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Effect of Vermicompost, Compost and Inorganic Fertilizer on Production of Onion at Southern Ethiopia, Wolaita Zone Humbo District

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Abstract

Combined application of fertilizers (organic and inorganic) could able to optimize production and productivity of onion. This experiment was conducted in Humbo district southern Ethiopia during 2019–2021 under irrigation to evaluate the effect of organic and inorganic fertilizer on bulb yield and general production of onion. Experiment was laid out in randomized complete block design with three replication and consisted of seven treatments: T1: control, T2: NPSB(82.2N, 31.4P, 13.4S, 0.2B); T3: compost alone (9 t/ha); T4: 2.25 t/ha compost + (50N, 23.5P, 10S, 0.15B); T5: 4.5 t/ha compost + (46N, 19.6P, 8.4S, 0.125B); T6: 6.75 t/ha compost + (41.1N, 15.7P, 6.7S, 0.1B) and T7: 9 t/ha compost + 23N. Soil of experimental area before planting was clay in texture slightly acidic in pH, medium amount of OC and TN, moderate of CEC, and very low contain of P. application of different level of organic and inorganic fertilizer combination significantly affect yield and yield components of onion in the study area. Maximum total bulb yield of 28.461 t/ha was obtained from the treatment combinations of 6.75 t/ha compost + NPSB (41.1N, 15.7P, 6.7S, 0.1B) which was statistically non-significant with 4.5 t/ha compost + NPSB (46N, 19.6P, 8.4S, 0.125B), 2.25 t/ha compost + NPSB (50N, 23.5P, 10S, 0.15B) and NPSB (82.2N, 31.4P, 13.4S, 0.2B) and the minimum total bulb yield of 10.731 t/ha was obtained at the control treatment. The maximum bulb yield (27.604 t ha-1), an acceptable marginal rate of return (3213%), maximum net benefit, and relatively low variable cost were obtained from the application of 2.25 t/ha compost + NPSB (50N, 23.5P, 10S, 0.15B) treatment. Therefore, to minimize production costs and due to environmentally friendly, the application of 2.25 t/ha compost + NPSB (50N, 23.5P, 10S, 0.15B) is recommended. However, the farmers can also use NPSB (82.2N, 31.4P, 13.4S, 0.2B) kg ha-1 (200 kg NPSB + 100 kg urea ha-1) as an alternative option.

Keywords: Compost, Inorganic Fertilizer, Onion, Yield

INTRODUCTION

Onion is the most important vegetable crop in the world [19]. It is commonly used as favoring or as vegetable in stews and salads. Onion is one of the richest source of flavonoids in human diet which has been associated with a reduced risk of cancer, heart disease and diabetes.

The area for onion production is increasing due to its high profitability and cash crops per unit area [6]. In Ethiopia, onions growing different agro climatic regions mainly in midlands under irrigation due to their considerably increasing importance in the daily diet and cash crops as income source for Ethiopians 1, 2]. However onion production is affected by different factors such as unbalanced fertilizer application, inappropriate rate application of fertilizer, lack of soil fertility and limited

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awareness of soil management practices [7]. continuous use of inorganic fertilizer and in appropriate soil fertility management practices are among the major factors limiting the productivity of onion in most part of the country [25, 27].

Farmers in the study area mostly use blanket recommendations of organic fertilizer for onion production. They rarely use organic manure for onion production on a small scale in gardens and near their homestead [25, 28]. Continuous use of inorganic fertilizers without supplementation of organic fertilizers has often resulted in micronutrients deficiency, imbalance of physical and chemical properties, and unsustainable crop production [26, 29].

Decomposition of organic material would provide additional nutrients to the growing medium which may lead to higher uptake of nutrients by the crop and subsequently high yield [17].

Moreover, in the study area there were no studies about combined application of organic and inorganic fertilizer on growth and yield of onions. Given this fact a systematic investigation of the effect of inorganic and locally available affordable organic fertilizer is of paramount importance for improving yield [26,22,8] Therefore the study was carried out to determine the response of onion to applied compost and inorganic fertilizer on growth, yield and yield components in humbo district southern Ethiopia.

MATERIALS AND METHODS

Description of Study Area

Experiment was conducted between 2019 and 2021 years under irrigation on farmer's field in humbo district Wolaita zone southern Ethiopia. The district is situated between $6^{0}38'$ and $6^{0}54'$N latitude and $37^{0}40'$S longitude and located at an altitude of 1100-2335 meters above sea level. It has received 840-1400mm mean annual rainfall with minimum of and maximum temperature of 15^{o}c and 29^{o}c respectively. Experimental area is known by mixed agricultural practice

Treatment Setup Design and Procedures

Conventional compost preparation was started by choosing a spot that was protected from the rain and the two compost pits were prepared in 1.5m depth. For the compost preparation locally available materials were collected from farmers to the preparation site. Materials for compost preparation were crop residues, green manures, cow dung, wood ash, top soil and water. Crop residues were chopped into 15 cm length and it was piled 15 cm thick first. The next layer was spread animal manure or cow dung to a thickness of about 10 cm and it was followed by 5cm wood ash and then top soil was added[16]. Finally compost piles were covered by green manure and watered until the pile was sufficiently moist. Another layer of the material was in the same sequence and repeated until a high of 1.5 meters of the compost pile was attained. The pile was attained over to another compost pit and mixed with spending fork after 3 weeks, then again after five weeks, and decomposed of three months. The conventional compost was incorporated into the soil before one month after well decomposition and preparation following recommended manual procedure. Onion seed variety red bomby was used as a test crop. Experiments treatment was consisted of 1) control (without fertilizer); T2: 200 kg/ha NPSB + 100 kg/ha urea (82.2N, 31.4P, 13.4S, 0.2B); T3: compost alone (9 t/ha); T4: 2.25 t/ha + 150 kg/ha NPSB + 50 kg/ha urea (2.25 t/ha compost + (50N, 23.5P, 10S, 0.15B)); T5: 4.5 t/ha + 125 kg/ha NPSB + 50 kg/ha urea (4.5 t/ha compost + (46N, 19.6P, 8.4S, 0.125B)); T6: 6.75 t/ha + 100 kg/ha NPSB + 50 kg/ha urea (6.75 t/ha compost + (41.1N, 15.7P, 6.7S, 0.1B)) and T7: 9 t/ha + 50 kg/ha urea (9 t/ha compost + 23N) and laid out in randomized complete block design (RCBD) with three replications. The plot size was 4m by 4m with 1m space between plots and blocks and the seeds were planted 10 cm by 40 cm spacing between plants and rows, respectively. Chemical fertilizer(inorganic fertilizer) was applied as per recommendation of previous study at planting time and Urea was applied in two terms half at planting time half after 35 days of planting at the area.

All other management practices were also applied as per site recommendation starting from field preparation to harvesting uniformly.

Data Collection and Measurement

Plant data collection was done as per recommendation and for plant height five plants were randomly selected and measured from each experimental plot at the stage of maturity. For statistical analysis we used average of these fife plants record.

For bulb diameter data; we use the same five plants bulb as sample and we measured at the wider portion of the bulb during at the time of harvesting by using the material digital caliper and we used average of those plant bulb for statistical analysis.

For Marketable yield; healthy and marketable bulbs that fall between in the range of 20 to 160 g in weight of bulbs from the net plot area were recorded during the time of harvesting. For unmarketable yield; bulbs that are under weighed and sized (less than 20g), diseased and decayed were used for data collection from each experimental plot and averages were taken for data analysis. For total bulb yield; total bulb yield was measured and recorded from the total harvest of the net plot as sum weight of marketable and under sized and under weighed bulbs (unmarketable) yields were measured[20].

Soil Sampling and Analysis

Composite soil sample (0–20 cm depth) were collected from the experimental area by zigza method before planting for determination of selected physiochemical properties of the soil. Collected g samples were air dried at room temperature and ground to pass through the 2 mm sieve for most parameters and through a 0.5 mm sieve to determine total nitrogen and organic carbon. Soil particle size distribution was determined by hydrometer method. Spoil pH was determined by potentiometric method at soil water ratio of 1:2.5 [23]. Cation exchange capacity was determined by 1M ammonium acetate method at pH 7 [3]. Organic carbon was determined by dichromate oxidation method [24]. Total nitrogen was determined by the conversation of organic carbon and available p was analyzed by Olsen method [14].

Statistical Analysis

SAS statistical software was used for data analysis of variance and mean separation among treatments done by least significant difference (LSD) at 0.0 probabilty level.

Economic Analysis

The economic analysis was estimated from the yield gained from the production of onion was valued with local market price average of two season of production. The average cost of Urea, NPSB, and onion bulb were 18.29, 25.17, and 19 ETB per kg, respectively, were used. A wage rate of 50 ETB a man per day was considered for the organic fertilizers collection and preparation and also for the application of both fertilizers at the field level. Average yield was adjusted downward by 10% to reflect the difference between the experimental field and the expected yield at farmer fields and with farmer's practices from the same treatments. The dominance analysis was used to select potentially profitable treatments; it is thus 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 is 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 is expressed as a percentage. A treatment to be considered a worthwhile option to farmers, a 100% rate of return (MRR) was considered as described in CIMMYT [4]

RESULT AND DISCUSSION SOIL PHYSICOCHEMICAL PROPERTIES OF EXPERIMENTAL SITE

Analysed soils sample result showed that the soil particle size distribution of the experimental site was in proportions of 36, 24, and 40 % of sand, silt and clay respectively (Table1). Based on USDA's

(1998) soil textural classification the textural class of the experimental soil is silt clay, which is suitable for onion production. The soil pH of experimental site before planting showed that the pH value was 6.4. According to [11], the rating of soil pH was under slightly acid soil reaction. pH of experimental site is ranged within satisfactory range for onion production as well as for most crops [10]. The OC and TN content of the experimental site was 1.61%and 0.14% respectively. Which is rated as under the medium range [9]

The high TN contents indicated that the soil of experimental site was sufficient in available N to support proper growth and development of agricultural crop production. The available P content of the site experimental is 5.48 ppm (Table 1) and rated as very low; and it is indicative that the soil has probable yield response to external P application [15]. Based on the analysis the cation exchange capacity (CEC) of the experimental site soil was 35.4 meq/100g (Table 1). According to [10] rating, the CEC of soil study was under high class and adequate for crop production. Furthermore such as high CEC value provides the soil with maximum buffering capacity so that one apply the required amount of fertilizer dosage without any immediate negative effects on the soil.

Analyzed soil data showed that application of organic fertilizer and in combination with inorganic fertilize r numerically increased the soil physio chemical parameters after harvest in the soil (Table 2). The soil pH reaction in the soil was ranged from 6.24 to 6.88 (slightly acidic to neutral). Organic carbon content of the soil sample collected from the study area before application of treatment was recorded at 1.61%. After harvest organic carbon content in the soil was found in the range 1.22 to 2.74 %(Table 2). According to Tekalegn (1991) rating, organic carbon content in the experimental site after harvesting was low to medium range. However residual organic carbon content soil after harvest was higher than before application of the treatment, and it has a major influence on soil aggregation, nutrients reserve and availability moisture retention and biological activity. Generally soil data showed that combined application of organic and inorganic fertilizers numerically increased the total nitrogen after harvest in the soil (Table 2). However the total nitrogen content of the sample from the control plot after harvest (0.11%) was somewhat decreased as compared to the total N of the soil before planting (0.14%) but with similar range. This may be due to soil degradation by different factors that could reduce nitrogen, because there was no any nitrogen added from any source. Maximum total nitrogen in the soil after harvesting was (0.24%) with the application of the treatment 6.75 t/ha + (41.1N, 15.7P, 6.7S, 0.1B), while the minimum total nitrogen (0.11%) was from T2 (alone application of inorganic fertilizer) and control. The residual N in the soil was ranged from 0.11 to 0.24 (medium to high) in the experimental area. Therefore the combined application of organic and inorganic fertilizers increases total N content in the soil up to 118% over control treatment.

Table 1. Physical and chemical properties of soil before planting.

Soil Properties	Values	Rating	Reference
% sand	36		
% silt	24		
% clay	40		
textural class		Clay	
Soil pH	6.4	slightly acidic	[11]
Organic carbon (%)	1.61	medium	[21]
Phosphorus (ppm)	5.48	Very low	[11]
Total nitrogen (%)	0.14	moderate	[21]
Available potassium (ppm)	59.55	Low	[11]
CEC (meq/100g)	35.4	High	[21]

Table 2. Residual effect of soil fertility status as influenced by the applied treatments in the experimental field.

Treatments	pH	%OC	%OM	%TN	P (ppm)
Control (no fertilizers)	6.54	1.22	2.11	0.11	8.22
NPSB (82.2N, 31.4P, 13.4S, 0.2B)	6.24	1.31	2.26	0.11	15.17
9 t/ha Compost	6.83	1.97	3.39	0.17	15.64
2.25 t/ha Compost + (50N, 23.5P, 10S, 0.15B)	6.88	1.93	2.64	0.13	19.91
4.5 t/ha Compost + (46N, 19.6P, 8.4S, 0.125B)	6.64	2.23	3.84	0.19	12.80
6.75 t/ha Compost + (41.1N, 15.7P, 6.7S, 0.1B)	6.83	2.74	4.72	0.24	18.06
9 t/ha Compost + 23N	6.72	2.62	4.52	0.23	13.74
Mean	6.67	2.01	3.35	0.17	14.79
SD	0.22	0.59	1.06	0.05	3.78
Min	6.24	1.22	2.11	0.11	8.22
Max	6.88	2.74	4.72	0.24	19.91

Result of soil data showed that combined application of organic and inorganic fertilizers increased the content of p availability (table 2). Application of 2.25 t/ha Compost + (50N, 23.5P, 10S, 0.15 B) gave the highest available soil P content (19.91 ppm) which is a 142% increment as compared to that of the control plot (8.22 ppm). Available P content of soil from the control plot after harvesting was relatively higher than the value obtained before planting, this indicated that low uptake by onion crop in control plot due to the imbalance of other macro and micronutrients. Residual P content in soil was ranged from 8.22 to 19.91 ppm (low to high range).

Growth Height

Analysis of variance indicated that application of organic and inorganic fertilizer had significantly affected ($p<0.05$) plant height of onion (Table 3). Maximum plant height of 48.9cm was obtained from the treatment combination of 4.5 t/ha compost + NPSB (46N, 19.6P, 8.4S, 0.125B) while the minimum (42.23 cm) was obtained at the control (Table 3). However there was statistically non-significant difference among the treatment combinations. Result of this experiment is agreed with the findings of [25] who reported that the increment in plant height in response to increased application of fertilizer.

Bulb Diameter

There was significance difference on the bulb diameter on application of organic and inorganic fertilizer. Application of fertilizer at rate of 6.75 t/ha compost + NPSB (41.1N, 15.7P, 6.7S, 0.1B) gave the highest (44.57 cm) bulb diameter of onion while the lowest of 28.23 cm were obtained from the control. Study indicate that the interaction effect of organic and inorganic N fertilizer can increase bulb diameter of onion. It could be attributed to the fact that increasing major elements particularly N level through organic manure might have selected the synthesis of chlorophyll and amino acids that resulting to more translocation of photosynthesis from leaves to bulb and causing enhancement bulb weight and diameter [22, 18].

Yield and Yield Components Biomass and Total Bulb Yield

Statistical analysis of variance indicted that biomass and total bulb yield of onion had significantly ($p<0.05$) influenced by application of compost and inorganic fertilizer (Table 4). Combined application of 6.75 t/ha compost + NPSB (41.1N, 15.7P, 6.7S, 0.1B) gave the highest biomass of 41.163 t/ha while the lowest (15.791 t/ha) was recorded from control treatment. Total highest bulb yield was obtained (28.461 t/ha) from treatment combinations of 6.75 t/ha compost + NPSB (41.1N, 15.7P, 6.7S, 0.1B) while the minimum total bulb yield (10.731 t/ha) was obtained from control (unfertilized plot). However, the maximum total bulb yield and biomass obtained from 6.75 t/ha compost + NPSB (41.1N, 15.7P, 6.7S, 0.1B) had statically non-significant with treatments 4.5 t/ha compost + NPSB (46N, 19.6P, 8.4S, 0.125B), 2.25 t/ha compost + NPSB (50N, 23.5P, 10S, 0.15B) and NPSB (82.2N, 31.4P, 13.4S, 0.2B). Reduction of yield on unfertilized plot might be due to the fact that plots were deficient of essential plant nutrients of organic and inorganic fertilizers. Findings in the present study could be due to activities of organic and/or inorganic fertilizers in promoting physiological and metabolic processes in plant which improved dry matter production and accumulation. Moreover beneficial effect of organic manures on yield might be due to additional supply of plant nutrients and improved physical and biological properties of soil [5].

Marketable and Unmarketable Bulb Yield

Marketable and unmarketable bulb yield significantly (<0.05) affected by combined application of organic and inorganic fertilizer (table 4). Maximum marketable bulb yield of 27.89 t/ha was obtained from treatment combination of 6.75 t/ha compost + NPSB (41.1N, 15.7P, 6.7S, 0.1B) which was statistically non-significant with 4.5 t/ha compost + NPSB (46N, 19.6P, 8.4S, 0.125B), 2.25 t/ha compost + NPSB (50N, 23.5P, 10S, 0.15B) and NPSB (82.2N, 31.4P, 13.4S, 0.2B) and the minimum marketable bulb yield of 10.451 t/ha was obtained at the control treatment. Application of 6.75 t/ha compost + NPSB (41.1N, 15.7P, 6.7S, 0.1B) improves marketable bulb yield production by 166.3% as compared with control treatment. Increment in marketable yield could be application of N which attributed to the increment in bulb diameter and average bulb weight [9, 12, 13],. Maximum unmarketable bulb yield of 0.669 t/ha was obtained from treatment combination of 6.75 t/ha compost +NPSB (41.1N, 15.7P, 6.7S, 0.1B) and minimum unmarketable bulb yield of 0.28 t/ha was obtained from control group.

Table 3. Organic and inorganic fertilizer effect on onion

Treatments	PH (cm)
Control (no fertilizers)	42.23b
NPSB (82.2N, 31.4P, 13.4S, 0.2B)	46.93ab
9 t/ha Compost	46.63ab
2.25 t/ha Compost + NPSB (50N, 23.5P, 10S, 0.15B)	45ab
4.5 t/ha Compost + NPSB (46N, 19.6P, 8.4S, 0.125B)	48.9a
6.75 t/ha Compost + NPSB (41.1N, 15.7P, 6.7S, 0.1B)	43.9ab
9 t/ha Compost + 23N	45.77ab
LSD(0.05)	6.25
CV (%)	7.7

Table 4 Bulb yield and yield components of Onion as affected by organic and inorganic fertilizer in Humbo district

Treatments	BD mm)	TB (t/ha)	MY (t/ha)	UMY (t/ha)	TY (t/ha)
Control (no fertilizers)	28.23c	15.791d	10.451d	0.280b	10.731d
NPSB (82.2N, 31.4P, 13.4S, 0.2B)	39.27b	36.284ab	24.75ab	0.600a	25.347ab
9 t/ha Compost	40.43ab	28.347c	18.003c	0.663a	18.667c
2.25 t/ha Compost + NPSB (50N, 23.5P, 10S, 0.15B)	41.97ab	40.381ab	26.982a	0.622a	27.604a
4.5 t/ha Compost + NPSB (46N, 19.6P, 8.4S, 0.125B)	42.4ab	39.534ab	27.663a	0.661a	28.224a
6.75 t/ha Compost + NPSB (41.1N, 15.7P, 6.7S, 0.1B)	44.57a	41.163a	27.829a	0.632a	28.461a
9 t/ha Compost + 23N	39.97b	33.759bc	22.36bc	0.536a	22.896bc
LSD(0.05)	4,4	6.846	4.607	0.156	4.525
CV (%)	6.3	11.4	11.1	15.3	10.9

Means in the table followed by the same letter(s) are not significantly different to each other at 5% level of significance, LSD (0.05) =Least significant difference at 5%; and CV (%) =Coefficient of variation, PH = Plant Height (cm), BD = Bulb Diameter (mm). TB = Total Biomass (t/ha), MY= Marketable Bulb Yield (t/ha), UMY = Unmarketable Bulb Yield (t/ha) and TY = Total Bulb Yield (t/ha).

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

Treatments	10% adj.MY	TR (ETB)	TVC (ETB)	NR (ETB)	DA	MRR (%)
Control (no fertilizers)	9405.9	178712.1	0	178712.1		
NPSB (82.2N, 31.4P, 13.4S, 0.2B)	22275	423225	8363	414862	ND	2823
2.25 t/ha Compost + NPSB (50N, 23.5P, 10S, 0.15B)	24283.8	461392.2	9515	451877.2	ND	3213
4.5 t/ha Compost + NPSB (46N, 19.6P, 8.4S, 0.125B)	24896.7	473037.3	12585.75	460451.6	ND	279
9 t/ha Compost	16202.7	307851.3	15300	292551.3	D	
6.75 t/ha Compost + NPSB (41.1N, 15.7P, 6.7S, 0.1B)	25046.1	475875.9	15656.5	460219.4	D	
9 t/ha Compost + 23N	20124	382356	16464.5	365891.5	D	

Note 10%adj. MY=10%adj marketable yield. TR=total revenue, TVC= total variable cost, NR=net return, DA= dominance analysis, D= dominated, ND=no dominated

Economic Analysis

The production of crop increase due to application of inputs might or might not be beneficial to farmers

Therefore partial budget analysis was employed to estimate net benefit analysis marginal rate of return that could be obtained from various alternative treatment, dominance analysis and marginal rate of return that could be obtained from various alternative treatment. According to analysis, maximum net return of 460451.6 ETB was obtained from plot applied with 4.5 t/ha compost + NPSB (46N, 19.6P, 8.4S, 0.125B) while the minimum net benefit (178712.1 ETB) was obtained from unfertilized or control plots (Table 5). However, the application of 6.75 t/ha compost + NPSB (41.1N, 15.7P, 6.7S, 0.1B), 2.25 t/ha compost + NPSB (50N, 23.5P, 10S, 0.15B) and NPSB (82.2N, 31.4P, 13.4S, 0.2B) were also at par net benefit of 460219.4 ETB, 451877.2 ETB and 414862 ETB with those treatments, respectively.

Items of cost that made up total of cost of production include labour cost incurred for different agronomic practices (ETB 50/day) such as organic fertilizer collection and preparation, fertilizer application purchasing. The result indicated that the net benefit was decreased as the total cost that varies increased beyond un-dominated fertilizer treatment application. Maximum marginal rate of return (3213%) and non-dominated value was obtained from application of 2.25 t/ha compost + NPSB (50N, 23.5P, 10S, 0.15B) when compared to other treatments. This treatment shows that maximum net benefit relatively low variable cost, and accepted marginal rate of return which was considered as the best for the recommendation.

CONCLUSION AND RECOMMENDATION

Application of different level of organic fertilizer in combination with in organic fertilizer significantly affected bulb yield components of onion in experimental site. Analysis of soil sample collected before planting indicated that experimental site had an insufficient amount of soil fertility status for onion crop production. Maximum bulb yield (27.604 t ha-1), the acceptable marginal rate of return (3213%), maximum net benefit, and relatively low variable cost were obtained from the application of 2.25 t/ha compost + NPSB (50N, 23.5P, 10S, 0.15B) treatment. Based on the current study, the combined application of organic and inorganic fertilizers should enhance the bulb yield and yield components of onion in the study area. Therefore, to minimize production cost and due to environmentally friendly, the application of 2.25 t/ha compost + NPSB (50N, 23.5P, 10S, 0.15B) could be recommended for study areas and other similar agroecology and soil types. However, the farmers can also use NPSB (82.2N, 31.4P, 13.4S, 0.2B) kg ha-1 (200 kg NPSB + 100 kg urea ha-1) as an alternative option.

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