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Effect of Inorganic NP Fertilizers and Vermicompost on Seed Yield and Seed Quality of Onion (*Allium cepa* L.) at Maitsebri, Northern, Ethiopia

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ABSTRACT

Field experiment was conducted at research station of Shire-Maitsebri Agricultural Research Center, located in northern Ethiopia to study the effect of inorganic NP fertilizers and vermicompost on seed yield and seed quality of onion (Allium cepa L.) during 2016/17 dry season under irrigation. Bombay Red onion variety was used for the study. The treatments consisted of five NP fertilizer rates {0, 25 %, 50 %, 75 % and 100 % of recommended NP fertilizer rates (69 kg N and 92 kg P_2O_5 ha^{-1})} and four rates of vermicompost (0, 2.5, 5.0, 7.5 t ha^{-1}). The experiment was laid out in a factorial arrangement using randomized complete block design with three replications. Data were collected on seed yield and seed quality. The results revealed that number of seeds per umbel, seed weight per umbel, and thousand seed weight were significantly affected by the main effect of NP fertilizer rates and vermicompost. The highest seed yield per hectare (1462.5 kg ha^{-1}) were obtained from plants grown at 75 % of RDF with vermicompost at 2.5 t ha^{-1} which were about 263% higher than seed yield from unfertilized control plot. Seed purity was significantly ($P<0.05$) improved by NP fertilizer and vermicompost. The interaction effect NP fertilizers and vermicompost also improved germination percentage, speed germination, seed vigour I and II. It can, thus, be concluded that the combined application of 75 % of RDF with vermicompost at 2.5 t ha^{-1} can improve yield and quality of seed of Bombay Red onion variety in the study area.

Keywords: Maitsebri, Onion, NP fertilizers, Seed quality, Vermicompost

INTRODUCTION

Onion (*Allium cepa* L.) is one of the most important biennial plant, but commercially grown as annual vegetable crops (Bassett, 1986; Sajid *et al.*, 2012). They are cross pollinated, cool season and tolerant to frost vegetable crops. They are highly sensitive to day length; varieties are classified as either short day, intermediate and long day cultivars(Baloch 1994; Rabinowitch 2002, Yadav; 2015).

Onion is an important bulb crop in Ethiopia. It is rapidly becoming a popular vegetable. Shallots were the traditional *alliaceous* crop of the Ethiopian high land, but research efforts so far made in the country have resulted in the development of onion varieties which are currently under wider production in different parts of the country (Lemma and Shimeles, 2003;EARO, 2004; MoARD, 2010).

Besides bulb production, there is a great potential for seed production in our country. Seed yield reaching about (1.1 t ha^{-1}) in Melkasa Agricultural Research center experimental site and on average 1.3 – 2.0 t ha^{-1} (**Nikus** and Mulugeta, 2010). In Tigray, particularly in the study area, they also have a potential to bulb as well as quality seed production (Personal observer). Seed production is one of the most important and potential area in the success of onion production that can bring a high economic benefit for small scale farmers. Onion seed prices are very high which provides a good motivation for prospective producers of seeds.

Complementary use of chemical fertilizer and organic manures has assumed great importance now-a-days to maintain as well as sustain a higher level of soil fertility and crop productivity (Shalini *et al*., 2002). Combined application of organics and inorganics help to improve the physic-chemical properties as well as biological properties of soils. According to the authors application of inorganic NP fertilizer with organic vermicompost significantly increased growth and vigor of the plants over application of inorganic fertilizers alone.

Studies on effect of nitrogen use efficiency and production efficiency of rice under rice-pulse cropping system with INM showed that the production efficiency of rice increased with reduced chemical fertilizer levels and highest production efficiency profitable treatments were recorded with application of 75% chemical fertilizers + vermicompost at 2.5 t ha^{-1} (Lakshmi *et al*., 2012). Other studies on the effect of vermicompost and other fertilizers on cultivation of tomato plants were showed that plants treated with vermicompost (6.68 t ha^{-1}) + 50% Chemical fertilizer displayed better results than those treated separately with vermicompost, chemical fertilizer, F.Y.M and F.Y.M supplemented with chemical fertilizers (Bhunia and Chakraborty, 2011). The research reported by Kachapur *et al*. (2001), indicated favorable effect of inorganic NP fertilizers and vermicompost on the production of Kahrif sorghum. He concluded that the crop had to be supplied with inorganic and vermicompost for higher and sustainable yield. In onion bulb production highest yield was obtained with 5.0 t ha^{-1} vermicompost applications with 50% of Nitrogen fertilizer. The increased availability of nutrients during crop growth and bulb production periods might have increased dry matter production, resulting in higher bulb yield (Yohannes, 2015).

The bottleneck problem for high production and productivity is limited availability of quality seed, in addition to lack of adaptable high yielding varieties, lack of proper soil fertility management practice and other agronomic practices, diseases and insects etc. The problem of farmers throughout the country is that they have little knowledge on the optimum amount of NP fertilization and advantage of incorporatic organic fertilizer especially vermicompost with inorganic fertilizer for the production of bulb as well as quality of seed onion (Zende *et al*., 1998; **Nikus** and Mulugeta, 2010). Farmers in Tigray, particularly in Northwestern Zone of Tigray also faced problems similar to other farmers in the country.

The nutrient management paradigm acknowledges the need for both inorganic NP and organic inputs especially vermicompost to sustain soil health, quality crop production and prevent soil degradation due to positive interactions and complementarities between them (Sanchez and Jama, 2001; Vanlauwe *et al*., 2002; Kachapur *et al*., 2001; Linus and Irungu, 2004). Therefore, the aim of this research was study the effect of inorganic NP fertilizers and vermicompost on seed yield and seed quality of onion under irrigation on Tselemti woreda, Northern Ethiopia.

METHODOLOGY

The field experiment was conducted at the research station of Shire-Maitsebri Agricultural Research Center, northern Ethiopia, during the dry season of 2016/2017. The experimental site is located 85 km from Shire along the way Shire to Gondar and lies at $13^{0}05'$N and $38^{0}08'$E and at an elevation of 1304 meters above sea level. The mean annual temperature ranges minimum of 15.66 ^{o}C

(November-January) and maximum of 36.64 ^{o}C (February-May). It is a low altitude area with average 5 years annual rainfall of 1296.5 mm. 'Bombay Red' onion variety, one of the most commonly and widely used variety in Northwestern Zone of Tigray was used for the study. The sources of the NP fertilizers were urea (46 % N) and Triple Super Phosphate, TSP (46 % P_2O_5) for supplying nitrogen and phosphorus, respectively. The vermicompost was obtained from Shire Agricultural Collage. The treatments comprise of 4 x 5 factorial combinations of vermicompost (0, 2.5, 5.0 and 7.5 t ha^{-1}) and NP fertilizers {0, 25 %, 50 %, 75 % and 100 % of recommended NP rates (69 kg N and 92 kg P_2O_5 ha^{-1})}. The treatments were replicated three times and laid out in a randomized complete block design.

The planting materials were medium sized bulbs of uniform diameter (4-5 cm), which were free from insect, disease and mechanical injuries, twins or split and very large were discarded. The planting materials were collected from Kobo-Alamata and were kept in storage house on wooden shelves for 15 days (Nikus and Mulugeta, 2010). Before planting, one fourth of the bulb tops were sliced off to promote sprouting (Sukprakarn *et al*., 2005). The selected bulbs were planted on 10 October 2016. The bulbs were planted to a depth of about 5 cm and covered with soil. All of the phosphorus fertilizer rates in the form of TSP and vermicompost were applied once along the rows at planting. Urea as nitrogen source was applied in split application where half rate was applied at planting and the other half a month after emergence.

Onion bulbs were planted in double row spacing at 50 x 30 x 20 cm. The spacing between furrows was kept at 50 cm and between the double rows at 30 cm and between plants 20 cm (EARO, 2004; Nikus and Mulugeta, 2010; Getachew, 2014). There were five double rows per plot and 28 plants in single double rows. The blocks were separated by 1.5 m width whereas the space between each plot within a block was 1.0 m.

Data were collected from the four double rows excluding the two extreme single rows on both sides. Eight stalks were randomly taken per plot for data collection. The plots were irrigated as per the recommendation for the area, i.e. at the interval of three days during the first phase of active growth of the plant. Later, the irrigation gap was increased to seven days interval (Lemma and Shimeles, 2003). Hoeing was done manually and the field was kept free of weeds throughout the growing period. For the control of disease (Purple blotch (*Alternaria porri*) and Downy mildew (*Perenosporus destractor*) Ridomil Gold 68WP and Thilt 250 EC with the rate spray of Ridomil at 2.5 kg ha^{-1} and Thilt 250 EC at 400 ml ha^{-1} were applied. For control of Thrips (*Thrips tabaci*) Dimethiote spray at 20 ml 15 lit^{-1} water was used (Nikus and Mulugeta, 2010).

Harvesting was started when greater than 50 % of black seeds were exposed on an umbel and was done by hand. All umbels per plant do not mature at one time due to difference in the stalks to flowering; hence harvesting may take 3-4 times. The umbels were dried on canvas and threshed by hand. The seeds were separated from stalks and other debris by winnowing and the chaff seeds were separated from well filled seeds by soaking seeds in water. The floating seeds were discarded as chaffy seeds because they are hollow and unable to sink in water while the sinking ones were considered as well filled and viable. The sinking seeds were dried under shade to 8 % moisture content, weighted and recorded as seed weight per plot (Nikus and Mulugeta, 2010).

1. Data Collection

Seed yield and seed quality parameters

Number of seeds per umbel*:* five umbels were randomly taken from the 8 randomly sampled plants in each plot and then dried, threshed and counted to obtain number of seeds per umbel.

Seed weight per umbel (g)*:* the weight of five randomly taken sample umbels was harvested to determine number of seeds per umbel weighted and adjusted to a moisture content of 8% and the average weight of seeds was calculated by dividing the total weight to number of the umbels.

Seed yield (kg ha^{-1})*:* The yield was estimated from seed yield per plot.

1000 seeds weight (g)*:* sample of seeds from the bulk in each plot was taken and 1000 seeds were manually counted and weighed using a sensitive balance after adjusted to the moisture content of 8%.

Purity seed test (%)*:* is the composition by weight of pure seed in a sample. Seed samples were carefully prepared in order to represent the whole seed plot.

$$\text{Purity \%} = \frac{\text{Weight of pure seed}}{\text{Total weight of the sample}} \times 100$$

Germination percentage (%): the test was performed according to (ISTA, 2008) rules. Seeds were placed on Petri dishes below and above filter paper and allowed to imbibe water with distilled water which was kept at room temperature until 12 days. A seed was considered germinated when approximately 1 mm radicle protrusion was attained. Then percent germination was determined from counts of normal seedlings and the total seeds placed on Petri dishes. Results were expressed as germination percentages.

Speed of germination*:* Seeds were placed on Petri dishes as it was done for germination test and the germinated seeds every day was counted, picked and removed from the Petri dishes starting from the first germination up to the final count when germination ceased. Speed of germination then determined by counting germinated seed every day and it was divided by the number of days for which the test is run. The speed of germination (SPG) was calculated according to the formula of (Maguire, 1962).

$$\text{Seed of Germination} = \frac{N1}{C1} + \frac{N2}{C2} + \ldots + \frac{NF}{C3}$$

Where N_1 = number of normal seedlings at first count, N_2 = number of normal seedlings at second count, Nf = number of normal seedlings at final count, C_1 = days to the first days to the first count, C_2= days to the second days to the second count, Cf = days to the final count.

Seedling vigour test*:* the test was performed simultaneously with the standard germination test. At the final count of seed germination, 10 normal seedlings were selected from each Petri dish and the length of shoot and roots of the seedlings as well as the seedling dry weight were measured as per the procedure described below.

Shoot length *(cm):* the shoot length of ten normal seedlings from the germination test was measured from the collar region to the point of attachment to the cotyledon and the average shoot length was calculated.

Root length (cm)*:* seedlings used for the shoot length measurement was used for measuring root length. The length of roots was measured from the collar region up to the tip of primary root and was express as mean root length in centimeter.

Seedling dry weight (g): ten selected seedlings that were used for shoot and root length measurement for each treatment combinations were used to determine the dry weight of seedlings. The seedlings were dried in a hot air oven at 70 + 1^0C for 48 hours and cooled in desiccators for one hour. Seedling dry weight was measured and the average weight was calculated.

Seedling vigour index I and II: After measuring the seedling shoot and root length as well as seedling dry weight, the seedling vigour index I and II were calculated according to the formula described by (Abdul-Baki and Anderson, 1973) as follows:
Seedling vigour index I: it was determined by multiplying seed germination percentage by sum of shoot and root length as:

Germination (%) x Seedling length [Seedling Root length + Shoot length (cm)]

Seedling vigour index II*:* it was determined by multiplying seed germination percentage by seedling dry weight as:

Germination (%) x Seedling dry weight (g)

Data analysis: The collected data was subjected to analysis of variance (ANOVA) using Gen Stat 14^{th} edition statistical software according to (Gomez and Gomez, 1984) statistical procedure. Data on the seed quality test were also subjected to analysis of variance for CRD. Mean comparison was done using least significant difference (LSD) at 5% probability level.

RESULTS AND DISCUSSION

Number of seeds per umbel

Main effect of NP fertilizer and vermicompost showed significant ($P<0.05$) differences on the number of seeds per umbel. The highest numbers of seeds per umbel were recorded in plots which received 50, 75 and 100 % RDF NP fertilizer rates compared with unfertilized and 25% RDF NP fertilized plots. The seeds per umbel from 75% RDF NP fertilizer was 32.89% more compared with nil application of NP fertilizers, (Table 1).

This result was similar with the reports of Getachew (2014) who found that the highest number of seeds per umbel was recorded from 115 N kg ha^{-1} and 114 P_2O_5 kg ha^{-1} and lowest from control with no significant difference from plants that received 85.5 N and 86.25 P_2O_5 kg ha^{-1}. Vermicompost fertilized plots gave significantly more number of seeds per umbel (than VC unfertilized plots (Table 1). The increment in seed per umbel was about 9.3 and 14.70% as VC application rate increased from nil to 2.5 and 5.0 t ha^{-1}, respectively. In agreement with the present result, vermicompost have been shown to increase the number and biomass of the flowers produced (Atiyeh *et al*., 2002; Arancon *et al*., 2008) and increase the number of fruits of vegetable crops such as tomato and strawberries (Atiyeh *et al*., 2000; Singh *et al*., 2008).

Table 1. Yield Components of Onion Seed as Affected by NP fertilizers and Vermicompost

Inorganic NP fertilizer (% of RDF)	Number of seeds per umbel	Seed weight per umbel (g)	1000 seeds weight (g)
0	675.0 b	2.28 c	3.10 c
25 % of RDF	714.2 b	2.63 b	3.26 bc
50 % of RDF	825.3 a	2.80 ab	3.39 ab
75 % of RDF	897.0 a	3.02 a	3.46 a
100 % of RDF	860.0 a	2.97 a	3.41 ab
LSD (5%)	83.0	0.284	0.164
VC (t ha^{-1})			
0	724.7 b	2.51 b	3.20 b
2.5	792.4 ab	2.73 ab	3.31 ab
5.0	831.2 a	2.86 a	3.39 a
7.5	829.0 a	2.85 a	3.39 a
LSD (5%)	74.3	0.249	0.051
CV (%)	12.6	12.3	6.0

Means followed by the same letter in the same column are not significantly different at 5 % probability level according to LSD. N = Nitrogen, P = Phosphorus, RDF = Recommended Dose of Fertilizers, VC = Vermicompost

Table 2. Seed Yield (kg) per hectare of Onion as Affected by NP fertilizer and Vermicompost

VC (t ha^{-1})	Inorganic NP fertilizer (% RDF)				
	0	25% RDF	50% RDF	75% RDF	100% RDF
0	402.8 h	454.7 h	527.8 gh	597.2 gh	743.1 fg
2.5	553.5 gh	865.2 ef	1192.3 bcd	1462.5 a	1189.7 bcd
5.0	948.1 def	869.3 ef	1448.6 a	1356.9 abc	1145.8 bcd
7.5	1050.9 de	958.8 def	1300.8 abc	1385.2 ab	1128.5 cd
LSD (5 %) = 217.4; CV (%) = 13.4					

Means with the same letter(s) in each treatment were not significantly different. LSD (5%) = least significant difference at P=0.05, CV (%) = Coefficient of variation in percent, VC = Vermicompost, N = Nitrogen, P = Phosphorus, RDF = Recommended Dose of Fertilizers

Seed weight per umbel (g)

Seed weight per umbel was significantly (P<0.05) affected by the main effect of NP fertilizer and vermicompost application. The highest significant seed weight per umbel was obtained from plants grown at 75 % of RDF NP fertilizer (3.02 g) which was statistically at par with the application of 50 % RDF (2.8 g) and 100% RDF (2.97 g) NP fertilizer rates. Significantly small seed weight (2.28 g) per umbel was recorded from nil application of NP and followed by 25 % RDF NP fertilizer (2.63 g). The increase in the seed weight per umbel at 75% RDF NP fertilizer applied plots compared with unfertilized plots was about 32.46% (Table 1). The result was in agreement with the study of (Getachew, 2014) and (Ali *et al*., 2008) who reported that seed weight per umbel was significantly increased by NP fertilizer 115 N kg ha^{-1} & 114 P_2O_5 kg ha^{-1} and 150 N & 80 P_2O_5 kg ha^{-1} application respectively. In the same way, plots which received vermicompost at 5.0 and 7.5 t ha^{-1} gave significantly highest seed weight of 2.86 and 2.85 g per umbel respectively, compared with nil vermicompost application (2.51 g) (Table 1). The increase in seed weight from nil to 5.0 t ha^{-1} vermicompost application was by about 13.94%. No statistical differences in seed weight per umbel between nil and 2.5 t ha[1] vermicompost applications and 2.5 t ha^{-1} vermicompost with 5.0 and 7.5 t ha^{-1} vermicompost application rates. The increased seed weight per umbel could be due to the role of vermicompost which is known to contain micronutrients apart from major nutrients and to contain several plant growth promoters, enzymes, beneficial bacteria and mycorrhizae (Gupta, 2005).

Thousand seeds weight (g)

The analysis of variance showed that 1000 seeds weight was significantly ($P<0.05$) influenced by the main effect of NP fertilizer and vermicompost while, NP fertilizers and its interaction with vermicompost did not show significantly results in 1000 seeds weight. The highest 1000 seeds weight was recorded from plants which received 75% of RDF NP fertilizers (3.46 g) which was significantly different from nil and 25% RDF NP application. No significant statistical differences in 1000 seed weight due to variation among 50, 75 and 100% RDF NP fertilizer application (Table 1). Application of 75% RDF NP fertilizer gave 11.61% increase in 1000 seed weight compared with NP unfertilized plots. The current result is in line with that of (Getachew, 2014) who reported significantly higher 1000 seeds weight from plants that grown with NP fertilizer application. In okra thousand seed weight reported the interaction of N and P significantly recorded maximum 1000 seeds weight over the control plots (Sajid *et al*., 2012). Nitrogen and phosphorus are involved as building block of the seed materials there by increased the weight of the seed of the onion (Marschner, 1995). Özer (2003) and Öztürk (2010) reported that higher rates of fertilizers application produced heavy weight seeds. On the other hand, the current study results were in contrast to Tamrat (2006), Ali *et al*. (2007) and Ali *et al*. (2008) who reported that nitrogen and phosphorous fertilizers did not show significant effect on 1000 seeds weight. Vermicompost at 5.0 and 7.5 t ha^{-1} gave significantly highest 1000 seed weight (3.39 & 3.39 g) compared with vermicompost unfertilized plots. Vermicompost at 2.5 t ha^{-1} at par with higher rates of vermicompost application rates in 1000 seed weight (Table 1). As vermicompost rates increased, the 1000 seed weight was also increased. This might be due to that vermicompost contains additional essential micronutrients actively involved as building block of the seed embryo by increased the weight of the seed onion (Garg *et al*., 2010).

Seed yield per hectare

The highest seed yield (1462.5 kg ha^{-1}) was obtained from plots which received 75 % RDF NP x 2.5 t ha^{-1} VC applications, followed by 50 % RDF NP x 5.0 t ha^{-1} and 75% RDF NP x 7.5 t ha^{-1} VC with no significant difference among them. The lowest seed yield per hectare was obtained from the plots with no NP fertilizer x no VC followed by 25% to 75% RDF NP fertilizer without VC and no NP fertilizer with 2.5 t ha^{-1} VC, which didn't vary significantly (Table 2). Application of 75% RDF NP x 2.5 t ha^{-1} gave 263% seed yield ha^{-1} increment compared with no NP fertilizers and no VC application rates.

The combination of vermicompost with chemical fertilizer increases the budget of essential soil micronutrients and promotes microbial population, which ultimately promotes the plant growth and production at sustainable basis (Suthar, 2012). The current result was in agreement with the work of Alemu *et al*. (2016) who found that application of N at a rate of 46 kg N ha^{-1}, 92 kg P_2O_5 ha^{-1} and vermicompost from 0 to 5.0 t ha^{-1} increased the total bulb yields of garlic by about 14.29, 20.61 and 9.57 % as compared to the untreated control, respectively. In onion bulb production highest yield was obtained with 50% of nitrogen fertilizer with 5.0 t ha^{-1} vermicompost applications (Yohannes, 2015). Similarly, Daniel (2006) showed that highest total yield of potato tuber 29.59 t ha^{-1} were obtained with combination of 75 % of RDF NP fertilizer combined with 8.0 t ha^{-1} vermicompost.

Seed Quality Parameters

Purity seed test (%)

The main effect of NP fertilizer and vermicompost significantly ($P<0.05$) affected purity of seed while, NP fertilizer and its interaction with vermicompost did not significantly affect purity seed test.

The highest significant purity seed test (98.5 – 99 %) were obtained from the main effect of NP fertilizer at 50- 100% RDF NP fertilizer rates with no statistical difference among them while lowest purity was recorded from nil NP fertilizer rate which did not show significant differences in purity from 25% RDF NP fertilized plots (Table 3). Likewise vermicompost application at the rate of 5.0 and 7.5 t ha^{-1} gave highest seed purity percentage while the lowest purity was recorded from seeds that did not receive VC fertilizer which was at par with 2.5 t ha-^{1} VC applied plots (Table

3). According to the International Rules for Seed Testing (IRST, 2004), onion seed's minimum purity is 97 % and the world standard of seed purity percentage for onion is set to be 97-98 % (FAO, 2010). So, the present purity test result was above the (IRST, 2004) and (FAO, 2010) for onion crops when grown on NP fertilizer rates at 50, 75, and 100 % of RDF and vermicompost at 7.5, 5.0 and 2.5 t ha^{-1}.

Table 3. Main effect of inorganic NP fertilizer and vermicompost on purity seed test (%) quality parameters of Bombay Red onion variety grown at Maitsebri

Inorganic NP fertilizer (% of RDF)	Purity seed test (%)
0	96.31 c
25 % of RDF	96.80 bc
50 % of RDF	98.47 ab
75 % of RDF	98.92 a
100 % of RDF	98.59 ab
LSD (5%)	1.787
VC (t ha^{-1})	
0	96.51 b
2.5	97.64 ab
5.0	98.51 a
7.5	98.61 a
LSD (5%)	1.598
CV (%)	2.2

Means in rows and columns with the same letter(s) in each treatment are not significantly different. LSD (5%) = least significant difference at P=0.05, CV (%) = Coefficient of variation in percent.

Table 4. Interaction effect of NP fertilizer and vermicompost on germination percentage (%) of Bombay Red onion variety grown at Maitsebri

VC (t ha^{-1})	Inorganic NP fertilizer (% RDF)				
	0	25% RDF	50% RDF	75% RDF	100% RDF
0	82.00 e	87.67 cd	95.33 a	97.00 a	96.67 a
2.5	82.67 e	92.33 b	96.67 a	97.67 a	97.67 a
5.0	86.33 d	95.67 a	97.67 a	97.67 a	97.33 a
7.5	89.00 c	96.00 a	97.33 a	97.67 a	97.00 a
LSD (5 %) = 2.391; CV (%) = 1.5					

LSD (5%) = least significant difference at P=0.05, CV (%) = Coefficient of variation in percent, ns= non significant. Means with the same letter(s) in each treatment were not significantly different. VC = Vermicompost.

Table 5. Interaction effect of NP fertilizer and vermicompost on speed germination of Bombay Red onion variety grown at Maitsebri

VC (t ha^{-1})	Inorganic NP fertilizer (% RDF)				
	0	25% RDF	50% RDF	75% RDF	100% RDF
0	31.50 c	28.47 d	26.43 f	27.43 e	24.50 h
2.5	32.50 b	25.43 g	25.53 g	22.60 j	23.80 i
5.0	33.63 a	25.50 g	23.27 i	22.57 j	24.53 h
7.5	28.60 d	24.87 h	23.43 i	21.77 k	24.63 h
LSD (5 %) = 0.5766 ; CV (%) = 1.3					

Means with the same letter(s) in each treatment were not significantly different. LSD (5%) = least significant difference at P=0.05, CV (%) = Coefficient of variation in percent, VC = Vermicompost, N = Nitrogen, P = Phosphorus, RDF = Recommended Dose of Fertilizers

Table 6. Interaction effect of NP fertilizers and vermicompost on seedling vigour index I of Bombay Red onion variety grown at Maitsebri

VC (t ha^{-1})	Inorganic NP fertilizer (% RDF)				
	0	25% RDF	50% RDF	75% RDF	100% RDF
0	623.2 j	739.0 h	858.1 def	863.2 def	876.5 cd
2.5	672.3 i	817.8 g	866.8 de	1005.9 ab	999.4 ab
5.0	739.5 h	845.1 ef	996.2 b	1022.2 a	892.1 c
7.5	756.2 h	841.6 f	1002.5 ab	1015.7 ab	879.5 cd
LSD (5 %) = 22.69CV (%) = 1.6					

Means with the same letter(s) in each treatment were not significantly different. LSD (5%) = least significant difference at P=0.05, CV (%) = Coefficient of variation in percent, VC = Vermicompost, N = Nitrogen, P = Phosphorus, RDF = Recommended Dose of Fertilizers

Germination percentage (%)

Germination percentage was significantly (P<0.01) affected by the main effect of NP fertilizers, vermicompost and the effect of the two factors interaction. The highest germination percentage (95.67-97.67 %) was counted at NP fertilizer and VC interaction of 50 % and above RDF combined with all levels of VC as well as 25% RDF combined with VC 5.0 and 7.5 t ha^{-1}. The lowest germination percentage was 82% from no NP and no VC fertilized plots which did not have significant difference with nil NP x 2.5 t ha^{-1} VC (Table 4). Application of 5.0 and 7.5 t ha^{-1} VC significantly improved seed germination percentage compared to the control and lower level of VC. In agreement with the present result, Zende *et al*. (1998) indicated that vermicompost helps in minimizing the use of chemical fertilizer to the extent of 25 to 50 percent. The reason behind this could be the interaction of NP fertilizers with vermicompost in increasing the proportion of seed umbels, thus improving seed quality.

This is because the embryos of seeds are larger from large sized umbels and due to the active involvement of the minerals in development of embryo and in buildup and activation of seed germination hormones (Suparno *et al*., 2013). The vermicomposts contains plant growth regulating substances including plant growth hormones and humic acids which are probably responsible for increase in germination, growth and yield of plants (Atiyeh *et al*., 2002; Arancon *et al*., 2006).

According to Lemma and Shimeles (2003) the germination percentage of 90-94 % is considered as high and 70 % as minimum requirement for most onion cultivars under Ethiopian condition. In this study, 75 % treatments produced seeds with >92% germination which could be categorized as high germination percentage and none of the treatments produced seeds with <82% germination indicating all the treatment combinations were producing seeds either with highest or above the minimum germination requirement of onion seeds in the country.

Speed of germination

The main effect of NP fertilizers and vermicompost with their interaction had highly significantly (P<0.01) influenced on speed of germination. The fastest speed of germination (33.63%) was recorded from plots received application of VC at 5.0 t ha^{-1} without NP fertilizers, followed by 2.5 t ha^{-1} VC with no NP fertilizers and no VC and no NP fertilized plots (control) and they differed significantly among each other (Table 5).

The fast rates of germinations might be due to the small sized seeds produced from those treatments and the ability of small seeds to germinate early as small seeds have small surface area and can imbibe enough moisture at a short time and commence the process of germination (Ndor *et al*., 2012).

Seed vigour index

The main effect of NP fertilizers, vermicompost and their interaction showed highly significant (P<0.01) influenced on seed vigour index I and II. The highest seedling vigour index I (1022.2) was obtained from the interaction of NP fertilizer 75 % RDF with VC 5.0 t ha^{-1}, followed by NP fertilizer 75 % RDF with VC 7.5 t ha^{-1} and NP fertilizer rate 75 % RDF x VC 2.5 t ha^{-1} and NP fertilizer 50 % RDF with VC 7.5 t ha^{-1} which did not have significant difference among themselves. However, the lowest (623.2) seedling vigour index I was recorded for seeds which did not receive NP fertilizer and vermicompost followed by VC at 2.5 t ha^{-1} alone (672.3) (Table 6).

Table 7. Interaction effect of NP fertilizer and vermicompost on seedling vigour index II of Bombay Red onion variety grown at Maitsebri

VC (t ha^{-1})	Inorganic NP fertilizer (% RDF)				
	0	25% RDF	50% RDF	75% RDF	100% RDF
0	10.18 m	14.90 l	29.87 ij	32.33 g	36.73 e
2.5	14.33 l	29.02 jk	34.48 f	47.86 a	43.95 c
5.0	28.20 k	31.00 ghi	45.58 b	46.55 ab	41.21 d
7.5	30.26 hij	31.68 gh	45.75 b	45.58 b	40.74 d
LSD (5 %) = 1.364; CV (%) = 2.4					

Means with the same letter(s) in each treatment were not significantly different. LSD (5%) = least significant difference at P=0.05, CV (%) = Coefficient of variation in percent, VC = Vermicompost, N = Nitrogen, P = Phosphorus, RDF = Recommended Dose of Fertilizers.

Likewise, the highest vigour index II (47.86) was recorded from interaction of NP fertilizer 75 % RDF x VC at 2.5 t ha^{-1}, which did not vary statistically from those of NP fertilizer at 75 % RDF x VC at 5.0 t ha^{-1} (46.55). Moreover, NP fertilizer at 50 and 75% RDF x 7.5 t ha^{-1} and NP fertilizer at 50% RDF x VC at 5.0 t ha^{-1} had statistically similar seedling vigour index II (45.58-45.75). On the other hand, significantly lowest vigour index II (10.18) was obtained from seeds in which the plants did not receive NP fertilizer and VC (Table 7).

The increase in seedling vigour in response to increasing the rate of vermicompost may be ascribed to several growth promoters, enzymes, beneficial bacteria and mycorrhyzae contained in vermicompost that led to high seedling vigour index through facilitating photosynthetic activities thereby increasing portioning of assimilate to the seed storage organ (Gupta, 2005). Furthermore, large seed size has more food reserve in cotyledon of the seed to sustain the seedling growth and make seedlings to be vigorous than the smaller seed sizes whose food reserve could be exhausted very soon (Ndor *et al*., 2012).

The works of Tamrat (2006), Ali *et al*. (2007), Ali *et al*. (2008) and **Getachew** (2014) show that high NP fertilizer applied gave vigorous seedlings. But, result of this study gave the highest seedling vigour index II when NP fertilizer 75 % RDF was combined with vermicompost at 2.5 t ha^{-1} which show the advantage of integrated NP fertilizer with vermicompost and the role of vermicompost which is known to contain micronutrients apart from major nutrients (Garg *et al*., 2010).

CONCLUSION

The field experiment was conducted to determine the effect of inorganic NP fertilizer and vermicompost on seed yield and seed quality of onion (*Allium cepa* L.) under irrigation at Maitsebri, northern Ethiopia. The results revealed that the number of seeds per umbel, seed weight per umbel, 1000 seed weight and purity seed test were significantly (P<0.05) affected by the main effect of NP fertilizer rates and vermicompost. Moreover, the interaction effect of NP fertilizer and vermicompost had highly significant (P<0.01) seed yield per hectare, germination percentage, speed of germination, vigour index I and II. Thus, according to this study, maximum seed yield (1462.5 kg ha^{-1}) and mostly seed quality parameters were high at 75 % of RDF NP fertilizer with vermicompost at 2.5 t ha^{-1} produced 263% more seed yield per hectare. So, to get better yield and higher economic benefit from onion seed productions farmers are suggested to use the combination rates of NP fertilizers at 75 % RDF x VC at 2.5 t ha^{-1}.

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Competing interests

Authors have declared that no competing interests exist.

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