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Combined application of compost and FYM with inorganic fertilizers for production of onion in debub ari district, Southwestern Ethiopia

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ABSTRACT

Soil fertility depletion is a serious problem in Ethiopian highland due to leaching of topsoil by runoff, which reduces production and productivity. This experiment conducted in Debub Ari district for two years with the aim of investigating single and combined effect of compost and FYM with inorganic fertilizer on soil fertility improvement and onion crop production. The treatment includes T1) Control, T2) Recommended NP (69/30), T3) NPSZnB (120N, $92P_2O_5$, 20.06S, 5.89Zn, 0.66B) kg ha^{-1} (264 kg NPSZnB + 161 kg urea), T4) 10 t ha^{-1} FYM, T5) 10 t ha^{-1} compost, T6) 5 tha^{-1} FYM + 50% of treatment-3 and T7) 5 t ha^{-1} compost + 50% of treatment-3. Treatments are arranged in randomized complete block design with three replications. Soil before the experiment showed moderately acidic, moderate in organic matter and boron, low in sulfur high in available P and total nitrogen. The results showed significant differences among the treatments on onion plant height, bulb diameter, marketable and biological yield. The highest total yield 19.99 t ha^{-1}, 19.59 t ha^{-1} and 19.25 t ha^{-1} was recorded from NPSZnB (120N, $92P_2O_5$, 20.06S, 5.89Zn, 0.66B) kg ha^{-1}, 5 t ha^{-1} compost + 50% of T-3 and 5 t ha^{-1} FYM + 50% of T-3 respectively and that increase yield by 39%, 35% and 33% over the control. Soils after the experiment become medium in sulfur remain static in available boron and total nitrogen. Economic feasibility that the maximum net benefit of 246059 and 242442 ETB ha^{-1} with acceptable %MRR of 290 and 1300 was obtained with the application of NPSZnB (120N, $92P_2O_5$, 20.06S, 5.89Zn, 0.66B) kg ha^{-1} and 5 t ha^{-1} FYM + 50% of T-3, respectively. Therefore, the application of those two treatments is recommended for higher yield production in the study area.

Keywords: Farmyard manure, Compost, Inorganic fertilizer, Onion

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Introduction

The onion (*Allium cepa* L.) is a main bulb crop in Ethiopia and introduced to the agricultural community in the early 1970s (Adgo, 2008). It was newly introduced and rapidly becoming acceptable by producers and consumers. Currently, it is widely grown by smallholder farmers and commercial growers throughout the year for local use and export market (Bikila, 2012).

In Ethiopia, onion believed to be more intensively consume than any other vegetable crops and a major share of 95% of the vegetables and fruits produced in the country out of the smallholder sector. Despite this, productivity of the crop remains low 10.02 t ha^{-1} (FAO, 2012). The average annual onion production in Ethiopia is about 230,745.2 tons with the productivity of about 9.5 t ha^{-1} (Nigatu *et al.*, 2018). In Ethiopia, onion is very important in the food interest and in daily stews as well as in different vegetable food preparation uses. Also, the chemical flavonoids, anthocyanins, fructo-oligosaccharides and organo-sulphur compounds found in the onion is considered as medicinal and health benefits to fight different diseases including cancer, heart and diabetic diseases (Goldman, 2011).

The problem of soil fertility reduction serious in the tropical regions where the soil lacks adequate plant nutrients and organic matter due to complete removal of crop residue and erosion of topsoil by intense rainfall. A system that integrates different practices of soil fertility program is required for optimum growth and development of crops and this include the use of mineral fertilizers and organic manures (Falodun *et al.*, 2013).

The combined application reduces the dependence of the farmer on inorganic fertilizer. It also reduces the exposure of the soil to the side effect of inorganic fertilizer application resulted in deficiency of micronutrients, imbalance in soil physiochemical properties and unsustainable crop production (Jeyathilake *et al.,* 2006). Therefore, utilization of locally produced compost and FYM in combination with inorganic fertilizer at the recommended dose may be increase vegetable production. The objective of this study was to investigate the single and combined effect of compost/FYM and inorganic fertilizer on soil fertility and onion yield improvement in Debub Ari District Southwestern Ethiopia.

Materials and Methods

Description of the study area

A field experiment was conducted for two consecutive years (2018 and 2019) at Debub Ari district of South Omo Zone, Southwestern Ethiopia. The experimental site is geographically located in 05°47'55.6"N and 36°37'59.7" E with an elevation of 1919 m.a.s.l. It found northeastern direction with 8 km a distant of Jinka town (principal city of the south Omo zone). The study site has a bi-modal rainfall pattern with shorter rainy season from March-May and longest rainy season from August- December. The district receives 1343 mm total annual rainfall. The annual mean temperature varies from 16.3 °C to 27.7 °C.

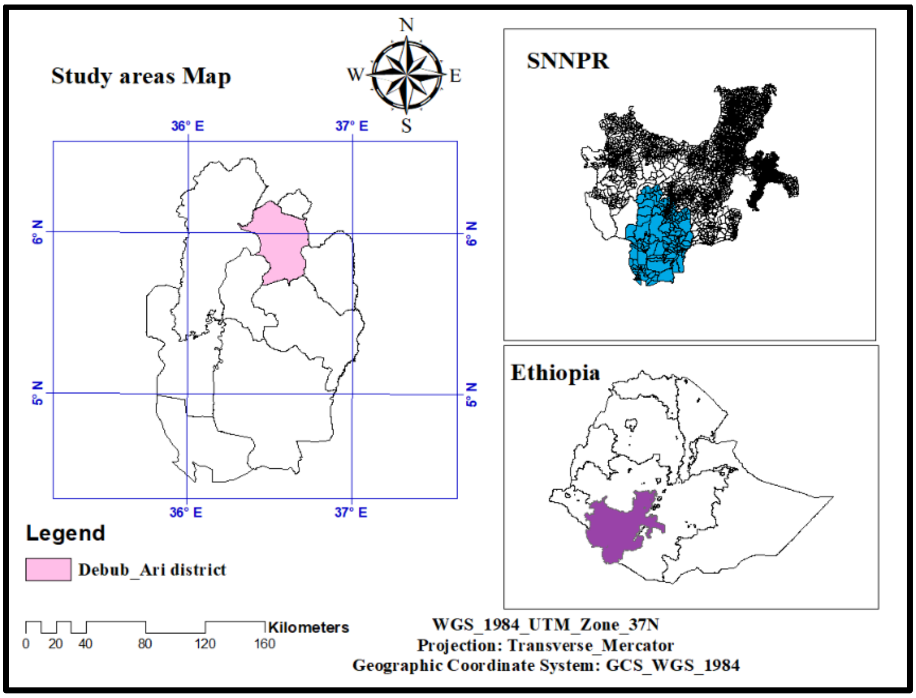

Fig. 1. Study area map.

Experimental layout and design

The experiments were laid out in a Randomized Completely Block Design (RCBD) with three replications. There were seven treatments: 1) Control (no fertilizers), 2) Recommended NP (69N/30P), 3) (120N, $92P_2O_5$, 20.06S, 5.89Zn, 0.66B) kg ha^{-1} = 264 kg NPSZnB + 161 kg urea top dress, 4) 10 t ha^{-1} FYM, 5) 10 t ha^{-1} compost, 6) 5 t ha^{-1} FYM + 50% of treatment-3 and 7) 5 t ha^{-1} compost + 50% of treatment-3. Urea used as N source and TSP used as for P source. Required doses of TSP and NPSZnB applied at planting while nitrogen was split twice, half was applied at planting and the remainder was applied 35 days after planting. Onion (Bombay red variety) used as test crop, which was widely used by local producers.

Soil sampling and laboratory procedures

Composite soil sample was collected from 0-20 cm soil depth before planting in zigzag pattern. Similarly, soil samples were collected after harvest. Finally, the samples were air dried and sieved through 2 mm sieve for selected physicochemical parameters and 0.5 mm sieve for organic carbon and total nitrogen. The procedures that followed at laboratory for each parameter were 1:2.5 soil to water suspension, Walkly Blacky, Olsen, Dilute HCL, Turbid metric and Morgar solution extraction methods for pH, % OC, available P (ppm), B ppm, available SO4-S (ppm) and available K (ppm), respectably.

Data collection

Important agronomic data for the crop including plant height, bulb diameter, weight of unmarketable and marketable bulb and total bulb yield collected. Plant height and bulb diameter collected randomly from five selected hills from each plot. For the rest adjusted harvestable row used.

Data analysis

Data was analyzed using SAS software (SAS version 9.1). Treatment means were compared with one-way ANOVA at α = 0.05 probability level. Tukey test employed for treatment mean separation.

Economic analysis

To estimate economic feasibility, the total tuber yield was valued based on average market price collected from the local markets during two consecutive years of production. The average cost of Urea, NPSZnB, and NP were 15.25, 15.48 and 15.24 ETB per kg, respectively, were used. A wage rate of 35 ETB a man per day considered for the organic fertilizers collection and preparation and for the application of both fertilizers at field.

The dominance analysis used to select potentially profitable treatments; it carried out by listing the treatments in order of increasing costs that vary. Any treatment with low net benefits and high cost compared to the treatments with low cost and high benefit dominated. For each pair of ranked non-dominated treatments, a percentage marginal rate of return (%MRR) was calculated. The percent MRR between any pair of non-dominated treatments denoted the return per unit of investment in crop management practices and it expressed as percentage. A treatment considered a worthwhile option to farmers, 100% rate of return (MRR) considered as described in CIMMYT (1988).

Results and Discussion

The initial soil physical and chemical analysis indicated that the study area generally characterized as medium to low in soil fertility and moderately acidic (Table 1). The availability of all analyzed nutrients ranged from low to medium for the growth of most crops. This could attributed to continuous cropping with little or no nutrient returns, which resulted in nutrient depletion and a decline in soil fertility. Combined application of organic and inorganic fertilizer did not significantly influence the pH of the soil. Soil pH varying from 5.6-6.0 values, which is reasonable enough for the availability of nutrients to the crop (Herrera, 2005).

Table 1. Soil fertility status before planting.

Soil parameters	Values	Rating	References
% of Sand	37		
% of silt	19		
% of clay	44		
Textural class		Sandy Clay	USDA Soil Texture Triangle
pH	5.75	moderately acid	Landon (2013)
%OC	2.73	low	Landon (2013)
%TN	0.24	medium	Landon (2013)
P ppm	22.4	medium	Jones (2003)
B ppm	0.58	low	Jones (2003)
SO_4-S ppm	8.553	low	Havlin *et al.* 1999
Av. K ppm	166.7	high	Jones (2003)

Prior to treatment arrangement and conducting the experiment the organic inputs, compost and FYM were analyzed for pH, TN, available P and sulfur following the standard laboratory procedures and the analysis result is indicated in the table below.

Table 2. Some nutrient analysis of compost and FYM before treatment application.

Parameters	Organic sources		Methods
	Compost	FYM	
	Values	Values	
pH	7.86	7.72	pH (1: 2.5 H_2O)
%TN	0.77	1.26	Keljdall distillation and digestion followed by titration
Av. P ppm	157.5	126.2	Olsen methods
SO_4-S ppm	27.6	19.3	Turbid metric methods

Table 3. Residual effect of soil fertility status as influenced by the applied treatments in the experimental field.

Treatment	pH	OC (%)	TN (%)	P (ppm)	B (ppm)	SO_4-S (ppm)	Av. k (ppm)
Control (no fertilizers)	5.60	2.60	0.20	8.3	0.45	8.70	150.7
69 kg N + 30 kg P ha^{-1}	5.90	2.57	0.22	10.7	0.43	13.20	147.0
(120N, $92P_2O_5$, 20.06S, 5.89Zn, 0.66B) kg ha^{-1}	5.90	2.53	0.22	8.4	0.46	15.30	128.0
10 t ha^{-1} FYM	6.00	2.49	0.26	11.3	0.42	17.50	163.6
10 t ha^{-1} compost	5.90	2.60	0.22	18.1	0.68	19.70	154.3
5 t ha^{-1} FYM + 50% of T-3	5.87	2.50	0.21	14.2	0.52	14.77	142.4
5 t ha^{-1} compost + 50% of T-3	5.81	2.60	0.22	6.8	0.48	15.40	152.4

Although nitrogen content of the added inputs, compost and FYM was 0.77 and 1.26%, respectively, which indicates very high amount of total nitrogen present in the applied organic fertilizer, however, any nutrient improvements not observed on the treated plots. This is probably due to the slow decomposition and nutrient release of these organic inputs. However, sulfur and soil pH increased in the treated plots compared to the control.

Table 4. Yield parameters of onion as affected by both organic and inorganic fertilizer.

No.	Treatments	PH (cm)	Bd (cm)	M yield ($t\ ha^{-1}$)	UM ($t\ ha^{-1}$)	TY ($t\ ha^{-1}$)
1	Control (no fertilizers)	47.0^{ab}	12.4^{b}	12.66^{c}	1.73	14.38^{c}
2	69 kg N + 30 kg P ha^{-1}	49.8^{ab}	15.4^{ab}	14.64^{c}	1.78	16.42^{bc}
3	(120N, 92P_2O_5, 20.06S, 5.89Zn, 0.66B) kg ha^{-1}	49.4^{ab}	16.1^{a}	17.85^{a}	2.14	19.90^{a}
4	10 t FYM ha^{-1}	46.5^{b}	15.7^{ab}	14.14^{c}	2.01	16.14^{bc}
5	10 t compost ha^{-1}	50.2^{ab}	14.8^{ab}	15.02^{bc}	1.78	16.81^{b}
6	5 t FYM + 50% of T-3 ha^{-1}	50.6^{ab}	17.2^{a}	17.58^{ab}	1.97	19.26^{a}
7	5 t compost + 50% of T-3 ha^{-1}	52.4^{a}	17.0^{a}	17.79^{a}	1.73	19.51^{a}
CV (%)		6.0	11.8	9.4	16.2	7.6
LSD		5.2	3.2	2.64	NS	2.39
Mean		49.4	15.5	15.67	1.87	17.49

Mean values with different letters within the column are statistically different at α ≤ 5%. PH = plant height, Bd=Bulb diameter, M= marketable, UM= Unmarketable yield t/ha, TY= Total yield t/ha.

Statistically significant difference was observed among all treatments except unmarketable yield (Table 4). Most measured parameters significantly influenced by application organic, inorganic and combined use fertilizers at α ≤ 5% probability level.

Plant height and Bulb diameter

Application of 5 t/ha compost + 50% of treatment -3 was significantly affected plant height compared to 10 t FYM ha^{-1}. This result is probably due to the decomposition difference between compost and FYM during application and probably compost released more nutrient throughout the growing period of onion. Significantly lower bulb diameter observed in the control plot, whereas statistical difference was not observed between all fertilizer treatments. In line with this (Nigatu *et al.*, 2018) and (Gebremichael et *al.*, 2017) reported that bulb diameter measured from non-fertilized plots was lowest compared to the plots treated by integrated application inputs.

Marketable and unmarketable yield

Based on the data indicated in table 4, significant difference (P ≤ 0.05) was observed in marketable yield of onion. Application of (120N, 92P_2O_5, 20.06S, 5.89Zn, 0.66B) kg ha^{-1} and the combined application of organic and inorganic fertilizer gave significantly higher yield compared to the control, recommended NP and sole application of organic fertilizers (compost and FYM). Accordingly the highest yield, 17.79 t and 17.85 t ha^{-1}, were recorded from the application of 5 t compost ha^{-1} + 50% of T-3 and in organic fertilizer (120N, 92P_2O_5, 20.06S, 5.89Zn, 0.66B) kg ha^{-1}, respectably. In addition, the lowest (12.659 t ha^{-1}) marketable onion yield was measured from the control followed by 10 t/ha FYM. In general, application of 5 t/ha compost + 50% of treatment-3 and (120N, 92P_2O_5, 20.06S, 5.89Zn, 0.66B) kg ha^{-1} gave 40% and 41% yield advantage over the control, respectively. This finding is similar with the report of Gebremichael *et al.* (2017). Similarly, total yield was affected by the applied treatments. Based on the result, significantly higher yield was measured from the plots received (120N, 92P_2O_5, 20.06S, 5.89Zn, 0.66B) kg ha^{-1}, 5 t compost ha^{-1} + 50% of treatment-3 and 5 t FYM ha^{-1} + 50% of treatment-3 compared to other treatments considered in this experiment.

Total yield

Analysis of variance indicated that the combined application of organic and inorganic fertilizer at (α ≤ 5%) was significantly affected total bulb yield. The maximum total yield 19.99 t ha^{-1}, 19.59 t ha^{-1} and 192.55 t ha^{-1} were obtained from (120N, 92P_2O_5, 20.06S, 5.89Zn, 0.66B) kg ha^{-1}, 5 t ha^{-1} compost + 50% of T-3 and 5 t ha^{-1} FYM + 50% of T-3, respectively while the minimum was recorded from the Control (no fertilizer). The highest yield obtained from (120N, 92P_2O_5, 20.06S, 5.89Zn, 0.66B) kg ha^{-1}, 5 t ha^{-1} compost + 50% of T-3 and 5 t ha^{-1} FYM + 50% of T-3 gave 39%, 35% and 33%, respectively yield advantage over the control.

Economic Analysis

Partial budget analysis indicated that the highest total cost (17,940 ETB ha^{-1}) and the lowest (0 ETB/ha) was incurred when 10 t ha^{-1} compost and no fertilized was applied, respectively. The highest net return 246,059 and 242,442 ETB/ha was obtained from the application of (120N, 92P_2O_5, 20.06S, 5.89Zn, 0.66B) kg ha^{-1} and 5 t ha^{-1} FYM + 50% of treatment-3, respectively, and the least net return (182,304 ETB ha^{-1}) was obtained from control (no inputs). In addition, the economic advantage obtained from (120N, 92P_2O_5, 20.06S, 5.89Zn, 0.66B) kg ha^{-1} was 34% and 27% over the control and 10 t ha^{-1} FYM.

Table 5. Economic (Partial budget, dominance and marginal rate of return) analysis of the organic and inorganic fertilizers on onion.

Treatments	10% adj. yield	TR (ETB)	TVC (ETB)	NR (ETB)	DA	MRR (%)
Control (no fertilizers)	11394	182304	0	182304	--	
RNP (69N, 30P)	13176	210816	7604	203212	ND	275
10 t ha^{-1} FYM	12726	203616	10300	193316	D	
5 t ha^{-1} FYM + 50% of T-3	15822	253152	10710	242442	ND	1263
(120N, 92P_2O_5, 20.06S, 5.89Zn, 0.66B) kg ha^{-1}	16065	257040	10980	246059	ND	1340
5 t ha^{-1} compost + 50% of T-3	16011	256176	14460	241716	D	
10 t ha^{-1} compost	13518	216288	17940	198348	D	

Note: RNP = Recommended Nitrogen and Phosphorus, 50% T-3=132 kg NPSZnB + 80 kg urea, TR = Total revenue, TVC = Total variable cost, NR = Net return, DA = dominance analysis, D = Dominated, ND=non dominated.

The items of cost that made up the total cost of production include: Labor cost incurred for different agronomic practices (ETB 35/day) such as, organic fertilizer collection and preparation, fertilizer application (2 split application), weeding (3 times), and Harvesting.

Conclusion and Recommendation

In conclusion, the finding of this study indicated that onion responded well to the application of organic and inorganic fertilizers. The present study revealed that combined application of compost or/FYM with inorganic fertilizers and use of inorganic fertilizers alone improved onion production in Debub Ari district, Southwestern Ethiopia. Accordingly, application of 5 t ha^{-1} FYM + 50% of treatment-3 and (120N, 92P_2O_5, 20.06S, 5.89Zn, 0.66B) kg ha^{-1} gave significantly higher yield with viable economic return. However, to minimize production cost and due to environmental friendly, application of 5 t ha^{-1} FYM + 50% of treatment-3 (132 kg NPSZnB + 80 kg urea ha^{-1}) is recommended. Onion growers can also use (120N, 92P_2O_5, 20.06S, 5.89Zn, 0.66B) kg ha^{-1} (264 kg NPSZnB + 161 kg urea ha^{-1}) as an alternative option.

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