13. Integrating Effect of Vermicompost with Nitrogen Fertilizer Equivalent Ratio on Soil Properties and Onion (*Allium Cepa* L.) Bulb Yield in North Western Amhara Region

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Abstract

The experiment was conducted to determine the integrated effects of vermicompost with equivalent nitrogen rates on soil chemical properties and the yield and yield components of onions at the Koga Irrigation Scheme in Northwest Ethiopia. The study comprised six treatments (Control, recommended Nitrogen, 75% recommended Nitrogen + 25% vermicompost, 50% recommended Nitrogen + 50% vermicompost, 25% recommended Nitrogen + 75% vermicompost, and 100% vermicompost) arranged in a randomized complete block design with three replications. Data on soil chemical properties and onion yield components were collected and analyzed using ANOVA with SAS software. The results indicated that different rates of vermicompost combined with nitrogen fertilizer significantly affected the yield components of onions. Soil properties, except for total nitrogen and organic carbon, were not significantly affected by the treatments. The application of 50% vermicompost with 50% nitrogen resulted in the highest bulb yield (23.6 t/ha) compared to the control and achieved the highest net benefit with an acceptable marginal return (above 100%), next to 100% vermicompost. Overall, the integration of vermicompost with nitrogen rates can improve the yield and yield components of onions. For the highest net benefit in a short period, applying 50% vermicompost with 50% nitrogen is preferable for yield improvement in the study area and similar agro-ecological environments. However, to ensure consistency, further research should be conducted widely and repeatedly in permanent plots.

Keywords: nutrient, organic fertilizer, amendement, irrigation, balancing

Introduction

Onion (*Allium cepa* L.) is one of the most important commercial vegetable crops grown intensively in the world. Onion has a significant contribution to the human diet, and economic earnings as well as valued for its medicinal properties (Gessesew et al., 2015). It is consumed primarily for unique flavor or the ability to enhance flavor in food (Yohannes et al, .2013). The common varieties of onion grown in Ethiopia include Han, Robaf, Lambada, Mata Hari, Rio Bravo, Sirius, and others (MAL, 2017). The total area covered by the onion crop is 31673.21ha, with a total production of 293887.585 tons and average productivity of 9.3 tons/ha (CSA, 2018). This is a very low yield compared to the world average of 19.7 tha^{-1} (Haq, 2016). The phenomenon is common in our region (Amhara) as compared to other regions. Low yield is attributed to factors, such as low soil fertility, pests, diseases, and poor storage facilities among others (Zziwa et al., 2015).

Moreover, the lack of fertile soil and the absence of recommended organic fertilizer rates are pertinent problems in any given area (Gessesew et al., 2015). Vermicompost is a product of organic matter degradation through interactions between earthworms and microorganisms (Arancon *et al.*, 2008). In this process earthworms fragment the waste, enhance microbial activity and accelerate rates of decomposition, as in composting, but by a non-thermophilic process (Abduli *et al.*, 2013). Vermicompost is not only the source of organic matter and nutrient but also improve microbial population, physical, biological, and chemical properties of the soil, as well as produce vigorous plants (Mavaddati *et al.*, 2010). Many researchers studied the role of organic fertilizers as a stimulant of plant growth and yield of onion (Shaheen *et al.*, 2007), improving bulb quality and storability (Al-Fraihat, 2016).

In Ethiopia, vermicompost application is getting more emphasis accounted for ease of preparation, input and labor availability, better nutrient composition as well as low cost as compared to inorganic fertilizer (Shanu *et al*., 2019). The principles of integrated nutrient management are the maintenance and possible management of soil fertility for sustaining crop productivity on a long-term basis. Judicious and proper use of organic and inorganic fertilizers is very essential not only for obtaining higher yield and quality but also to maintain soil health and sustainability for a longer period. *Therefore, to improve onion production, a number of inputs are required, including adequate soil fertility management through integrated organic and inorganic fertilizers.* Since integrated nutrient management for the crop is lacking in the study area, therefore, this study aimed to evaluate the effectiveness of vermicompost and N fertilizer rate on soil chemical properties and determine the optimum agronomic and economical rate of vermicompost and N fertilizer for the production of onion at the Koga irrigation scheme

Materials and Methods

Description of the Study Area: The experiment was conducted for two consecutive growing seasons (2020 and 2021) at the Koga irrigation scheme in the Mecha district on a farmer's field in North West Amhara region Ethiopia. It is one of the irrigation schemes developed by the government of Ethiopia to enhance the production and productivity of horticultural crops in northwestern Ethiopia. The irrigation scheme is about 7,000 ha large and is mostly used for the production of vegetables including onion, tomato, pepper, cabbage, carrots and etc. Moreover, cereal crops like wheat and maize are also produced during both irrigation and the main rainy season in the scheme. The topography of the irrigation scheme is a gentle slope and the soil type of the area is Nitosol. The area is located at 11° 23′ latitude and 37° 05′E to 37° 06′E longitude with an average altitude of about 1972 meters above sea level with an annual mean rainfall of about 1,395.23 mm. The mean maximum and minimum temperatures of the area are 27 and 12.8°C, respectively.

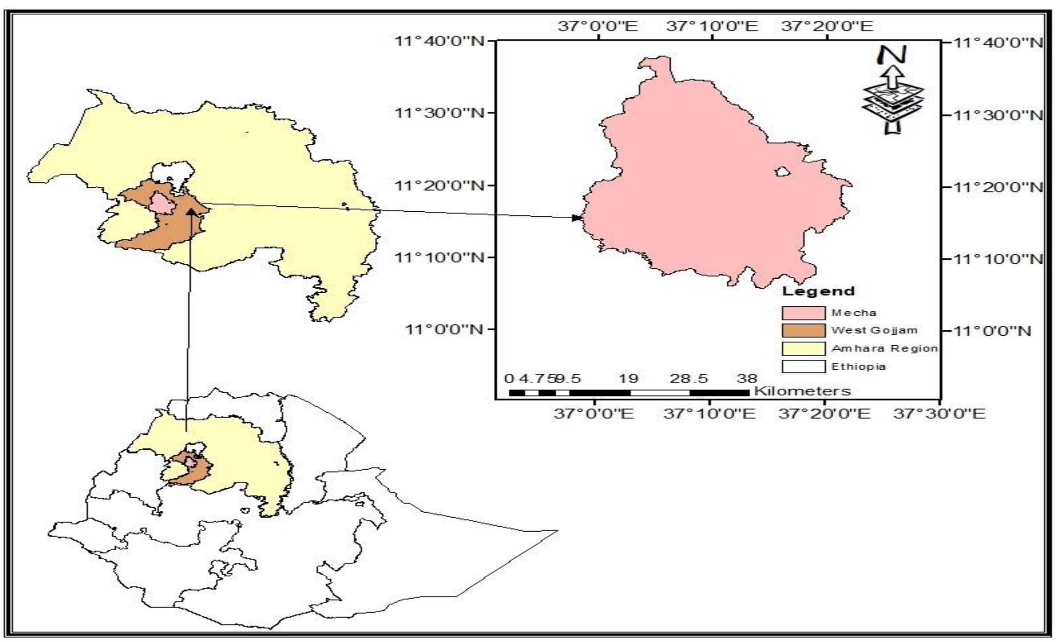

Figure 1. The geographical location of the study area

Experimental Design and Procedure: The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications which has six treatments control (without N), recommended N (137N Kgha^{-1}), 75% recommended N (103N Kgha^{-1})+25% VC (2.65 tha^{-1}), vermicompost 50% equivalence (5.3 tha^{-1})+50% recommended N (68.5N Kgha^{-1}), 25% recommended N (34.3)+75% VC (7.95 tha^{-1}) and 100% VC (10.6 tha^{-1}). The equivalence vermicompost rates were adjusted based on recommended Nitrogen. Urea and TSP were used as a source of synthetic N and P_2O_5 during the transplanting period. The experiment was carried out under irrigation and the onion variety Red Bombey was used as a test crop. The total area of each plot was 11.55 m^2 having 1.5m space between plots and blocks with 0.4m furrow width. Plants and rows were spaced 0.05 and 0.15m respectively. Vermicompost was incorporated in ridges during the transplanting. P_2O_5 was applied as basal on all plots at planting time while inorganic N was applied in two splits, half at transplanting planting and the remaining half 30 days after transplanting planting.

Data Collection, Preparation and Analysis:

Vermicompost Analysis: Representative composite sample vermicompost was taken from the whole collected vermicompost from well-prepared pits for analysis of (pH), total Nitrogen (TN%), cation exchange capacity (CEC), organic carbon (OC%), available Phosphorus (avP) and carbon-Nitrogen ratio (C: N ratio) by following laboratory procedures (Sahlemedhin and Taye, 2000).

Table 1. Chemical analysis of vermicompost before planting

PH	TN%	CEC(cmol Kg^{-1})	OC%	avP(mgKg^{-1})	C:N
7.61	1.3	65.71	18.16	477.63	14

OC%=organic carbon percent, TN%=total Nitrogen percent, C: N=carbon to Nitrogen ratio, CEC = cation exchange capacity, avP=available Phosphorus, and pH= Power of hydrogen concentration.

Soil Sampling and Analysis before Sowing: Before transplanting, representative soil samples were collected from 0-20 cm depth in a random sampling method from 10 spots in the field by using an auger. All samples were mixed together and one composite sample was formed. The composite sample was grounded using a mortar and passed through a 2mm sieve to analyze soil texture, CEC, pH, and available P; a 0.5 mm sieve was used to determine the organic carbon (OC) and total N.

Table 2. Soil Physico-chemical properties before transplanting

Texture	PH	TN%	CEC (cmol Kg^{-1})	OC%	avP ($mgKg^{-1}$)	C:N
Clay	5.11	0.185	31.32	2.48	20.60	13.41

Similarly, before transplanting and after harvesting soil samples were collected from 0-20 cm depth in a random sampling method from 10 spots in each experimental unit based on treatments through an auger. Determination of particle size distribution was done using the hydrometer method (procedures) compiled by Sahlemedhin and Taye (2000) and the sand, silt, and clay percent were calculated and identified using FAO textural triangle. The major chemical properties of soil such as OC, pH, CEC, total N, and available P were analyzed following the compiled laboratory manual of Sahlemedhin and Taye (2000). Soil pH was measured in water at a ratio of 1:2.5 using a glass electrode pH meter. The soil OC content was determined following the wet digestion method as outlined by Walkley and Black (1954) which involves the digestion of the OC in the soil samples with Potassium dichromate ($K_2Cr_2O_7$) in a sulphuric acid solution. The avP was determined by Olsen (1954) extracting method. The total N content in the soil samples was determined following the Kjeldahl method. CEC was determined by extracting the soil samples with ammonium acetate (1N NH_4OAc) followed by repeated washing with ethanol (96%) to remove the excess ammonium ions in the soil solution. Percolating the NH_4^+ saturated soil with sodium chloride would displace the ammonium ions adsorbed in the soil and the ammonium liberated from the distillation was titrated using 0.1N NaOH (sodium hydro oxide).

Crop Data Collection

Plant Height: it was measured at the maturity stage by taking five randomly selected plants from ground level to the top apex and averaged for a single reading.

Leaf Number: it was taken by counting all leaves randomly from five middle rows at the maturity stage and computed for the mean value.

Leaf Length: it was measured at the maturity stage by taking five randomly selected plants from each randomly measured leaf and averaging for a single reading.

Bulb Diameter: it was done by taking three plants bulb atharvest from middle rows measured by caliper then the values were averaged for a single reading.

Marketable Bulb Yield and Un-Marketable Bulb Yield: it was determined by personal judgment by considering all diseased attacked, shriveled, and sizes below 20mm bulbs could be un-marketable while the others are marketable

Total Bulb Yield: it was measured atharvesting by using both marketable and non-marketable bulbs from the net middle plot area (six ridges) of 3.3m x 3m.

Economic Analysis: Economic analysis was performed to make a rational choice among the applied variables in the production of onion. The partial budget and marginal rate of return (MRR) were used for evaluating the change in farming methods that affect partial rather than the whole farm practice and also concerned with a planning tool to estimate the profit change within a farm (CIMMYT, 1988). This was computed by adjusting the yield downward by 10% and multiplying it with the local field price (20 Ethiopian ETB per Kg of onion). Dominance analysis was done by listing treatments in increasing order of cost and thathave net benefit less than or equal to treatments with lower costs that vary dominated (CIMMYT, 1988).

Statistical Analysis: All data were subjected to analysis of variance through GLM procedure by using the SAS software program version 9.4 (SAS Institute, 2002). A list significant test (LSD) at 0.05 probability level was employed to separate treatment means where significant differences exist (Gomez and Gomez, 1984).

Results and Discussion

Effect of Vermicompost with Nitrogen on Soil Chemical Properties after Harvest: Soil chemical properties analysis after harvest from each experimental site were indicated in Table 3. Except for soil Nitrogen (@Y1S1 (year one site one) and organic carbon (@Y2S1 (year two site one) the other soil properties were not affected by the application of vermicompost with N equivalence rates (Table 3). The non-significant effects of the applied treatments on these parameters might be due to the slow release of nutrients from vermicompost, which was applied during the experimentation period to soil solution related to short cropping season onion cultivation. However, applied vermicompost and N rates had a significant ($P < 0.05$) effect on Nitrogen at site Y1S1 (year one site one) and organic carbon at Y2S1 (year two site one) (Table 3). Numerically the highest Nitrogen and organic carbon content were obtained by the application of (75% N with 25%VC) and (50%N+50%VC) respectively as compared to the control (Table 3). The increment of soil organic carbon in treated plots might be due to the improvement of soil organic matter by the application of vermicompost. These results were in agreement with the investigation of

Geremew *et al.*, 2019 who reported that the application of dry bio-slurry (14tha^{-1}) with blended fertilizer increased the soil OC content after harvest by scoring the highest value as compared to the control. Similarly, Tilahun *et al*., 2013 also, indicated that soil OC content just after the rice harvest responded significantly to the application of FYM, and the highest carbon (8.7%) was recorded from the application of FYM at the rate of 15 tha^{-1}. Similarly, the integration effect of both vermicompost and Nitrogen on total Nitrogen may be due to the addition of mineral N from vermicompost and urea fertilizer sources into the soil solution which makes increased the nutrient availability in the soil root system. The results agreed with the investigation of Iqbal *et al*., 2021 who reported that the combined application of vermicompost with inorganic Nitrogen (25%VC+25%N) on onion increased the soil total Nitrogen and other nutrient content after the harvest of onion as compared to the control.

Table 3. Integration effect of vermicompost and Nitrogen fertilizer on selected soil properties

Y1S1						
Treatment	pH	TN %	CEC (cmolKg^{-1})	OC%	avP (ppm)	C: N
Control (0,0)	5.08	0.15c	26.75	2.17	24.39	14.45
RN (100%) (137N Kgha^{-1})	5.17	0.20ab	27.61	2.30	24.37	11.60
75%RN (103N Kgha^{-1}) +25% VC (2.65tha^{-1})	5.12	0.21a	28.05	2.23	24.69	10.73
50%RN (69NKgha^{-1}) +50% VC (5.3tha^{-1})	5.09	0.17bc	27.45	2.08	27.32	11.96
25%RN (34NKgha^{-1}) +75% VC (7.95tha^{-1})	5.12	0.19ab	27.68	2.02	26.92	10.82
100% VC* (10.6tha^{-1})	5.08	0.19ab	27.82	2.19	27.82	11.31
LSD	NS	0.03	NS	NS	NS	NS
CV%	2.29	7.95	11.70	7.36	18.05	12.40
Y1S2						
Treatment	pH	TN%	CEC (cmolKg$^{-1)}$	OC%	avP (ppm)	C: N
Control (0,0)	4.95	0.17	27.52	2.17	29.21	12.51
RN (100%) (137N Kgha^{-1})	4.79	0.20	28.29	2.15	30.91	10.49
75%RN (103N Kgha^{-1}) +25% VC (2.65tha^{-1})	4.85					

Treatment	pH	TN%	CEC ($cmolKg^{-1)}$	OC%	avP (ppm)	C: N
Control (0,0)	5.08	0.21	29.07	2.26bcd	39.52	10.66
RN (100%) (137N $Kgha^{-1}$)	5.01	0.21	29.63	2.40abc	41.12	11.70
75%RN (103N $Kgha^{-1}$) +25% VC (2.65tha^{-1})	5.13	0.21	27.45	2.21cd	41.76	10.46
50%RN (69N$Kgha^{-1}$) +50% VC (5.3tha^{-1})	5.11	0.22	26.31	2.53a	42.36	11.62
25%RN (34N$Kgha^{-1}$) +75% VC (7.95tha^{-1})	5.19	0.20	25.75	2.43ab	40.14	12.10
100% VC (10.6tha^{-1})	5.17	0.23	25.51	2.15d	41.08	9.48
LSD	NS	NS	NS	0.21	NS	NS
CV%	4.53	8.20	10.13	5.01	11.46	10.73

*NB: VC= vermicompost, RN = recommended Nitrogen, Y1S1 = year one site one, Y1S2 = year one site two and Y2S1= year two site one

Integrated Effect of Vermicompost with Nitrogen on Onion Growth Parameters: Integrated application of vermicompost and inorganic Nitrogen significantly affected on plant height of onion ($p<0.05$) beyond leaf number and leaf length. Numerically, the highest value of plant height of onion was observed by application 50%VC (5.3tha^{-1}) with 50%N (69KgN) as compared to the control (untreated plots). Increasing plant height in response to the application of vermicompost (VC) with Nitrogen (N) fertilizer may be due to the improvement of chemical properties of the soil that resulted from the mineralization of vermicompost and release of N from urea fertilizer into soil solution for easy uptake by plant for its growth. In addition, it might be a positive effect of vermicompost in increasing water absorption and holding capacity that helps for nutrient utilization of the plant root system (rhizosphere).

Moreover, application of vermicompost may deliver balanced micro and macronutrients as well as enhanced availability of plant nutrients, which would help to enhance the metabolic activity of microorganisms and improvement of plant growth. The result is in agreement with the findings of Melkamu *et al.,* (2020) who observed that longer plants when onion plants were applied with farm yard manure (13.5tha^{-1}) and NPS (245.1Kgha^{-1}). lt is also harmonized with the findings of Bhavana *et al*., 2022 who recorded maximum plant height of onion from the application of 50% vermicompost with 50% inorganic fertilizer while the minimum value was recorded from the control treatment. Another study that was conducted by Muhammad *et al*., 2017 reflected that the highest value of mung bean plant height (78.08 cm) was recorded from the treatment which received 20:50 NP Kgha^{-1} with inoculation Rhizobium as compared to the lowest value 68 cm on control treatment

Table 4. Response of onion growth parameters for vermicompost and inorganic fertilizer application at Koga irrigation scheme

Treatment	Leaf Number	Leaf Length (cm)	Plant height (cm)
Control (0,0)	8.9	27.8	32.8b
RN (100%) (137N Kgha^{-1})	8.9	29.5	35.2ab
75%RN (103N Kgha^{-1}) +25% VC (2.65tha$^{-1)}$	8.9	30.9	36.5a
50%RN (69N Kgha^{-1}) +50% VC (5.3tha^{-1})	8.7	31.1	37.3a
25%RN (34N Kgha^{-1}) +75% VC (7.95tha^{-1})	8.5	29.2	35.0ab
100% VC (10.6tha^{-1})	8.7	29.6	35.0ab
LSD (0.05)	NS		2.8
CV%	7.9	8.2	8.4

**NB: VC= vermicompost, RN= recommended Nitrogen*

Integrated Effect of Vermicompost with Nitrogen on Onion Yield Parameters: The bulb diameter and yield of the onion were significantly affected ($p<0.05$) by the application of vermicompost and inorganic Nitrogen fertilizer (Table 5). Due to this, the highest value of bulb diameter and yield was observed by the application of 50% VC (5.3tha^{-1}) with 50% inorganic Nitrogen (69N Kgha^{-1}) as compared to control (untreated plots) (Table 5). This may be due to the application of organic manures which provide major and micronutrients resulting in increased photosynthetic activity, chlorophyll formation, Nitrogen metabolism, and auxin contents in the plants ultimately improving the diameter of the bulb. The higher total bulb yield might be due to an increase in plant height, number of leaves, and other yield attributes for the fresh weight of the whole plant bulb. Moreover, it might be due to the release of N from vermicompost (VC) and Urea to soil solution that makes for plant better growth and development.

Moreover, it could be due to the addition of both macro and micronutrients from the vermicompost by improving soil Physico-chemical properties. Similar results have been reported by Sioflo *et al*., (2020) who reported that the highest value of onion bulb yield (19,8tha^{-1}) was observed through the application of 20tha^{-1} vermicompost before transplanting of onion as compared to control by folding 7.9 times. Another study conducted by Bosco *et al*., (2017) also indicated that the amendment of experimental plots by farmyard manure gives the highest bulb yield of onion (12tha^{-1}) than untreated plots (control). Kirose *et al*., 2018 also reported that an application of 75%

recommended fertilizer with 2.5tha^{-1} vermicompost gives the highest onion seed yield (1462.5Kgha^{-1}) which was 263% higher than control (untreated) treatments.

Table 5. Response of onion yield parameters for vermicompost with inorganic Nitrogen application at Koga irrigation scheme

Treatment	Bulb Diameter (mm)	Bulb Yield (tha^{-1})
Control (0,0)	45.5c	15.6c
RN (100%) (137N Kgha^{-1})	50.1ab	23.2a
75%RN (103N Kgha^{-1}) +25% VC (2.65tha$^{-1)}$	49.2b	19.3b
50%RN (69N Kgha^{-1}) +50% VC (5.3tha^{-1})	51.8a	23.6a
25%RN (34N Kgha^{-1}) +75% VC (7.95tha^{-1})	49.5ab	18.6b
100% VC* (10.6tha^{-1})	50.4ab	17.3bc
LSD (0.05)	2.3	2.7
CV%	4.9	14.4

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**NB: VC= vermicompost, RN =recommended N*

Partial Budget Analysis: Net benefits were calculated by the current fertilizer (Urea) cost of 13.643 ETBKg^{-1}, cost of vermicompost Kg^{-1} 0.2 ETB, field price of onion was 20 ETBKg^{-1}, and cost of labor per man day in the area is 70 ETB. The marginal rate of returns of 100% was used to determine the ar.024ze of atmentse T(is)--31er.024zc a(a)4(ysli)-4isoindicated -tatd n

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Table 6. Partial budget and marginal analysis of onion as affected by the application of vermicompost with Nitrogen.

Treatments	Actual yield tha^{-1}	10% Adjusted Bulb Yield tha^{-1}	Total variable Cost $ETBha^{-1}$	Net Benefits $ETBha^{-1}$	MRR%
Control (0,0)	15.6	14.04	0	280800.0	0
100% VC* (10.6tha^{-1})	17.3	15.57	3240	308160.0	844.4
25%RN (34N $Kgha^{-1}$) +75% VC(7.95tha^{-1})	18.6	16.74	3726.4	331073.6	D
50%RN (69N $Kgha^{-1}$) +50% VC (5.3tha^{-1})	23.6	21.24	4212.8	420587.2	18403.2
75%RN (103N $Kgha^{-1}$) +25% VC (2.65tha^{-1})	19.3	17.37	4699.2	342700.8	D
RN (100%) (137N $Kgha^{-1}$)	23.2	20.88	5185.6	412414.4	D

**NB: VC = vermicompost, RN =recommended Nitrogen, D = dominated*

Conclusions and Recommendations

Applied vermicompost with N (Nitrogen) had a positive impact on plant height, bulb diameter, and Total bulb yield. Among treatments used for this experiment undominated once gave a better net benefit response with over 100% marginal rate of return than the control. Therefore, resource-poor producers or small-scale farmers can be benefited, if they apply these soil improvement rates depending on their convenience. The study identified that the highest net benefit could be obtained from the application of vermicompost with N fertilizers. Related to this application 50% vermicompost with 50% N gives a higher net benefit with 184.032% marginal return. As a result, small-scale farmers could use it for onion production in the area (for an irrigation scheme). In the future, similar studies should be done in different locations, crops, and years in permanent plots in order to confirm the current findings and to give a concrete recommendation for crop production and soil health amendment in the Koga irrigation scheme.

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