RESEARCH ARTICLE

Effect of integrated nutrient management on growth and bulb yield of onion (*Allium cepa* L.) under irrigation at Selekleka, Northern Ethiopia

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ABSTRACT

Onion is an important crop both as a condiment and income generation for smallholder farmers in north western Zone of Tigray. However, Continuous use of inorganic fertilizers and inappropriate soil fertility management practices are among the major factors limiting onion productivity in the region. Therefore, a field experiment was undertaken in Selekleka district north western zone of Tigray, from October 2015 to June 2016 to assess the effects of integrated nutrient management on growth and bulb yield of onion (Allium cepa L.). The treatments consisted of combinations of two rates of farmyard manure (FYM) (10 and 20 t ha^{-1}) and two rates of vermicompost (VC) (2.5 and 5 t ha^{-1}) each combined with three rates of nitrogen (25, 50 and 75) of recommended N fertilizers, RDF. In addition, 100% RDF N (69 kg N ha^{-1}), 100% (5 t ha^{-1}) of VC, 100% (20 t ha^{-1}) FYM and zero rates (unfertilized treatment) were used for comparison. The experiment was laid out in a randomized complete block design with three replications. Results revealed that combined application of 5 t ha^{-1} VC+50% inorganic N fertilizers recorded the highest plant height (71.67 cm), leaf number (16.15), leaf length (45.19 cm), neck thickness (1.51 cm), bulb length (5.51 cm), bulb diameter (5.90 cm), mean bulb weight (92.64 g), biological yield (131.42 g), harvest index (82.18%), marketable yield (35.13 t ha^{-1}), bulb dry weight (35.46%), total dry biomass (40.27 g), and total yield (35.25 t ha^{-1}). It could, thus, be concluded that, based on the partial budget analysis and result of soli analysis after harvest the application of 5 t ha^{-1} vermicompost and 50 % recommended inorganic nitrogen was the appropriate combination for better onion production with minimum weight loss in the study area.

Keywords: farmyard manure, integrated nutrient management, nitrogen, Onion, vermicompost.

INTRODUCTION

Onion is one of the most important vegetable crops cultivated mostly under irrigated conditions in north western Zone of Tigray Region, particularly in Selekeleka district. During 2014/15 cropping season the irrigable area in the district covered by onion and shallot were 1154.75 and165 ha respectively, according to wereda Biro of Agriculture (Unpublished data). According to Shire-Maitsebri Agricultural Research Center problem appraisal (Unpublished data) continuous use of inorganic fertilizers and inappropriate soil fertility management practices are among the major factors limiting onion productivity in Selekeleka district.

Onion shows significant response to organic and inorganic fertilizers (Nasreen and Hossain, 2000). Therefore, the usage of organic manures as alternative source of nitrogen would give better result in its growth and yield. Organic material, such as farmyard manure improves soil physico-chemical properties that are important for plant growth (Snyman *et al.,* 1998). Decomposition of materials would provide additional nutrients to the growing medium which may lead to higher uptake of nutrient by the crop and subsequently high yield. Besides, organic manures have positive effect on root growth by improving the root rhizosphere conditions (structure, humidity, etc.) and also plant growth is encouraged by increasing the population of microorganisms (Shaheen *et al*., 2007).

Farmers in north western Tigray, especially in Selekeleka district, mostly use synthetic fertilizers on blanket recommendation (DAP 200 kg ha^{-1} and Urea 100 kg ha^{-1}) for onion production (Nikus and Mulugeta, 2010). They rarely use organic manure on small scales in gardens and /or near their homestead mainly due to scarcities of these resources and lack of knowledge about advantage of organic manure. A major constraint in increasing onion crop yield is the supply of nutrients particularly the nitrogen. Continuous use of inorganic fertilizers with no supplementation of organic manure has resulted in deficiency of micro nutrients, imbalance in soil physico-chemical properties and unsustainable crop production. Use of organic manures in combination with chemical fertilizers in an appropriate proportion improves the overall soil health for sustainable onion production (Gupta *et al,* 1999). Therefore, integrated nutrient management is available strategy for advocating judicious and efficient use of chemical fertilizers with matching addition of organic manures for sustainable onion cultivation. This study was, therefore conducted to assess the effect of integrated nutrient management on growth and bulb yield of irrigated onion and to find economically appropriate integrated nutrient management for onion.

MATERIALS AND METHODS

Description of the Study Area

The study was conducted at Selekeleka Research site, in Tigray Regional State in northern Ethiopia in October, 2015. Selekeleka is located 1065 km north of Addis Ababa at 14°6′43′′ N, 38°27′50′′E, and at an altitude of 1951 m above sea level. The mean annual rainfall is 680 mm. The soil textural class is clay loam with pH of 7.2. The organic matter, total nitrogen, available phosphorus, organic carbon, CEC, EC, exchangeable potassium and available potassium content were 1.910 %, 0.1736 %, 23.7ppm, 1.108 %, 46.2 (meq/100 gram), 0.17 (ms/cm), 173 ppm and 134ppm, respectively. The rainy season extends from June to September and the maximum rain is received in the months of June to August (Mekelle Meteorological Station). The rural area around the study site is known for the mixed crop-livestock farming system in which cultivation of Teff, Sorghum, Maize, Finger Millet and pulse crops are the major cropping activities (Yayneshet, 2010).

Treatments and experimental design

The treatments consist of combinations of two rates of FYM (10 and 20 t ha^{-1}) and two rates of VC (2.5 and 5 t ha^{-1}) each combined with three recommended rates (25, 50 and 75%) of inorganic N fertilizers. In addition, 100% recommended rate of inorganic N fertilizer (69 kg N), 100% (5 t ha^{-1}) of VC, 100% (20 t ha^{-1}) FYM and zero rates (unfertilized treatment) were used for comparison. The experiment was laid out in a randomized complete block design with three replications. The gross plot size was 2 m x 3 m (6 m^2). The distance between blocks were 1.5 meters whereas the distance between plots were 1m and the spacing between rows and plants were 40cm (with double rows at 20 cm) and 10cm, respectively.

Experimental procedure

Seedlings of Bombay Red onion were raised in a nursery at Shire-maitsebri Agricultural Research Center (SMARC). All proper agronomic practices were carried out until the seedlings were transferred to the main field as per the procedure described by EARO, (2004).

The experimental field was plowed three times using ox plough before transplanting seedlings. Experimental plots of 2 m x 3 m were prepared. Well decomposed farmyard manure was uniformly applied to the plots and mixed thoroughly 15 days before transplanting and vermicompost was applied during transplanting date as par the treatment levels. Healthy seedlings having 12-15 cm height were transplanted on October 16, 2015 at the spacing indicated above.

The experiment was conducted under irrigation using furrow irrigation method, at interval of two times a week for the 1st four weeks at five days interval afterwards until 14 days to harvest. Other recommended agronomic practices like weeding, insect pest and disease control, etc., were kept uniformly for all treatments. Harvesting of onion bulbs was done when 70 % plants showed neck fall (EARO, 2004). Harvesting of onion was done on March 2, 2016.

Data Collection

Measurements on the following growth parameters (plant height, leaf number, leaf length, leaf diameter, total dry biomass and harvest index) and bulb characters (bulb length and diameter, average bulb weight, were recorded at physiological maturity and harvesting time, respectively. The data set is the average of nine randomly taken plants in each experimental plot.

Days to physiological maturity referred to the actual number of days from transplanting to a day at which more than 80% of the plants in a plot showed yellowing of leaves. Total bulb yield was computed based on the weight of matured bulb yield per plot and converted in to hectare base and expressed in tones. Marketable bulb yield was determined after discarding bulbs smaller than 3 cm in diameter, splitted, thick necked, rotten and discolored. Split bulbs percentage was determined by counting the number of split bulbs per plot and expressed in percentage in reference to total number of normal bulbs per plot.

Data Analysis

Data on all parameters/response variables were subjected to analysis of variance (ANOVA) using the Gen Stat statistical package (Gen Stat, 13th Edition). When ANOVA showed significant differences, mean separation was carried out using Least Significant Difference (LSD) test at 5% level of significance.

Economic Analysis

In order to identify economically feasible recommendations, partial budget analysis was carried out according to CIMMYT (1988). The analysis was based on the data collected from the woreda office of Agriculture and Rural development. The mean prices of onion, FYM, VC and urea, in 2015/16 in the study area were 8.60, 3, 5 and 13.34 Birr kg^{-1}, respectively, and used for calculating partial budget analysis.

RESULTS AND DISCUSSION

Days to maturity

Days to maturity of onion plant was significantly ($P < 0.001$) influenced by combined application of organic and N fertilizer rates (Table 1). The application of 5 t ha^{-1} VC + 50 % N T5 fertilizers resulted in earlier maturity (125.3 days) next to control (117.7 days). The result confirms the findings of Hegde and Dwivedi (1993) who reported that integration of organic manure with inorganic fertilizers fasten maturity period of the crop. The application of 100 % N made the onion to mature late (136 days). The delayed maturity observed in response to increasing the rate of nitrogen application could be attributed to enhanced vegetative growth and photo assimilation that may have prolonged the start of physiological maturity (Krshnappa, 1989).

Plant height

Analysis of variance showed that plant height was highly influenced ($p<0.001$) by the combined application of organic manure and nitrogen fertilizers (Table 1). The highest plant height (71.67 cm) was recorded from application of 5 t ha^{-1} VC + 50 % N (T5) followed by plants treated with from 5 t ha^{-1} VC + 75 % N. On the other hand, least plant height (45.52 cm) was noted from control. The inorganic fertilizer treated plants also had lower plant height than most other treatments that received combined application of inorganic nitrogen and farmyard manure and/or vermicompost. The result is corroborated with the reports of Farooq *et al.* (2015) that show increase in height of plants with increase in application of organic fertilizers. It is also in agreement with the finding of Jayathilake *et al*. (2002) who reported highest plant height obtained through the application of organic manures+50% N and 100% PK in onion.

Table 1. Effect of integrated nutrient management on growth parameter of onion plant

Treatment combinations	Days to physiological maturity(days)	Plant height (cm)	Leaf length (cm)	Number of leaves per plant
2.5 t ha^{-1} VC + 25% RDF N	130.3 de	50.26 fg	29.30 ef	8.63 de
2.5 t ha^{-1} VC + 50% RDF N	132.0 f	52.04 ef	28.52 f	8.85 c
2.5 t ha^{-1} VC + 75% RDF N	127.7 c	58.15 c	36.33 c	12.15 b
5 t ha^{-1} VC + 25% RDF N	132.0 f	52.26 ef	29.96 def	8.81 de
5 t ha^{-1} VC + 50% RDF N	125.3 b	71.67 a	45.19 a	16.15 a
5 t ha^{-1} VC + 75% RDF N	131.7 ef	62.30 b	41.33 b	13.22 b
10 t ha^{-1} FYM + 25% RDF N	130.7 def	51.59 efg	29.48 ef	8.81 de
10 t ha^{-1} FYM + 50% RDF N	132.0 f	51.33 efg	31.48 de	9.67 cd
10 t ha^{-1} FYM + 75% RDF N	132.0 f	51.74 efg	28.11 f	8.67 de
20 t ha^{-1} FYM + 25% RDF N	132.0 f	52.63 de	28.85 f	8.81 de
20 t ha^{-1} FYM + 50% RDF N	131.7 ef	50.67 efg	29.26 ef	8.67 de
20 t ha^{-1} FYM + 75% RDF N	129.7 d	54.93 d	32.30 d	10.33 c
5 t ha^{-1} VC	131.3 ef	50.00 fg	27.93 f	8.30 ef
20 t ha^{-1} FYM	132.0 f	51.37 efg	28.85 f	9.19 cde
100% RDF N	136.0 g	49.48 g	29.11 f	8.93 de
Absolute control	117.7 a	45.52 h	22.48 g	7.26 f
LSD (5%)	1.541	2.339	2.338	1.233
CV	0.7	2.6	4.5	7.6
SEM	0.534	0.810	0.810	0.427
F-test	***	***	***	***

*Means followed by the same letter within a column are not significantly different at (P≤0.05); ***= indicates significant at 0.1%.*

Leaf length

Onion leaf length was significantly ($P < 0.001$) influenced by the integrated use of organic manure and nitrogen fertilizers (Table 4). The application of 5 t ha^{-1}+ 50% N increased leaf length by 101% over the control and by about 55 % over the RDF rate.

It is obvious that nitrogen is a necessary input for protein synthesis by the plant and many more physiological functions like photosynthesis, cell division and plant growth. Based on the current study, the application of vermicompost along with inorganic fertilizers provides excellent effect on overall plant growth and encourages the growth of new shoots /leaves and improves plant height. The result are concurrent with that of Chadha *et al.* (2006) who stated that the combined application of vermicompost and nitrogen fertilizers increased bulb length of the onion crop.

Leaf number

There was highly significant ($p<0.001$) variation among the treatments on leaf number (Table 1). The maximum average leaf number per plant (16.15) was obtained from the application of 5 t ha^{-1} VC + 50% RDF N followed by the application of 5 t ha^{-1} VC + 75% RDF N (13.22) and the minimum leaf number per plant was 7.26 obtained from the control. Plants from the control treatments tended to be stunted, grow slowly, and produce fewer leaves than fertilized plots. From these study it could be proved that the application of 5 t ha^{-1}+ 50% RDF N increases leaf number by 122.45% over the control and 81% over 100% RDF N. The production of greater number of leaves can be due to higher metabolic activity because of the higher availability of macro and micro nutrients from vermicompost and N from inorganic fertilizer resulting in higher production of carbohydrates and phytohormones which were manifested in the form of enhanced growth as explained by Govindan and Purushottam (1984).

Neck thickness

The neck thickness is one of the important growth parameters which indicates the vigour and extended growth of the plant and was highly significantly ($p<0.001$) influenced by combined application of organic and inorganic fertilizers. Higher levels of organic manures recorded significantly higher neck

Table 2. Effect of integrated nutrient management on yield traits of onion

Treatment combinations	Neck thickness (cm)	Bulb diameter (cm)	Bulb length (cm)	Mean bulb weight(g)	Biological yield (g/plant)
2.5 t ha^{-1} VC + 25% RDF N	1.211 bc	4.44 fg	4.41 ef	62.84 h	90.43 h
2.5 t ha^{-1} VC + 50% RDF N	1.085 cd	4.69 efg	4.33 efgh	67.76 f	94.18 g
2.5 t ha^{-1} VC + 75% RDF N	1.259 bc	5.29 bc	4.79 c	74.41 c	105.93 c
5 t ha^{-1} VC + 25% RDF N	1.148 c	4.64 efg	4.30 fgh	69.38 e	97.15 f
5 t ha^{-1} VC + 50% RDF N	1.511 a	5.90 a	5.51 a	92.64 a	131.42 a
5 t ha^{-1} VC + 75% RDF N	1.393 a	5.52 b	5.19 b	81.55 b	116.09 b
10 t ha^{-1} FYM + 25% RDF N	1.207 bc	4.41 g	4.30 fgh	57.67 j	84.60 j
10 t ha^{-1} FYM + 50% RDF N	1.089 cd	4.72 def	4.41 ef	59.79 i	87.97 I
10 t ha^{-1} FYM + 75% RDF N	1.133 cd	4.65 efg	4.40 efg	62.29 h	91.21 h
20 t ha^{-1} FYM + 25% RDF N	1.148 c	4.69 efg	4.36 efgh	65.66 g	93.75 g
20 t ha^{-1} FYM + 50% RDF N	1.185 bc	4.90 de	4.44 e	71.57 d	100.00 e
20 t ha^{-1} FYM + 75% RDF N	1.233 bc	5.02 cd	4.58 d	72.11 d	102.43 d
5 t ha^{-1} VC	1.115 cd	4.65 efg	4.41 ef	55.54 k	84.26 jk
20 t ha^{-1} FYM	1.148 c	4.46 fg	4.27 gh	55.20 k	82.31 kl
100% RDF N	0.933 de	4.62 efg	4.26 h	52.94 l	80.58 l
Absolute control	0.803 e	3.74 h	3.76 I	37.87 m	59.61 m
LSD (5%)	0.214	0.307	0.136	1.218	2.050
CV	11.0	3.9	1.8	1.1	1.3
SEM	0.085	0.106	0.047	0.422	0.710
F-test	***	***	***	***	***

*Means followed by the same letter within a column are not significantly different at (P≤0.05); ***=indicates significant 0.1%.*

thickness (Table 2). This could be attributed to luxurious plant growth with and formation of more number of leaves per plant (Bangali *et al.* 2012). The maximum neck thickness (1.51 cm) was measured under treatment of 5 t ha^{-1} VC + 50% RDF N and 5 t ha^{-1} VC + 75% RDF N (1.4 cm) while minimum neck thickness was from control plots (0.80 cm). These results are also corroborated with the findings of Yadav *et al.* (2015) who reported that the highest neck thickness (1.25 cm) was obtained from the application of 50% vermicompost + 50% RDF.

Bulb diameter

The results indicated that application of both organic and inorganic fertilizers had highly significant ($p < 0.001$) impact on the onion bulb diameter. Application of 5 t ha^{-1} of VC + 50% RDF N gave the highest bulb diameter (5.90 cm) whereas plots treated with nil fertilizers gave the lowest bulb diameter (3.74 cm). Application of 5 t ha^{-1} of VC + 50% N resulted in about 58% bulb diameter increment as compared to the control treatment. When the vermicompost dose was increased from 2.5 t ha^{-1} to 5 t ha^{-1} and inorganic N from 25% to 50%, there was an increase in bulb diameter by 32.9% (Table 2). Yoldas *et al.* (2011), Akoun (2005), and Jayathilake *et al.* (2003) also showed that the interaction of organic and inorganic fertilizers can increase the diameter of the shallot bulbs.

Bulb length

Integrated application of organic and inorganic sources showed highly significant ($p<0.001$) variations in respect of bulb length of onion (Table 2). The highest bulb length (5.51 cm) was achieved from application of 5 t ha^{-1} of VC + 50% RDF N while the control plot gave the lowest bulb length (3.76 cm). Obviously the integration of organic and inorganic N fertilizers supplied the necessary requirements for the proper vegetative growth of plant that helps in obtaining the highest bulb size. In agreement with the present result, Hussain *et al.* (1988) reported that organic manures increased the efficiency of chemical fertilizers.

Mean bulb weight

There was highly significant ($P \leq 0.001$) difference among the treatments in mean bulb weight and the highest mean bulb weight (92.64 g) was obtained from the combined application of 5 t ha^{-1} VC and 50% RDF N followed by application of 5 t ha^{-1} VC and 75% RDF N (81.55 g) and the lowest mean bulb weight (37.87 g) was obtained from the control (Table 2). The integrated use of 5 t ha^{-1} of vermicompost and 50% nitrogen fertilizers increased the bulb weight of onion by 144.62% and 75% over the untreated plots and those fertilized by 100% RDF nitrogen, respectively. In general, all plots that received either vermicompost or farmyard manure alone or in combination with inorganic nitrogen significantly increased mean bulb weight of onions. This might be due to more translocation of photosynthates from leaves to bulb causing increased bulb weight and diameter (Singh *et al*. 1997). This was also due to solubilization effect of plant nutrients by the addition of vermicompost and FYM leading to increased uptake of NPK (Subbiah *et al.,* 1982).

Biological yield

Significantly highest biological yield (131.42 g) was obtained from the application of 5 t ha^{-1} VC + 50% RDF N while the lowest biological yield (59.61 g) was recorded from the control (Table 2). This treatment increased biological yield by 120.47% over the control and 63% over the 100 % RDF nitrogen fertilizer. Treatments that included combinations of vermicompost or farmyard manure and inorganic nitrogen increased biological yield of onion by 41.9% to 94.7% over the control treatment. This could be due to the fact that the major nutrient supplied by the inorganic fertilizers is utilized quickly by the crops and all other micro and macro nutrients available in organic manure will be released slowly (Wikipedia 2016).

Bulb dry matter content

From the data presented in Table 6 it could be noted that maximum percent bulb dry weight (35.46%) was recorded under the application of 5 t ha^{-1} VC + 50% RDF N, followed by control plot(29.97%). On the other hand, minimum percent bulb dry weight (22.70%) was recorded under the application of 20 t ha^{-1} FYM + 50% RDF N (Table 3). The increase in dry weight by combined application of 5 t ha^{-1} VC + 50% RDF N

Table 3. Effect of integrated nutrient management on yield and traits of onion

Treatment combinations	Bulb dry matter content (%)	Total yield (t ha^{-1})	Total dry biomass (g/pl)	Harvest Index (%)
2.5 t ha^{-1} VC + 25% RDF N	24.95 efgh	28.47 cdefg	21.76 efg	72.63 ef
2.5 t ha^{-1} VC + 50% RDF N	23.77 fgh	28.83 cdefg	21.76 efg	72.71 ef
2.5 t ha^{-1} VC + 75% RDF N	28.28 bcd	31.28 bc	27.33 c	77.26 bc
5 t ha^{-1} VC + 25% RDF N	24.45 efgh	29.13 cdef	22.73 ef	74.44 de
5 t ha^{-1} VC + 50% RDF N	35.46 a	35.25 a	40.27 a	82.18 a
5 t ha^{-1} VC + 75% RDF N	29.87 bc	32.31 b	30.83 b	78.77 b
10 t ha^{-1} FYM + 25% RDF N	29.39 bc	27.74 defg	23.22 e	74.68 de
10 t ha^{-1} FYM + 50% RDF N	25.65 defg	27.78 defg	21.13 g	71.78 f
10 t ha^{-1} FYM + 75% RDF N	25.51 defg	27.97 defg	21.33 fg	72.93 ef
20 t ha^{-1} FYM + 25% RDF N	23.31 gh	28.60 cdefg	21.30 fg	72.69 ef
20 t ha^{-1} FYM + 50% RDF N	22.10 h	30.12 bcde	22.11 efg	73.31 ef
20 t ha^{-1} FYM + 75% RDF N	26.75 cdef	30.48 bcd	25.25 d	76.20 cd
5 t ha^{-1} VC	28.18 bcd	27.56 efg	21.46 fg	68.70 ef
20 t ha^{-1} FYM	26.92 bcde	27.27 fg	20.63 g	71.36 f
100% RDF N	29.66 bc	26.25 g	21.75 efg	73.59 ef
Absolute control	29.97 b	19.91 h	17.68 h	68.70 g
	3.118	2.836	1.576	2.293
	6.9	5.9	4.0	1.9
	1.080	0.982	0.546	0.794
	***	***	***	***

*Means followed by the same letter within a column are not significantly different at (P≤0.05);, ***=indicates significant at 0.1%.*

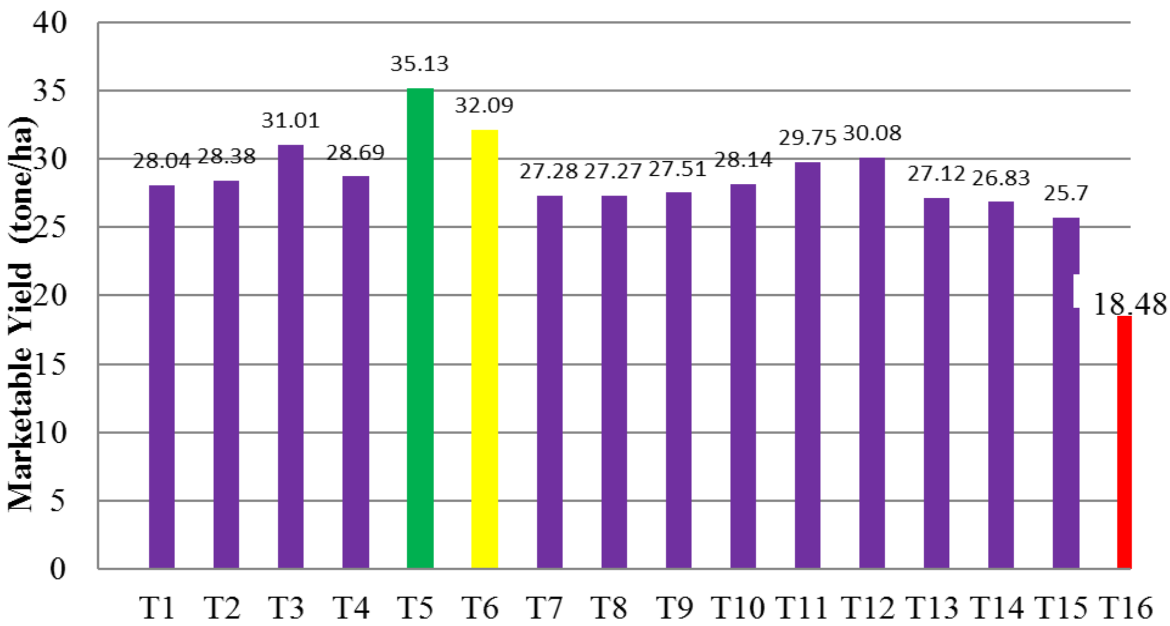

Fig. 1: Marketabke Yield (t/ha

might be attributed to increasing the amount of nutrients in the soil, that plant nutrient uptake and thereby increase its leaf area and this leads to a higher growth rate of crop and finally increase in dry matter. This might be due to most of the photosynthate is translocated for bulb formation, resulting in significantly high dry weight of bulb (Gardner *et al.,* 1991).

Total dry biomass

The highest total dry biomass (40.27 g plant^{-1}) was recorded in plots treated with 5 t ha^{-1} VC + 50% RDF N followed by application of 5 t ha^{-1} VC + 75% RDF N with the value of 30.83 g plant^{-1}. In contrast, the lowest total dry biomass (17.68 g plant^{-1}) was observed in the control plots receiving no organic or inorganic fertilizer (Table 3). Application of 5 t ha^{-1} VC + 50% RDF N increased total dry biomass by 127.8% over the control and by 85% over 100% RDF treated plots. This shows the beneficial effect of vermicompost in improving plant growth and dry matter yield when added to the soil (Zaller, 2007).This result is in line with the result of Nasreen *et al.* (2007) and El-Tantawy and El-Beik (2009) indicated that application of higher N doses increased total dry biomass yields of onion.

Marketable yield

The analysis of variance showed that a combined application of organic manure and inorganic fertilizers had highly significant ($P < 0.001$) effect on marketable bulb yield of onion (Table 3). The highest marketable yield (35.13 t ha-1) of onion was obtained from the application of 5 t ha^{-1} VC + 50% N while and the lowest (18.48 t ha^{-1}) marketable yield was recorded from nil fertilizer treated plots. The increment of marketable yield of onion by this treatment was 90% over the control and 36.7% over the 100% RDF N fertilized plots. Both vermicompost and inorganic nitrogen fertilizer produced significant increases in plant growth and marketable yield. It is evident from previous data that the highest growth and yield attributing parameters were recorded from application of 5 t ha^{-1} VC + 50% RDF N, followed by 5 t ha^{-1} VC + 75% RDF N. Thus, this treatment appeared to be the most favorable treatment combination compared to the other integration ratios. Likewise, Sankar *et al.* (2009) reported that the marketable bulb yield of onion was significantly improved by the addition of organic manures and application of organic growth stimulants.

Total yield

Highly significant ($P \leq 0.001$) variation existed among the treatments with respect to total bulb yield (Table 3). The highest total bulb yield was achieved with 5 t ha^{-1} vermicompost +50% RDF N (35.25 t ha^{-1}) followed by 5 t ha^{-1} vermicompost + 75% RDF N (32.31 t ha^{-1}) and lowest yield obtained from control (19.91 t ha^{-1}). The lowest yield in the control treatment may be due to the fact that plots did not receive any organic and inorganic fertilizers and hence were deficient of

Table 41. Partial budget analysis of onion as influenced by integrated nutrient management

Treatment combinations	Unadjusted marketable yield (t ha^{-1})	adjusted marketable yield (t ha^{-1})	gross benefit (ETB ha^{-1})	variable cost (ETB)	net benefit (ETB ha^{-1})	MRR (%)
Absolute control	18.48	16.63	143018	0	143018	0
100% RDF N	25.7	23.13	198918	2016	196902	2672
2.5 t ha^{-1} VC + 25% RDF N	28.04	25.24	217064	13004	204060	65
2.5 t ha^{-1} VC + 50% RDF N	28.38	25.54	219644	13508	206136	411
2.5 t ha^{-1} VC + 75% RDF N	31.01	27.91	240026	14012	226014	3944
5 t ha^{-1} VC	27.12	24.41	209926	25000	184926^{D}	
5 t ha^{-1} VC + 25% RDF N	28.69	25.82	222052	25504	196548^{D}	
5 t ha^{-1} VC + 50% RDF N	35.13	31.67	272362	26008	246354	9882
5 t ha^{-1} VC + 75% RDF N	32.09	28.88	248368	26512	221856^{D}	
10 t ha^{-1} FYM + 25% RDF N	27.28	24.55	211130	30504	180626^{D}	
10 t ha^{-1} FYM + 50% RDF N	27.27	24.54	211044	31008	180036^{D}	
10 t ha^{-1} FYM + 75% RDF N	27.51	24.76	212936	31512	181424^{D}	
20 t ha^{-1} FYM	26.83	24.15	207690	60000	147690^{D}	
20 t ha^{-1} FYM + 25% RDF N	28.14	25.33	217838	60504	157334^{D}	
20 t ha^{-1} FYM + 50% RDF N	29.75	26.78	230308	61008	169300^{D}	
20 t ha^{-1} FYM + 75% RDF N	30.08	27.07	232802	61512	171290^{D}	

essential plant nutrients. Similar study by Lalitha *et al.,* (2000) also noted that application of organic inputs like vermicompost attributed to better growth of plants and higher yield by slow release of nutrients. The current result is in agreement with that of Mehla *et al.* (2006) who obtained highest total yield in onion when inorganic fertilizer was supplemented with 50% vermicompost. Similar results were attained by Mouna *et al.* (2013) and Rizk *et al.* (2014), whose findings recorded the highest yield of onion bulbs by the combination of organic with inorganic fertilizers than with mineral fertilizers alone.

Harvest index

Combined application of vermicompost and nitrogen levels had a highly significant effect ($P < 0.001$) on harvest index of onion plant (Table 3). The highest harvest index (82.18%) was obtained from the application of 5 t ha^{-1} of VC and 50% N followed by application of 5 t ha^{-1} of VC and 75% RDF N (78.77%) and the lowest harvest index (68.70%) was recorded at control. Similar study by Surindra (2009) showed that integrated nutrient supply, in the form of traditional inorganic NPK and in the form of organic manures, brings an excellent biochemical changes in soil structure, which ultimately promotes plant growth and production. Similar result was also obtained by Abdissa *et al.* (2011) who reported that the highest onion harvest index (86%) was obtained in response to increased rate of nitrogen application.

Partial Budget Analysis

From the economic point of view, it was found that, the treatment combination of 5 t ha^{-1} VC +50% RDF N gave the highest net return 246,354 Birr ha^{-1} with marginal rate of 9882% followed by 2.5 t ha^{-1} VC + 75% RDF N (T3) 226,014 Birr ha^{-1} with marginal rate of 3944%. Hence, this treatment combination appears to be economical for onion production in the study area.

CONCLUSION

The result of the experiment clearly indicates that the application of 5 t ha^{-1} vermicompost and 50% recommended inorganic nitrogen not only gave higher yield (35.13 t ha^{-1}) but also economically feasible (246,354 Birr ha^{-1}) Hence, it would be reasonable to point out that application of 5 t ha^{-1}VC + 50% RDF N was the appropriate combination for onion production in the study area for investors as well as small holder farmers. However, as this result is from one season-one location study, further investigations should be carried out under various climatic and soil condition to draw sound recommendation regarding integrated nutrient management for better onion productivity.

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