYM: Farm yard manure. Means followed by the same letter(s) within the same column are not significantly different

Table 3: Effect of farm yard manure and nitrogen fertilizer on root weight of lettuce

N (kg ha^{-1})	Root weight (g)
0	19.78
75	22.43
150	22.88
LSD (5%)	5.93
FYM (t ha^{-1})	
0	17.71^{b}
15	25.19^{a}
30	22.20^{ab}
LSD (5%)	5.93
CV (%)	25.00

N: Nitrogen, FYM: Farm yard manure. Means followed by the same letter(s) within the same column are not significantly different

Table 4: Interaction effect of farm yard manure and nitrogen fertilizer on total yield of lettuce

FYM t ha^{-1}	N kg ha^{-1}	Total yield (t ha^{-1})
0	0	20.1700^{bc}
	75	22.5400^{abc}
	150	18.5700^{bc}
15	0	20.1900^{bc}
	75	24.6800^{abc}
	150	31.3400^{a}
30	0	17.3000^{c}
	75	26.5400^{ab}
	150	22.9700^{abc}
LSD (5%)		9.1800
CV (%)		0.2187

N: Nitrogen, FYM: Farm yard manure. Means followed by the same letter(s) within the same column are not significantly different

by 20%. The highest mean leaf width (13.91 cm) was obtained at 75 kg ha^{-1} N and 30 t ha^{-1} FYM. However, it was not statistically different from application of 75 kg ha^{-1} N and 15 t ha^{-1} FYM (13.66). While the lowest leaf width (8.83 cm) was recorded at 0 kg ha^{-1} N and 0 t ha^{-1} FYM (Table 2).

Root length (cm): The analysis of variance for the interaction of nitrogen with farm yard manure fertilizer showed highly significant ($p<0.01$) difference on root length of lettuce (Table 2). The tallest root length of lettuce (13.44 cm) was obtained from 15 kg ha^{-1} farm yard manure and 75 kg ha^{-1} Nitrogen. However, it was statically similar with that of 15 kg ha^{-1} farm yard manure and 0 kg ha^{-1} Nitrogen. Shortest root length was recorded from control.

Root weight (g): The main effects of Nitrogen and farm yard manure on root weight were significant, while the interaction effect was non-significant ($p>0.05$). Separate application of farm yard manure at different levels illustrated a highly significant difference on root weight. The highest mean root weight (25.19 g) was obtained at 15t ha^{-1} farm yard manure, which was on par with 30 t ha^{-1}. While the lowest (17.71 g) root weight was obtained from 0 t ha^{-1} FYM. Accordingly, the results indicate that higher application rate of N and FYM not significantly increase root weight of lettuce (Table 3).

Total fresh leaf yield (t ha^{-1}): The analysis of variance for the interaction effect of nitrogen and farm yard manure showed significant ($p<0.05$) difference for total yield.

Increasing the combination level from 0-150 kg ha^{-1} of N and 0-15 t ha^{-1} of FYM resulted in progressive increase in leaf yield of lettuce. Further increase in farmyard manure fertilizer to 30 t ha^{-1}, respectively did not significantly increase the yield. The highest yield of lettuce (31.34 t ha^{-1}) was obtained when the plots received combined application of 150 kg ha^{-1} of N and 15 t ha^{-1} of FYM which was statistically similar with the levels of 75 kg ha^{-1} of N; 30 t ha^{-1} of FYM (Table 4).

It was remarked that higher yield was achieved with higher doses of nitrogen and farm yard manure due helping plants for higher vegetative growth[15,14,13,19,17].

High Nitrogen application rates, however, may adversely affect product quality by increasing nitrate accumulation within the leaves[20]. High nitrate levels are generally considered to be a cause of concern for human health[21].

Many studies were conducted to decrease nitrite and nitrate accumulation in vegetables[22] indicated that increasing rates of N in soils caused an increase in nitrate accumulation in lettuce, particularly in outer leaves. Moreover, there are evidences that the slow release N fertilizers increased the efficiency use of N and minimized the loss of N in form of ammonia gas (NH_3) by volatilization and leaching of NO_3^- from soils, which pollute the underground water Hedge[23] reported that application of slow release N fertilizers was very effective in increasing nutrient use efficiency, crop production and reducing nutrient lose, Awaad *et al.*[24] also explained that the application of N fertilizer increased the nitrate contents of lettuce plants compared with un applied. Urea application caused greater nitrate content in lettuce plant than the other fertilizers that prevented excessive accumulation of NO_3^- in the vegetables, including lettuce plants and leaching of N from the soil. The highest marketable yield was obtained from inorganic fertilizers[25-27]. Similarley[28] in a study on yield and quality of leafy vegetables grown with organic fertilizers showed that vegetables grown with organic fertilizers grew better and resulted in a higher total yield than those grown with chemical fertilizers.

CONCLUSION

Application of 75 kg N ha^{-1} and 30 t ha^{-1} is better to provide maximum and quality lettuce. The recommendation of maximum dose of Farm Yard Manure is due to slow-release of nutrients which have lower nitrate accumulation. Therefore, the present study suggested that lettuce grown with 30 t ha^{-1} farm yard manure and 75 kg ha^{-1} nitrogen is optimum combination for better growth and yield of lettuce in the study area. Because high Nitrogen application rates adversely affect product quality by increasing nitrate accumulation within the leaves which directly influence human health.

SIGNIFICANCE STATEMENT

This study discovered the optimum farm yard manure and nitrogen fertilizer rate on growth and yield of lettuce that can be beneficial for lettuce growers. This study will also help the researchers to uncover the critical areas of lettuce agronomic practices, that many researchers were not able to explore. Thus, a new theory on the present study related issues may be arrived at.

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