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Effect of Combined Application of Organic Manure and Inorganic Nitrogen on Marketable Yield, Shelf Life of Onion and Soil Fertility Status after Harvest

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Authors' contributions

This work was carried out in collaboration between all authors. Author YG designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors KW and FG managed the analyses of the study. Author FG managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Low soil fertility is one of the most important constraints limiting onion production in Eastern Africa. Farmers northern Ethiopia should tackle this problem through combined application of organic and mineral fertilizers, which amend the soil environment. An investigation was carried out to study the effect of combined application of organic manure and inorganic nitrogen on marketable yield, shelf life of onion and soil fertility status after harvest from, October 2015 to June 2016. The treatments consisted of combinations of two rates of farmyard manure (FYM) (10 and 20 t ha^{-1}), two rates of vermicompost (VC) (2.5 and 5 t ha^{-1}), and three rates of recommended N fertilizers (RDF) (25, 50 and 75%). 100% RDF N (69 kg N ha^{-1}), 100% (5 t ha^{-1}) of VC, 100% (20 t ha^{-1}) FYM and (absolute

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control) were used for comparison. Results from the experiment revealed that onion storage life significant influenced by the combined application of organic and inorganic N fertilizers. Application of 5 t ha^{-1} VC + 50% RDF N recorded the highest marketable yield and lowest onion bulb weight loss throughout the storage period. While, maximum bulb weight loss (36.16%) was recorded during 12^{th} week of storage under the application of 100% RDF N. The absolute control showed the least % bulb rotting and sprouting, hence, the lowest % bulb rotting (1.67, 2.27; and 4.06) were recorded during the 8^{th}, 10^{th}, and 12^{th} week storage period respectively, in bulbs from the control treatment. On the other hand combined use of 2.5-5 t ha^{-1} VC with 25-75% of N resulted in higher total nitrogen, available K, available P, CEC, EC, OC; and organic matter of the soil over the control treatments. Applications of organic inputs in combination with chemical fertilizer were found better option than application of organic manure or chemical fertilizer alone for better onion yield, shelf life and soil fertility replenishment. Therefore, it is concluded that the application of organic fertilizer (vermicompost) along with inorganic fertilizer (nitrogen) could be better for onion yield, shelf life and soil fertility replenishment.

Keywords: Merchandisable yield; organic fertilizer, inorganic fertilizer; Allium cepa L.; duration of conservation; soil richness.

1. INTRODUCTION

Onions are important vegetable crops worldwide, ranking second among all vegetables in economic importance. Onions contribute significant nutritional value to the human diet and have medicinal properties are primarily consumed for their unique flavor or for their ability to enhance the flavor of other foods [1]. The species shows a great diversity in form, varying in color, shape, dry matter content and pungency. This diversity is reflected in the success of the species in adapting to a wide range of environments [2]. Onion is used as a delicious vegetables and it is very common in almost all food preparations [3]. People consume onion daily as salad and pickle, as boiled, fried and baked condition as well as in curries [4]. Meanwhile 100 g of onion recipe could serve energy (40 calories), water (89%), protein (1.1g), carbohydrate (9.3 g), sugar (4.2 g), fiber (1.7g) and fates (0.1 g) [5].

Worldwide, postharvest losses in fruits and vegetables range from 24-40% [6] or even greater [7] reaching up to 50% in developing tropical countries [8]. Postharvest loss in onion has been estimated to reach 30% in Sudan [9] and 50-76% in Nigeria [10]. A comprehensive statistics for such losses is not available for Ethiopia; however, it has been estimated that the postharvest losses of horticultural crops in general may reach 25-35% in the state farms and in the peasant sector [11].

According to [12] a long cropping history and low manure and fertilizer inputs, the nutrient status of Ethiopian soils is generally low and nitrogen is the most limiting nutrient for crop production. [13] describes nitrogen an important component of proteins, enzymes and vitamins in plants and it is a central part of essential photosynthetic molecule, chlorophyll. Onion is a heavy feeder of mineral elements. It was reported that 35 tons of onion removes approximately 120 kg of N, 50 kg of P_20_5 and 160 kg of K_20 ha^{-1}. Hence, an adequate and uniform, supply of nitrogen is essential for onion growth [14].

As an export commodity, onions are key contributors to the economies of many low-income countries like Ethiopia [15]. Onions is considered as one of the most important vegetable crops produced on small scale in Ethiopia. It also occupies an economically important place among vegetables in the country. The area under onion is increasing from time to time mainly due to its high profitability per unite area and ease of production, and the increases in small scale irrigation areas. There is a great scope in improving the yield, quality and shelf life of onion [16] with using organic and inorganic fertilizers. Yield and shelf life of onion is affected by different organic and inorganic fertilizers. However, the appropriate organic manure and inorganic nitrogen fertilizer combination for maximum yield, shelf life of onion is crucial. Hence, the present studies was under taken with the objective to determine the effect of different source of organic manures and inorganic nitrogen fertilizers on the yield, shelf life of onion (*Allium cepa* L.) and soil nutrient balance.

2. MATERIALS AND METHODS

2.1 Description of the Study Area

The study is located at the 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%, 23.7 ppm, 1.108%, 46.2 meq/100 g, 0.17 ms/cm, 173 ppm and 134 ppm, respectively. The rainy season extends from June to September and the maximum rain is received in the months of June to August.

2.2 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 1 m and the spacing between rows and plants were 40 cm (with double rows at 20 cm) and 10 cm, respectively.

The treatments details are given below

1. 2.5 t ha^{-1} VC + 25% RDF N (17.25 Kg ha^{-1}N)
2. 2.5 t ha^{-1} VC + 50% RDF N (34.5 Kg ha^{-1}N)
3. 2.5 t ha^{-1} VC + 75% RDF N (51.75 Kg ha^{-1}N)
4. 5 t ha^{-1} VC + 25% RDF N (17.25 Kg ha^{-1}N)
5. 5 t ha^{-1} VC + 50% RDF N (34.5 Kg ha^{-1}N)
6. 5 t ha^{-1} VC + 75% RDF N (51.75 Kg ha^{-1}N)
7. 10 t ha^{-1} FYM + 25% RDF N (17.25 Kg ha^{-1}N)
8. 10 t ha^{-1} FYM + 50% RDF N (34.5 Kg ha^{-1}N)
9. 10 t ha^{-1} FYM + 75% RDF N (51.75 Kg ha^{-1}N)
10. 20 t ha^{-1} FYM + 25% RDF N (17.25 Kg ha^{-1}N)
11. 20 t ha^{-1} FYM + 50% RDF N (34.5 Kg ha^{-1}N)
12. 20 t ha^{-1} FYM + 75% RDF N (51.75 Kg ha^{-1}N)
13. 5 t ha^{-1} VC
14. 20 t ha^{-1} FYM
15. 100% (69 Kg ha^{-1}N) RDF
16. Unfertilized plot (absolute control)

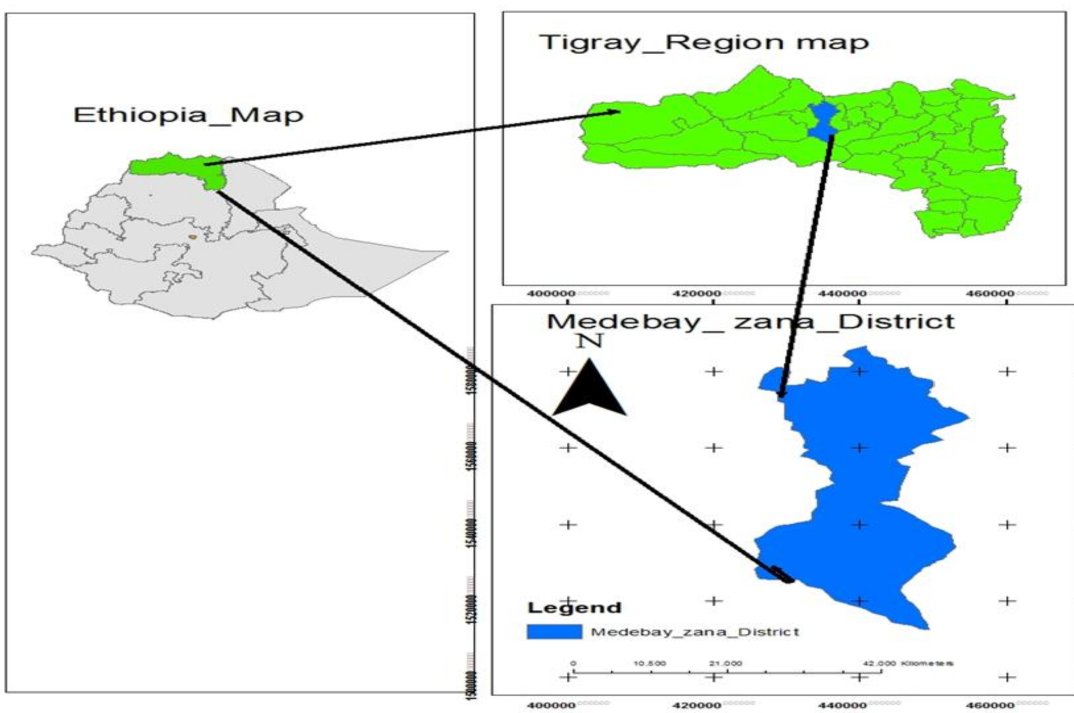

Fig. 1. Map of the study area

2.3 Experimental Procedure

2.3.1 Data collection

Well decomposed farmyard manure was uniformly applied to the plots and mixed thoroughly 15 days before transplanting and vermicompost was applied during transplanting date. Only healthy seedlings having 12-15 cm height were transplanted on October 16, 2015 at the spacing indicated above. All proper agronomic practices were carried out until the seedlings were transferred to the main field as per the procedure described by [17].

The crop was harvested on March 2, 2016 when about 70% of the plants attained maturity. Data were collected from ten randomly selected plants for determination of marketable yield. After harvest, bulbs were kept under a shade for 7 days for curing. Then, for storage studies, 60 medium size bulbs from each treatment were taken, divided into 3 equal splits, each representing a replicate and stored on cemented floor at normal room condition for 90 days, starting on March 10th till June 10th, 2016. The observations were done for sprouting, rotting, and total weight loss at 15 days intervals. The rotten and sprouting bulbs from each treatment were sorted out at the time of recording the data. The following are some of the quality parameters of bulb storage life.

Bulb Weight loss (%): Percent weight loss was determined following the procedure of [18]. The difference between the initial weight and successive weights gave the weight loss percentages.

$$\%\ \text{weight loss} = \frac{\text{wi} - \text{wf}}{\text{wi}} x100$$

Where, w_i = intial weight, w_f = final weight.

Bulb sprouting (%): Percentage of bulbs sprouted was cumulative, which was based on the number of bulbs sprouted in biweekly storage period. The incidence of sprouting was ascertained by counting the number of bulbs sprouted at the beginning and mid of each month. The sprouted bulbs were discarded after each biweekly count to avoid double counting. Bulbs that sprouted and rotted at the same time were classified as sprouting.

Bulb rotting (%): The measurement of percentage bulbs rotten was cumulative and was based on the number of bulbs rotted in biweekly storage period. The incidence of rotting was determined by counting the number of bulbs rotted at the beginning and mid of each month. The rotted bulbs were discarded after each biweekly count to avoid double counting.

2.3.2 Data analysis

Data on all parameters/response variables were subjected to analysis of variance (ANOVA) using the Gen Stat statistical package [19]. When ANOVA showed significant differences, mean separation was carried out using Least Significant Difference (LSD) test at 5% level of significance.

2.3.3 Soil sampling and analysis

Soil samples were taken from the experimental site before and after harvesting. Representative soil samples before harvesting were taken using an auger at 0-30 cm depth from five different places of experimental field in zigzag pattern. Further, after harvesting of the crop, soil samples were collected from each treatment plot from the three replications made composite samples of the sixteen treatments. The collected soil samples were air-dried in wooden tray ground and sieved to pass through a 2 mm sieve. The samples were analyzed for pH by using digital pH meter [20], organic carbon content of the soil was determined based on oxidation of organic carbon with acid dichromate medium following the Walkley and Black method as described by [21]. Total nitrogen in both soil and compost were determined by micro-kjeldahl method [21] and soil cat ion exchange capacity (CEC) was determined by ammonium acetate method [22]. Available phosphorus was determined using Olsen method as described by [23]. Particle size (soil texture) was determined by using hydrometer method of Bouyoucos [24]. Exchangeable bases were extracted with 1.0 M-ammonium acetate at pH 7. A sample of vermicompost and farmyard manure was analyzed for determination of OM, total N, available P, and exchangeable K and moisture contents.

3. RESULTS AND DISCUSSION

Data on marketable yield, storage condition and soil parameters were recorded during the entire period of the study. The results of the study are presented and discussed as follows.

3.1 Physico-Chemical Properties of the Experimental Soil, FYM and Vermicompost

3.1.1 Physico-chemical properties of the experimental soil before planting

The result of the physical and chemical analysis of experimental soil (Table 1) before planting revealed that the textural class of the surface soil (0-30 cm) was clay loam with a particle size distribution of 29% sand, 43% silt and 28% clay [25].The pH value was 7.2, which is neutral according to the rating of [26]. The optimum pH for onion production lies between 6 and 8 [27]. Hence the pH of the soils is 7.2 which are best for onion cultivation. The organic matter content and total nitrogen of the soils were 1.910% and 0.1736% which are generally low and medium, respectively, according to [12]. The results further showed that the soil is generally rich in Cation exchange capacity with CEC 46.2 meq/100 g of soil [28]. In general, soils of the study area are good in their selected physicochemical properties for onion cultivation except organic matter and total nitrogen. Therefore, the soil fertility management in the study area should focus on scenarios that could improve the soil organic matter and nitrogen by applying the optimum levels of organic manure and inorganic fertilizers to improve the soil physicochemical properties.

3.1.2 Properties of the FYM and vermi-compost

The analyzed results of the farmyard manure and vermicompost as presented in Table 2 the Vermicompost was better in adding the essential nutrients, organic carbon, organic matter, total nitrogen, available potassium, available phosphorous and moisture content by 4.163%, 7.178%,2.037%, 0.0155%, 0.044% and 4.963% fold more than that of the farmyard manure. Vermicompost also showed salinity by 13.08% less than the FYM.

3.1.3 Chemical properties of the experimental soil after harvest

Results of the current study on soil properties indicated that the combined application of vermicompost and chemical fertilizers would help to maintain the long-term soil productivity for sustainable onion production (Table 3). Similar result from [33] found that addition of vermicompost at rate of 15 t ha^{-1} has significantly increased the total organic carbon and physical properties of soil. [34] Also reported that application of vermicompost at 10 t ha^{-1} along with 50% chemical fertilizers influenced nutrient status of the postharvest soil and conserved more organic C, N, P, K, Ca, Mg, S, Zn and B contents over control. Vermicompost amendment increased organic C content, P; and N. The pH of mixture soil and vermicompost decreased lightly and the electrical conductivity increased without producing salinity effect [35]. In consonance with the current result, [36] reported that cation exchange capacity, available P and K, and organic carbon significantly increased with organic manure in conjunction with inorganic fertilizer. Vermicompost contains enzymes like amylase, lipase, cellulase and chitinase, which can break down the organic matter in the soil to release the nutrients and make it available to the plant roots [37]. It has been confirmed that vermicompost has the capacity to supply both macro and micronutrients in the soil for optimum plant growth [38]. Combined application of organic and inorganic fertilizers provides excellent opportunities to overcome all the imbalances besides sustaining soil health and enhancing crop production. It optimizes the benefits from all possible sources of plant nutrients in an integrated manner [39].

3.2 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 4). 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 the control. 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. Besides supplying the essential nutrients, the positive effect of vermicompost on the growth of onion might be related to the presence of plant growth substances, humic acids, increased microbial diversity and activity and improvement of the physical structure of the soil [40]. Likewise, [41] and [42] reported that the yield of marketable onion bulbs increased with N application.

Table 1. Physico-chemical characteristics of the experimental soil before planting

Soil property	Values	Rating	Source
pH	7.2	neutral	[26]
Organic carbon (%)	1.108	low	[29]
Total nitrogen (%)	0.1736	medium	[12]
Available phosphorus (ppm)	23.7	medium	[30]
Available potassium (ppm)	134	medium	[31]
Exchangeable potassium (ppm)	173	medium	[30]
Cation exchange capacity (meq/100g)	46.2	very high	[28]
Electrical conductivity (ms /cm)	0.17	low salinity	[32]
Organic matter (%)	1.910	low	[12]
Particle size distribution			
Sand (%)	29		
Silt (%)	43		
Clay (%)	28		
Textural class	clay loam		[25]

Table 2. Chemical properties and moisture content of the FYM and VC used in the experiment

Parameter	FYM	Vermicompost
pH	7.88	7.2
EC (ms/cm)	2.68	2.37
OC (%)	8.502	12.665
OM (%)	14.657	21.835
Total nitrogen (%)	3.654	5.691
K (%)	0.1575	1.022
P (%)	0.978	1.022
Moisture content (%)	16.054	21.017

3.3 Storability Condition

3.3.1 Bulb weight loss

Poor handling and inadequate storage facility as well as lack of appropriate packaging techniques to suit every food type have resulted in the loss of vast quantities of food. Post-harvest losses are extremely rife in the fruit and vegetable production sector and that these losses have been estimated to be more than 40-50% in the tropics and sub tropics [43]. Under all storage conditions, onion bulbs continually lose water and dry matter, but the more serious losses arise from storage rots and from sprouting and rooting [44]. Farmers in the study area are commonly stored onions in cemented floor.

The percentage of weight loss of onion bulbs at different periods of storage was highly significant (P<0.001) influenced by the combined application of organic and inorganic fertilizers (Table 5). In periodical observation at an interval of 15 days, it was found that as the storage period extended, the cumulative loss of bulb weight increased due to increase in water loss, rotting and sprouting. The stored bulbs of all treatments showed loss in weight gradually and the maximum bulb weight loss (36.16%) was recorded during 12th week of storage under the application of 100% RDF N. The same trend was found by [45]; [46] and [47] they reported that extensive application especially of nitrogen fertilizers causes maximum total weight loss percentages of onion bulbs.

On the other hand, application of 5 t ha^{-1} VC + 50% DF N recorded the lowest onion bulb weight loss throughout the entire storage period. In general, integration of inorganic nitrogen with vermicompost lowered weight loss of onion compared treatments that included farmyard combinations. Loss in weight of bulb is usually known to occur due to rotting, dehydration transpiration, respiration, sprouting, etc. The weight loss is generally caused due to prevailing high temperature, high humidity in storage environment. This is closely related to the moisture deficiency of the surrounding air rather than temperature. Regarding the present study, plots which were treated with the combined application of vermicompost and nitrogen fertilizers scores a little bit minimum bulb weight loss over the rest treatment combinations which could be attributed to higher dry matter accumulation of bulbs from these treatments while relatively high moisture content and succulence might be responsible for the weight loss bulbs in the remaining treatments.

Table 3. Soil fertility status after harvest as influenced by integrated nutrient management

Treat-ments	TN (%)	Rating (a)	Av. P (ppm)	Rating (c)	Av. K (ppm)	Rating (e)	OC (%)	Rating (a)	OM (%)	Rating (b)	CEC(meq/100g soil)	Rating (b)	EC (ms/cm)	Rating (b)	pH
T1	0.181	Med	34.66	V. high	140	Med	1.26	Low	2.175	M	37.60	High	0.13	Low	8.0
T2	0.18	Med	33.88	V. high	143	High	1.42	Low	2.45	M	37.00	High	0.09	Low	8.0
T3	0.177	Med	27.78	V. high	139	Med	1.32	Low	2.28	M	39.40	High	0.09	Low	7.6
T4	0.178	Med	29.66	V. high	146	High	1.41	Low	2.44	M	37.20	High	0.08	Low	7.9
T5	0.198	Med	29.16	V. high	137	Med	1.5	Low	2.52	M	35.56	High	0.09	Low	7.0
T6	0.191	Med	27.50	V. high	149	High	1.81	Med	3.11	High	37.16	High	0.11	Low	7.0
T7	0.188	Med	28.00	V. high	135	Med	1.2	Low	2.06	M	38.66	High	0.17	Low	7.0
T8	0.184	Med	27.02	V. high	138	Med	1.07	Low	1.84	Low	39.00	High	0.19	Low	7.6
T9	0.092	Low	30.06	V. high	133	Med	1.25	Low	2.15	M	34.80	High	0.13	Low	7.9
T10	0.109	Low	20.12	High	139	Med	1.35	Low	2.32	M	37.40	High	0.15	Low	7.9
T11	0.101	Low	21.64	High	132	Med	0.98	Low	1.70	Low	37.12	High	0.12	Low	7.0
T12	0.105	Low	22.5	High	140	Med	1.03	Low	1.78	Low	37.56	High	0.14	Low	7.9
T13	0.098	Low	16.52	Med	141	Med	1.04	Low	1.79	Low	39.36	High	0.16	Low	7.0
T14	0.091	Low	19.74	High	138	Med	1.03	Low	1.78	Low	41.60	V.high	0.13	Low	7.9
T15	0.081	Low	14.56	Med	120	Med	0.97	Low	1.68	Low	39.40	High	0.29	Low	7.6
T16	0.067	Low	14.66	Med	122	Med	0.94	Low	1.62	Low	39.00	High	0.14	Low	7.9

The lower case alphabet indicates the source, a= according to [12]. b= [32]. c= [22]. d= [26], based on this rating (T1, T2, T4, T9, T10, T12, T14 and T16 are M. alk), (T3, T8 and T15 are Mi.alk) and (T5, T6, T7 and T13 are Neut).e= [31]. Where TN = total nitrogen, AvP = available phosphorous, OC = organic carbon, OM = organic matter, CEC = cation exchange capacity, EC = electrical conductivity, V = very, M = moderate, Mi = miled, Med = medium, Ne = nuteral and alk = alkaline

3.3.2 Bulb rotting

No rotting bulbs were observed until the 4th week storage period (Table 6). A significant difference (P<0.05) were observed during 8th to 12th week of storage period. During the 8th week, the control treatment, followed by 2.5 t ha^{-1}VC + 50% RDF N, 5 t ha^{-1} VC + 75% RDF N, 10 t ha^{-1} FYM + 25% RDF N and 5 t ha^{-1}VC, with no significance difference among them resulted in a lower percentage of bulb rotting. On the other hand, highest percentage bulb rotting (7.86 and 7.956%) were recorded in bulbs from 5 t ha^{-1} VC + 50% RDF N and 20 t ha^{-1} FYM + 50% RDF N treatments, respectively. However, these high values did not vary significantly from those observed in 5 t ha^{-1} VC + 25% RDF N, 10 t ha^{-1} FYM + 50% RDF N and 20 t ha^{-1} FYM + 25% RDF N treatments. The same trend was observed during the 10 and 12 week where at the last observation bulb rotting reached the maximum of 9.1% in 10 t ha^{-1} FYM + 75% RDF N while the value was only 4.1% in the control treatment.

The increase in rotting of bulbs due to increase in nitrogen combined with farmyard manure could be attributed to the fact that higher rates of nitrogen encourage plants to produce large bulbs with soft succulent tissues which make them susceptible to the attack of disease causing microorganisms and produce bulbs with thick neck which render them difficult to dry. The result is in agreement with the report of [48] and [49] who showed rotting of bulbs was increased with increase in nitrogen fertilization. Onion bulbs produced without nitrogen application had the lowest rotting (22%) while highest rotting (36-54%) was recorded in bulbs produced under high dose of nitrogen [50].

3.3.3 Bulb sprouting

The combined application of organic and inorganic fertilizers showed highly significant (P<0.001) effect on onion bulb sprouting (Table 7). Plots treated under nil fertilizer were observed to have minimum (1.69 and 2.33% on 10th and 12th week of storage period, respectively) while the maximum bulb sprouting were observed in 20 t ha^{-1} FYM + 25% RDF N on week 10 (8.5%) and in 20 t ha^{-1} FYM + 50% RDF N on week 12 (12.94%). Absence of bulb sprouting at early stage (up to week 10) could be attributed to the inherent bulb dormancy, high temperature, low relative humidity and curing treatment that inhibits onion bulb sprouting. The current study corroborated with the findings of [51] who reported that higher sprouting was exhibited when NPK fertilizers and organic manure were applied compared to the control. The results are also in agreement with that of [52] who reported that minimum sprouting (9.97%) occurred in small size bulbs compared to sprouting of 13.62% in large size bulbs.

Table 4. Combined effect of organic and inorganic fertilizers on marketable yield of onion

Treatment combinations	Marketable yield (t ha^{-1})
2.5 t ha^{-1} VC + 25% RDF N	28.04 defg
2.5 t ha^{-1} VC + 50% RDF N	28.38 cdefg
2.5 t ha^{-1} VC + 75% RDF N	31.01 bc
5 t ha^{-1} VC + 25% RDF N	28.69 cdef
5 t ha^{-1} VC + 50% RDF N	35.13 a
5 t ha^{-1} VC + 75% RDF N	32.09 b
10 t ha^{-1} FYM + 25% RDF N	27.28 defg
10 t ha^{-1} FYM + 50% RDF N	27.27 defg
10 t ha^{-1} FYM + 75% RDF N	27.51 defg
20 t ha^{-1} FYM + 25% RDF N	28.14 defg
20 t ha^{-1} FYM + 50% RDF N	29.75 bcde
20 t ha^{-1} FYM + 75% RDF N	30.08 bcd
5 t ha^{-1} VC	27.12 efg
20 t ha^{-1} FYM	26.83 fg
100% RDF N	25.70 g
Absolute control	18.48 h
LSD (5%)	**2.826**
CV	**6.0**
SEM	**0.979**
F-test	***

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

Similar results were also reported by [53] where bulbs fertilized with 60 or 120 kg N ha^{-1} sprouted twice as much under common storage as compared to those which were not fertilized. He further explained that the role of nitrogen in increasing the sprouting of bulbs could be attributed to increase in the concentration of growth promoters than inhibitors with high N nutrition. [48] Also reported that high dose of nitrogen produced thick-necked bulbs that increased sprouting in storage due to greater access of oxygen and moisture to the central growing point.

Table 5. Combined Effect of organic and inorganic fertilizers on percentage of onion bulb weight loss

Treatment combinations	**Storage weeks**					
	2nd week	**4th week**	**6th week**	**8th week**	**10th week**	**12th week**
2.5 t ha^{-1} VC + 25% RDF N	2.933 bcd	2.983 ab	6.787 bcd	7.17 a	9.12 ab	13.81 bc
2.5 t ha^{-1} VC + 50% RDF N	2.857 bcd	4.423 cde	7.500 de	8.50 b	10.65 cd	14.68 cd
2.5 t ha^{-1} VC + 75% RDF N	2.563 ab	3.437 abc	6.247 ab	8.93 bc	10.16 bc	12.08 ab
5 t ha^{-1} VC + 25% RDF N	2.737 abc	4.520 cde	7.547 de	9.19 bc	11.67 de	14.94 cd
5 tha^{-1} VC + 50% RDF N	2.073 a	2.577 a	5.813 a	6.79 a	7.86 a	10.27 a
5 t ha^{-1} VC + 75% RDF N	3.890 fg	5.430 ef	7.533 de	9.71 c	12.42 ef	14.21 c
10 t ha^{-1} FYM + 25% RDF N	3.163 bcde	3.923 bcd	6.847 bcd	12.24 f	14.74 gh	18.72 f
10 t ha^{-1} FYM + 50% RDF N	3.103 bcd	5.977 fg	9.627 f	11.34 de	14.94 h	18.68 f
10 t ha^{-1} FYM + 75% RDF N	3.240 bcdef	7.147 gh	6.663 bc	10.79 d	13.59 fg	17.92 ef
20 t ha^{-1} FYM + 25% RDF N	2.950 bcd	5.037 def	7.923 e	10.76 d	12.15 e	16.17 de
20 t ha^{-1} FYM + 50% RDF N	6.067 h	7.940 h	10.447 g	13.26 g	17.26 j	23.49 h
20 t ha^{-1} FYM + 75% RDF N	3.817 efg	7.187 gh	9.257 f	12.18 ef	15.27 hi	18.95 f
5 t ha^{-1} VC	3.367 cdef	4.803 def	9.000 f	12.38 f	15.87 hi	21.54 g
20 t ha^{-1} FYM	3.520 def	4.780 def	9.647 fg	13.87 g	17.52 j	22.72 gh
100% RDF N	7.347 i	10.890 i	15.043 h	17.05 h	26.28 k	36.16 i
Absolute control	4.353 g	5.590 ef	7.080 cd	8.84 b	16.26 ij	24.08 h
LSD (5%)	0.6816	1.278	0.8120	0.8588	1.290	1.896
CV	11.3	14.2	5.9	4.8	5.5	6.1
SEM±	0.2360	0.442	0.2811	0.2974	0.447	0.656
F-test	***	***	***	***	***	***

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

Table 6. Combined effect of organic and inorganic fertilizers on percentage of onion bulb rotting

Treatment combinations	Storage weeks			
	6th week	8th week	10th week	12th week
2.5 t ha^{-1} VC + 25% RDF N	1.113 a	5.057 bc	6.497 d	6.967 bcdef
2.5 t ha^{-1} VC + 50% RDF N	1.667 a	3.947 ab	4.710 bcd	5.523 abcd
2.5 t ha^{-1} VC + 75% RDF N	1.113 a	5.047 bc	4.730 bcd	6.210 abcde
5 t ha^{-1} VC + 25% RDF N	1.667 a	5.633 bcd	4.190 abcd	6.257 abcde
5 t ha^{-1} VC + 50% RDF N	1.113 a	7.860 d	6.103 cd	7.770 cdef
5 t ha^{-1} VC + 75% RDF N	1.667 a	3.953 ab	5.317 bcd	6.787 abcdef
10 t ha^{-1} FYM + 25% RDF N	1.670 a	3.387 ab	4.107 abc	4.827 ab
10 t ha^{-1} FYM + 50% RDF N	1.670 a	5.647 bcd	3.593 ab	6.827 abcdef
10 t ha^{-1} FYM + 75% RDF N	1.113 a	5.047 bc	3.550 ab	9.193 f
20 t ha^{-1} FYM + 25% RDF N	1.667 a	6.763 cd	6.017 cd	5.153 abc
20 t ha^{-1} FYM + 50% RDF N	2.223 a	7.957 d	9.250 e	8.830 ef
20 t ha^{-1} FYM + 75% RDF N	1.670 a	4.517 bc	6.513 d	5.080 abc
5 t ha^{-1} VC	1.667 a	3.390 ab	5.243 bcd	9.260 f
20 t ha^{-1} FYM	1.670 a	5.083 bc	5.347 bcd	6.910 bcdef
100% RDF N	2.223 a	4.547 bc	5.380 bcd	8.113 def
Absolute control	0.557 a	1.667 a	2.267 a	4.063 a
LSD (5%)	1.939	2.581	2.383	2.832
CV	76.0	31.1	27.6	25.2
SEM±	0.671	0.893	0.825	0.981
F-test	Ns	**	**	*

*Means followed by the same letter within a column are not significantly different at P≤0.05; *=indicates significant different at 5%, **=significant different at 1%*

Table 7. Combined effect of organic and inorganic fertilizers on percentage of bulb sprouting

Treatment combinations	Percentage of bulb sprouting (BST %)	
	10th week	12th week
2.5 t ha^{-1} VC + 25% RDF N	4.740 bcd	6.327 cd
2.5 t ha^{-1} VC + 50% RDF N	4.113 abc	3.110 ab
2.5 t ha^{-1} VC + 75% RDF N	5.337 bcde	7.443 cd
5 t ha^{-1} VC + 25% RDF N	4.793 bcd	8.130 cd
5 t ha^{-1} VC + 50% RDF N	7.923 ef	9.103 d
5 t ha^{-1} VC + 75% RDF N	3.510 ab	5.640 bc
10 t ha^{-1} FYM + 25% RDF N	3.520 ab	5.467 bc
10 t ha^{-1} FYM + 50% RDF N	4.793 bcd	8.073 cd
10 t ha^{-1} FYM + 75% RDF N	5.323 bcd	9.203 d
20 t ha^{-1} FYM + 25% RDF N	8.500 f	6.450 cd
20 t ha^{-1} FYM + 50% RDF N	6.780 def	12.940 e
20 t ha^{-1} FYM + 75% RDF N	3.540 ab	5.720 bc
5 t ha^{-1} VC	6.427 cdef	6.790 cd
20 t ha^{-1} FYM	7.153 def	7.527 cd
100% RDF N	5.380 bcde	7.507 cd
Absolute control	1.693 a	2.327 a
LSD (5%)	2.587	2.960
CV	29.7	25.4
SEM±	0.896	1.025
F-test	***	***

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

4. 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 marketable yield (35.13 t ha^{-1}) but also improves soil fertility with minimum bulb weight loss. 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 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 combined application of organic manure and inorganic nitrogen fertilizers for better onion productivity, storability and soil nutrient balance.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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