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Effect of Farmyard Manure and Nitrogen Fertilizer Rates on Growth, Yield and Yield Components of Onion (*Allium cepa* L.) at Jimma, Southwest Ethiopia

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Abstract: A field experiment was conducted at Jimma University College of Agriculture and Veterinary Medicine research field from October 2011 to March 2012 under irrigation to assess the response of onion to farmyard manure and nitrogen fertilizer rates. The study consisted of four levels of FYM (0, 15, 30 and 45 ton FYM ha^{-1}) and four levels of nitrogen (0, 50, 100 and 150 kg N ha^{-1}). The experiment was arranged in 4×4 factorial arrangements in a randomized complete block design with three replications. Data on growth, yield and quality parameters were recorded and analysed using SAS Computer Software version 9.2. Results revealed that interaction of FYM and N fertilizer significantly ($p<0.05$) influenced Plant height, number of leaves, leaf length, maturity, average bulb weight, total yield, marketable yield; harvest index and bulb dry matter. However, leaf diameter, bulb length, bulb diameter and unmarketable yield were not affected by the combined application of FYM and N fertilizer. The findings highlighted that the performance of onion at Jimma area can be enhanced through application of FYM and N fertilizers. The highest bulb yield of onion (36.85 ton ha^{-1}) was obtained when the plots received combined application of 100 kg ha^{-1}of N and 45 ton ha^{-1} of FYM which significantly increased the total bulb yield by about 53% as compared to the unfertilized plot (17.45 ton ha^{-1}). This however, was statistically similar with the combined application of 150 kg ha^{-1}of N and 30 ton ha^{-1}of FYM and also150 kg ha^{-1} of N and 45 ton ha^{-1} of FYM. In this study, maximum dry bulb yield of onion (33.30 ton ha^{-1}) was obtained when the plots received combined application of 150 kg ha^{-1} of N and 30 ton ha^{-1} of FYM. Therefore, from statistical point of view and labour requirements to prepare and apply FYM, a combined application of FYM at 30 ton ha^{-1} and nitrogen fertilizer at 150 kg ha^{-1} rates can be considered optimum for obtaining high onion bulb yield at Jimma area.

Key words: Onion, farmyard manure, nitrogen, growth, yield

INTRODUCTION

Onions contribute significant nutritional value to the human diet and have medicinal properties and are primarily consumed for their unique flavor or for their ability to enhance the flavor of other foods (Randle, 2000). Onions benefit from high soil fertility as they have limited root systems. Organic manure, compost or chemical fertilizers, provide nutrients for producing of high yield and quality bulb. The amount of manure and/or fertilizers applied however, depends on soil fertility level of the specific area.

Nitrogen is the principal plant nutrient required in much greater quantities. It is the important component of proteins, enzymes and vitamins in plants and is a central part of essential photosynthetic molecule, chlorophyll (Marschner, 1995). Plants demand for N can be satisfied from a combination of soil and fertilizer N to ensure optimum growth. While exogenous N application is known to increase yield of onions, many researchers on the other hand, found that high levels of nitrogenous fertilizer resulted in reduced onion storage life (Kato *et al*., 1987), cause delay in bulb maturity and results in bolting, which is undesirable characteristic of onion (Aliyu *et al*., 2008).

Though, onions are more susceptible to nutrient deficiencies than most crop plants because of their shallow and unbranched root system (Brewster, 1994), application of 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 evaporation or by leaching in drainage water and causes dangerous environmental

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pollution (Aisha *et al.*, 2007). In addition, continuous usage of inorganic fertilizer affects soil structure and those fauna found in the soil. Hence, organic manures can serve as alternative to mineral fertilizers as reported by Naeem *et al.* (2009) for improving soil structure (Ajayi *et al.*, 2008) and microbial biomass (Suresh *et al.*, 2004).

With the increased cost of inorganic fertilizers, application of recommended dose is also difficult to be afforded by the small and marginal farmers. Hence, renewable and low cost sources of plant nutrients for supplementing chemical fertilizers and that are affordable to the majority of farming community need to be used. In this context, integrated nutrient management would be a viable strategy for advocating efficient use of chemical fertilizers with matching addition of organic manures and bio fertilizers (Tandon, 1987). Farmyard manure is a conspicuous organic component of an integrated nutrient supply system, which improves soil health, increases the productivity and releases macro and micronutrients (Kale et *al*., 1992).

Onions are grown widely during the wet and dry seasons. However, yields are much higher during the dry season because of fewer incidences of pests and diseases. Due to this, in recent years, dry season production of onion is in the increase in different parts of the country. Farmers in Jimma area (Southwest Ethiopia) are aware of the response of onion to the applied nutrients and raise the crop in homesteads using farmyard manure, household wastes etc. However, the rate of farmyard manure and its combined effect with inorganic fertilizers for high production of the crop is not well known. Currently little research has been done on integrated use of organic and inorganic fertilizers application pertaining to yield and yield related components of onion. In view of this fact, a systematic investigation of the effect of using commercial fertilizer like nitrogen and locally available, accessible and affordable farmyard manure is of paramount importance for improving yield and quality of onion bulb.

This experiment was therefore initiated with the objective of assessing the effects of combined use of different levels of Farmyard manure and Nitrogen fertilizer on growth, yield and yield components and hence to identify optimum combination of farmyard manure and nitrogen fertilizer which could give an economic yield of onion in the study area.

MATERIALS AND METHODS

Description of the study area: The experiment was conducted at Jimma University, College of Agriculture and Veterinary Medicine research field in the year 2011/2012 under irrigation. The area is geographically located 346 km southwest of Addis Abeba at about 7°, 33'N latitude and 36°, 57' E longitude at an altitude of 1710 m.a.s.l. The mean maximum and minimum temperatures are 26.8 and 11.4°C, respectively and the mean maximum and minimum relative humidity are 91.4 and 39.92%, respectively (BPEDORS, 2000). The mean annual rainfall of the area is 1500-1800 mm (Melaku, 2008).

Experimental design and treatments: The experiment consisted of four levels of Farmyard manure (0, 15, 30 and 45 tons ha^{-1}) and four levels of Nitrogen (0, 50, 100 and 150 kg N ha^{-1}) and was set up in 4×4 factorial design arranged in RCBD with three replications.

Seedlings of onion cultivar called 'Bombay Red' were raised on a seed bed of 1×5 m following the recommended agronomic procedures. Different rates of well decomposed manure was carefully prepared and thoroughly applied as a single application into the experimental plots, watered and left for one week before transplanting (Olufolaji, 1990). Healthy and vigorous seedlings of 12-15 cm height (at 3-4 true leaf stage) were carefully uprooted from a seed bed prepared for this purpose and transplanted at a spacing of 20×10 cm between rows and plants, respectively. The different levels of N were applied in the form of Urea (46% N) in two split doses of equal amounts at a time of transplanting and one and half month after transplanting. Recommended cultural practices were uniformly applied for all treatment combinations.

Data on growth, yield and quality parameters were recorded and subjected to Analysis of Variance (ANOVA) using SAS computer software version 9.2 (FAO, 2008). When ANOVA showed significant differences, mean separation was carried out using Least Significant Difference (LSD) test at 5% significance level.

RESULTS AND DISCUSSION

Mean number of leaves per plant was significantly ($p<0.05$) affected by combined application of N and FYM (Fig. 1). The highest mean value (15.44) was obtained from the combined application of 150 kg ha^{-1} N and 45 ton ha^{-1} FYM and the lowest mean value (7.86) was recorded in the control treatment. This treatment increased the mean number of leaves by about 49% as compared with the unfertilized plots.

Similar results were reported by Nasreen *et al.* (2007), who found that application of 120 kg N ha^{-1} significantly increased the number of leaves per plant, but further increase of N supply to 160 kg ha^{-1} tended to decrease it.

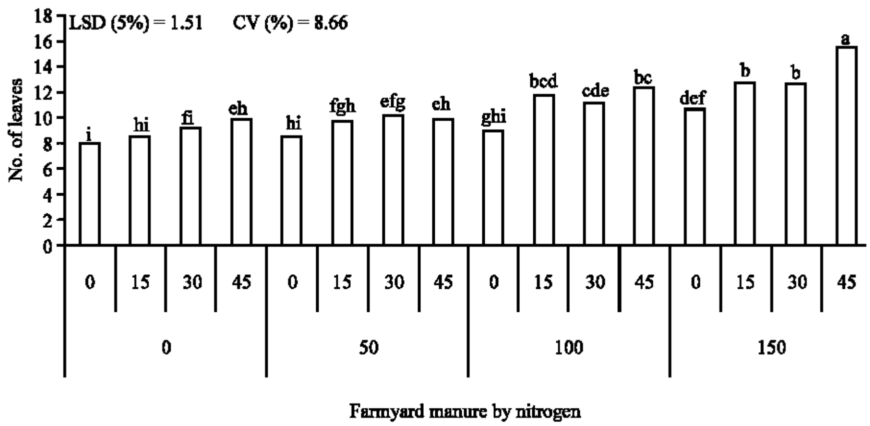

Fig. 1: Interaction effect of farmyard manure and nitrogen fertilizer on leaf Number per plant of onion at Jimma

Vachhani and Patel (1993) also reported the highest number of leaves per plant at the application rate of 150 kg ha^{-1}. 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.

Application of N and Farmyard manure highly significantly ($p<0.001$) influenced leaf length. But, their interaction was not significant. Increasing the level of FYM application from 0-45 ton ha^{-1}, increased the mean leaf length per plant by about 28% when compared with the control (33.60) (Table 1). Similarly, in this study application of N at different levels showed a highly significant ($p<0.001$) effect on the mean leaf length per plant (Table 1). The plots that were fertilized with the maximum rate of N (150 kg ha^{-1}) showed about 16% increase in mean leaf length per plant over the control (35.70 cm) which is statistically at par with value (42.05) registered from plots that received only 100 kg of N ha^{-1}. Further application of N above 100 kg ha^{-1} did not bring change on mean leaf length onion.

The result is in agreement with Bungard *et al*. (1999) who reported that N is the major constituent of proteins and the presence of abundant protein tends to increase the size of the leaves and ultimately increase carbohydrate synthesis. Kumar *et al.* (1998) and Singh and Chaure (1999) also indicated that application of N at 150 kg ha^{-1} gave the best result with regard to onion leaf length.

Application of Nitrogen and FYM did not significantly affect diameter of onion leaves grown in this experiment (Table 1). The result was not in agreement with those results reported by Kumar *et al*. (1998). In their experiment the application of 150 kg N ha^{-1} gave the highest value with regard to leaf diameter of the longest leaf. This result is also in contrast with the finding of Suresh *et al.* (2004) who reported that numerically higher leaf width was observed with treatment receiving FYM at 100% and lowest leaf width while the lowest value was obtained at a recommended dose of fertilizers used as a control. However, the application of N and FYM fertilization did not indicate any significant change on this response variable in this experiment probably due to the nature of the variety used.

Table 1: Effect of farmyard manure and nitrogen fertilizer on leaf length and leaf diameter of onion in Jimma

N (kg ha^{-1})	Leaf length (cm)	Leaf diameter (cm)
0	35.70^{b}	0.81^{a}
50	37.46^{b}	0.84^{a}
100	42.05^{a}	0.91^{a}
150	42.50^{a}	1.00^{a}
LSD (5%)	2.45	ns
FYM (ton ha^{-1})		
0	33.60^{d}	0.81^{a}
15	36.85^{c}	0.83^{a}
30	40.88^{b}	0.89^{a}
45	46.38^{a}	1.02^{a}
LSD (5%)	2.45	ns
CV%	7.47	21.2

N: Nitrogen, FYM: Farmyard manure and ns: Non significant at 5% level, Means followed by the same letter(s) in the same column are not statistically significantly at 5% level of significancy

The level of farmyard manure and interaction with nitrogen did not significantly influence mean bulb length of onin plant. This is because of the fact that nitrogen is responsible for vegetative growth of plants and later it increases the bulb weight through increasing bulb diameter rather than bulb length (Brewster, 1994). Although, FYM fertilization did not affect bulb length in this study, a number of findings disclosed an increased bulb length in response to N fertilization (Yadav *et al*., 2003; Reddy, 2005). But, separate application of N at different levels illustrated a highly significant ($p<0.001$) effect on mean bulb length (Table 2). Of all the levels tested, the maximum rate of N

Table 2: Effect of farmyard manure and nitrogen fertilizer on bulb length, bulb diameter and average bulb weight of onion in Jimma

N (kg ha^{-1})	Bulb length (cm)	Bulb diameter (cm)	Average bulb weight (g)
0	4.54^{c}	5.47^{b}	40.37^{c}
50	4.77^{bc}	5.77^{a}	49.85^{b}
100	5.03^{ab}	5.93^{a}	58.98^{a}
150	5.18^{a}	5.94^{a}	64.34^{a}
LSD (5%)	0.35	0.23	5.67
FYM (ton ha^{-1})			
0	4.73^{a}	5.59^{b}	48.92^{b}
15	4.85^{a}	5.73^{b}	49.20^{b}
30	4.87^{a}	5.80^{ab}	54.01^{b}
45	5.06^{a}	5.99^{a}	61.42^{a}
LSD (5%)	ns	0.23	5.67
CV%	8.83	4.90	12.74

N: Nitrogen, FYM: Farmyard manure and ns: Non significant at 5% level, Means followed by the same letter(s) in the same column are not statistically significantly at 5% level of significancy

(150 kg ha^{-1}) increased the mean bulb length by about 12% in reference to the control treatments (4.54 cm), which was statistically similar with the result obtained by the application of 100 kg ha^{-1} N. The result indicates that further application of nitrogen did not affect onion mean bulb length.

Nitrogen and Farmyard manure highly significantly ($p<0.001$) influenced the mean bulb diameter of onion grown during this experiment. However, their interaction did not show any significant effect. Application of FYM at a rate of 45 ton ha^{-1} gave the highest mean bulb diameter (5.99 cm); which was statistically similar with 30 ton ha^{-1} (Table 2). The smallest bulb diameter (5.59 cm) was found at control (0 ton FYM ha^{-1}).

In another study it was found that applications of farmyard manure, pelleted manure, neem (*Azadirachta indica*) seed powder and karanj cake (*Pongamia pinnata*) with 75% of the recommended inorganic fertilizer [100 kg ha^{-1} N, 60 ha^{-1} phosphorus (P) and 80 kg ha^{-1} potassium (K)] resulted in increased onion bulb diameter compared with using inorganic fertilizers alone (Mondal *et al*., 2004). Similarly, N fertilization (150 kg ha^{-1}) increased bulb diameter by about 8% in reference to the control (5.47 cm), which may be linked to the increase in dry matter production and allocation to the bulb. Larger bulb diameter in onion with N application could be associated with promoting nature of nitrogen in cell elongation, above ground vegetative growth and synthesis of more chlorophyll to impart dark green color of leaves which may be linked to the increase in dry matter production and translocation to the bulb (Brady, 1985).

A significant ($p<0.05$) interaction effect of nitrogen with farmyard manure was also observed on mean bulb weight of onion. Mean bulb weight increase of about 43% was obtained in response to application of 150 kg ha^{-1} N and 30 ton ha^{-1} FYM as compared to the control. But, additional application did not bring any significant change. Likewise, mean bulb weight of onion was highly and significantly affected by farmyard manure alone, where the application of 45 ton ha^{-1} gave the maximum mean value (61.42 g) which resulted in 20% increases as compared to the control (Table 2).

Abbey and Kanton (2004) found that application of Farmyard Manure (FYM), Inorganic Fertilizer (IF) or a combination of manure and inorganic fertilizer (FYM+IF) resulted in an increase of onion bulb weight. The mean bulb weight improvement in response to N could be attributed to the increase in number of leaves, leaf length and extended physiological maturity in which case mean bulb weight showed significant and strong correlation with each of these variables (Table 2). The increase in leaf number and length resulted in an increase in assimilate production and allocation to the bulbs.

Significant interaction effect ($p<0.05$) of nitrogen and farmyard manure was observed on plant height and total bulb yield of onion (Table 3). Application of 100 kg N ha^{-1} and 15 ton FYM ha^{-1} increased onion plant height by about 21% compared to the control (41.47 cm). However, further increase of rate of fertilizer did not affect to plant height. The highest mean plant height (54.16 cm) was obtained at 100 kg ha^{-1} N and 45 ton ha^{-1} FYM, while the lowest (41.47 cm) was obtained at a treatment combinaton of 0 kg N ha^{-1} and 0 ton FYM ha^{-1}(Table 3). The result is in line with the findings of Gupta *et al.* (1999) who reported that application of FYM at 72.0 quintals ha^{-1} along with ammonium sulphate at 565 kg ha^{-1} were effective in increasing the growth and yield in onion. The mixture of these fertilizers improved the vegetative growth characters of onion.

Increasing the application of combined level of N from 0 to 100 kg ha^{-1} and FYM from 0 to 30 ton ha^{-1} resulted in progressive increase in total bulb yield of onion. Further increase in nitrogen and farmyard manure fertilizer to 150 kg ha^{-1} and 45 ton ha^{-1}, respectively did not bring any difference. The highest bulb yield of onion (36.85 ton ha^{-1}) was obtained when the plots received combined application of 100 kg ha^{-1} of N and 45 ton ha^{-1} of FYM which was statistically similar with the levels of 150 kg ha^{-1} of N; 30 ton ha^{-1} of FYM and 150 kg ha^{-1} of N ; 45 ton ha^{-1} of FYM. This increased the total bulb yield by about 53% as compared with the unfertilized plot (17.45 ton ha^{-1}).

An integration of organic amendments with inorganic fertilizers resulted in higher yields and greater growth than the inorganic fertilizer alone (Jayathilake *et al*., 2002). In addition, the inclusion of organic manures and bio-fertilizers reduced the required amounts of inorganic N, P and K required for fertilization (Selvakumari *et al*., 2001).

Table 3: Interaction effect of farmyard manure and nitrogen fertilizer on plant height, total bulb yield, marketable bulb yield and unmarketable bulb yield of onion at Jimma

FYM (ton ha^{-1})	N (kg ha^{-1})	Plant height (cm)	Total bulb yield (ton ha^{-1})	Marketable bulb yield (ton ha^{-1})	Unmarketable bulb yield (ton ha^{-1})
0	0	41.47^{f}	17.45^{e}	15.83^{e}	1.61^{a}
	50	42.12^{ef}	21.70^{cde}	20.16^{cde}	1.53^{a}
	100	48.86^{bc}	23.40^{bcd}	21.97^{bcd}	1.42^{ab}
	150	51.44^{ab}	26.62^{bc}	25.05^{bc}	1.57^{a}
	0	46.29^{cd}	18.96^{de}	17.66^{de}	1.29^{ab}
15	50	47.78^{cd}	22.71^{bcd}	21.45^{bcd}	1.26^{ab}
	100	52.33^{a}	23.41^{bcd}	21.95^{bcd}	1.45^{ab}
	150	54.11^{a}	26.98^{b}	25.38^{b}	1.60^{a}
	0	45.21^{de}	18.97^{de}	17.55^{de}	1.42^{ab}
30	50	52.19^{a}	23.11^{bcd}	21.78^{bcd}	1.33^{ab}
	100	53.11^{a}	23.29^{bcd}	21.82^{bcd}	1.47^{ab}
	150	53.29^{a}	33.30^{a}	32.50^{a}	1.26^{ab}
	0	47.61^{cd}	26.70^{bc}	25.16^{bc}	1.54^{a}
45	50	51.72^{ab}	25.84^{bc}	24.25^{bc}	1.59^{a}
	100	54.16^{a}	36.85^{a}	36.32^{a}	1.28^{ab}
	150	54.01^{a}	34.78^{a}	33.52^{a}	1.26^{ab}
LSD (5%)		3.18	5.01	5.01	ns
CV (%)		3.84	11.89	12.58	21.78

N: Nitrogen, FYM: Farmyard manure, Means followed by the same letter(s) within the same column are not significantly different at 5% level of significancy

Table 4: Pearson correlation (r) among growth, yield and yield components of onion

Parameter	PH	LL	LD	MD	BD	BL	TBY	MBYC	UMY
PH	1.00								
LL	0.70***	1.00							
LD	0.27^{ns}	0.39***	1.00						
MD	0.77***	0.68***	0.30*	1.00					
BD	0.47**	0.60**	0.39**	0.45**	1.00				
BL	0.40*	0.45**	0.28*	0.56**	0.28*	1.00			
ABWT	0.63**	0.69**	0.47**	0.72**	0.55**	0.50**			
TBY	0.62***	0.76***	0.47***	0.72***	0.54**	0.53**	1.00		
MBY	0.62**	0.75**	0.49**	0.72**	0.53**	0.55**	0.99**	1.00	
UMY	-0.20^{ns}	-0.16^{ns}	-0.36*	-0.26^{ns}	-0.06^{ns}	-0.36**	-0.30*	-0.37*	1

PH: Plant height, LNPP: Leaf number per plant, LL: Leaf length, LD: Leaf diameter, BD: Bulb diameter, BL: Bulb length, TBY: Total bulb yield, MBY: Marketable bulb yield, UMY: Unmarketable bulb yield ns: Non-significant, *** and ***Indicate significant difference at probability level of 5, 1 and 0.1%, respectively

Highly significant ($p<0.01$) interaction effects were observed on marketable yield (Table 3). But, no effect of the treatment combinations was observed on the unmarketable bulb yield. The highest marketable bulb from all the fertilizer combinations, treatments that had more amount of farmyard manure fertilizer gave highest yield. On the other hand, the highest unmarketable bulb yield was recorded from the unfertilized plots. In onion, low as well as lack of nitrogen fertilizer may have been associated with early bulb formation, stunted growth, with bulbs size and marketable yields reduced.

Highly significant ($p<0.01$) interaction effect of nitrogen with FYM was also observed with respect to the harvest index (data not shown). The highest harvest index (0.90) was recorded from treatment combination of 150 kg ha^{-1} N and 45 ton ha^{-1} FYM, which is not significantly different from plots received 150 kg ha^{-1} N and 30 ton ha^{-1} FYM. Increasing the level of combined application of nitrogen and FYM from 0 to 150 kg ha^{-1} and 0 to 45 ton ha^{-1}, highly significantly increased the harvest index by about 36% over the respective control treatment.

Investigating correlations between the different response variables, it was observed that plant height was significantly and positively correlated (Table 4) with leaf number per plant (r = 0.70***), total bulb yield (r = 0.62***), marketable bulb yield (r = 0.62***) and bulb dry matter content (r = 0.38**). This indicates that selection of fertilizer combination for high plant height, results to the indirect selection of fertilizer combination for onion yield.

CONCLUSION

Onions are heavy feeders and require more fertilizer than is used in most vegetable crops. The amount to be applied depends on the type and fertility status of the soil. For economic production of the crop, this, however, requires identification of optimum fertilizer: Organic, inorganic or their combination levels.Integrated nutrient management is a viable strategy for promoting efficient use of chemical fertilizers with some amount of addition of organic manures. In this experiment, it was observed that main effect of FYM and N as well as their interactions had considerable influence on plant height, number of leaves, average bulb weight, marketable yield and total yield of onion. Leaf length, leaf diameter, bulb diameter, bulb length and unmarketable bulb yield were not found responding to the treatments. From this study, it was observed that 30 ton ha^{-1} FYM and 150 kg ha^{-1} N is the optimum treatment combination for onion production in the study area.

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