Effects of the Combined Use of Compost, Nitrogen and Phosphorus on the Yield of Barley using tie-ridge

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Abstract

This trial was carried out with the overall objective of assessing the composting potential of the local composting materials and their integration with inorganic fertilizer for improving the productivity of barley. The experiment was undertaken by preparing compost and testing it effect on barley production on two locations for two years. Mean treatment differences were analyzed using ANOVA proc-GLM procedure. The two years combined analysis of the experiment in Dahana and Lalibela areas showed that application of blanket recommended inorganic fertilizer gave the maximum biomass and grain yield. However, using one tonne compost with half recommended N and P gave a comparable biomass and grain yield in addition to improving soil physical and chemical properties through time. Hence, one tonne compost with half recommended N and P is recommended for Wag and Lasta highland and similar agro-ecologies growing barley.

Key words: compost, grain, biomass, barley, organic fertilizer

Introduction

increasing yield on areas now cultivated and to a lesser extent by increasing the area under cultivation. Without the increased use of fertilizers together with optimum moisture in the soil, yield would have been very much less.

Barley is an important cereal crop in unfavorable environments. Its production is also considered relatively stable as compared to other cereals. It can give acceptable grain yield in areas where other crops cannot produce at all. Farmers use their land for barley or tef if rainfall fails to come early in May, to plant sorghum. Sorghum is more drought resistant than wheat and can be growing in regions of even minimum rain fall rainfall (Hailu and Joop, 1996). But in spite of its importance and capability to grow in such environmental

More immediate strategies using farmer available resources are needed that could reach more farmers sooner. Although fertilizers are used in much of Sub Saharan Africa, the amounts applied are insufficient to meet crop demands together with socio-economic and environmental factors aggravating this problem. Organic inputs are often proposed as alternatives to mineral fertilizers (Palm et al, 1997). Most soil fertility management in barley has been seen using inorganic fertilizers. For example, results at Holetta showed that the response to N and P application was significant on the Notosol (Hailu and Joop, 1996).

When the long-term carryover of compost is considered, even a onetime application may become economically viable. Studies have shown that a one-time compost treatment can result in increases in SOM, total N, P, K, and water infiltration many years beyond the initial application year (Butler and Muir 2006; Hartl et al. 2003; Ippolito et al. 2010; Reeve etal. 2012).

Compost is an organic fertilizer that can be made on the farm at low cost. In composting, unlike other organic fertilization process, the natural decomposition process in the soil can the ingredients such as crop residues and or animal manure, can be easily found around the farmer. In addition to that, composting do have an advantage on further improvement of manure quality i.e weed seed that might exist in the animal dung will lose their viability by composting process. Raussen (1997; 92) states that the weed seeds, that exist in the dung, will germinate in the moist compost and die there as a result of light shortage.

Wag and Lasta area is one the drought affected area in the country. According to the farming system characterization by EARO, 2000, chemical fertilizer usage is not a common practice, because farmers questioned the benefits of fertilizer. It burned their crop substantially reduce the yield especially during shortage of rain or early termination, harvest more yield from the unfertilized field under the same moisture condition, and further associated with crop failure. So that this proposal was initiated to select the best combination of compost and inorganic fertilizers for better yield of barley and soil chemical and physical properties improvement.

Materials and Methods

Geographic Location of the study Area

The study area is located in eastern part of the Amhara National Regional State; Wag-Lasta which is characterized by a unimodal rainfall pattern that extends from late June to late August or early September, where crops are cultivated in summer season. The mean annual rainfall varies from 333 to 1016 mm and the mean minimum and maximum annual temperatures were 8 and 21^{o}C, respectively. The major agro-ecological characteristics of this catchment are hot and warm sub-moist to semiarid lowland with tepid to cool sub-moist environment.

The general slope range on which the farmlands occur varies between 0 and 8%, but could be normally found on 0-25% slope range. The soil type is predominantly locked on alluvial deposits, well drained, light to dark brown in color, and with very shallow-to-shallow soil depth, sandy to sandy clay loam in texture, highly eroded and continuously cultivated, with rock outcrops of basalt and sandstone (Akundabweni, 1984). The study was conducted in 2008/9 and 2009/2010 cropping season on farmers field.

Compost Preparation

To make quality compost from locally available materials, the following procedures were followed: Wood ash, FYM, mixture of straws (collected from cattle feed waste) and maize Stover were collected from different sources and then the following Compost layering trend was followed:

- Two pits with 1m width, 1m length and 1m depth were dug for making compost and used rotationally every 21 days for inverting the compost material and able to get a uniformly decomposed material.
- Sorghum stover cuttings were put in the first layer to improve aeration of the pit. Mound up to 30 cm thick and sprinkled with water.
- Second layer of the mixture was of straws and FYM to about 15 cm and 9 cm thick, respectively and sprinkled with water.
- The next layer, wood ash, was added up to 3 cm thickness.
- 3 cm thick forest top soil was added. The soil contains an essential microorganism that helps in decomposition of fresh and semi-decomposed organic material.
- This layering was continued up to the top of the pit where it reached a meter depth.
- Finally the composting material was covered with grass to avoid moisture loss.

In every layer, water was sprinkled to keep the material moist and hasten the decomposition. Long stick was inserted at an angle of 45^o and removed and checked once a week to improve air circulation and checking for moisture and temperature variation. After one month the compost was turned into the other pit and it was matured within three months.

Field trial

The experiment was laid down in a randomized complete block design with three replications with a gross plot size of 22 m x 11 m. The experimental units were laid on a plot size of 4 m x 3 m.

The treatments were:

1. Control (no fertilizer)
2. Blanket recommendation (41 kg ha^{-1}N + 46 kg ha^{-1} P_2O_5)
3. 20.5 kg ha^{-1}N + 23 kg $ha^{-1}$$P_2O_5$ + 1 tonne compost
4. 13.7 kg ha^{-1}N + 15.3 kg $ha^{-1}$$P_2O_5$ + 3 tonnes compost with four levels of compost
5. 5 t ha^{-1}compost.

The compost was applied to treatment 3, 4 and 5 one month earlier to planting. All phosphorus was applied at planting barley and nitrogen was applied in split, half at planting and half at knee height.

Soil Analysis

From each treatment, disturbed (by using auger) soil samples were collected at a depth of 0-20 cm across the replications and composited to make one composite sample per treatment. The collected samples were air-dried and ground to pass through a 2 mm diameter sieve for laboratory analysis following the standard procedures.

Particle size: Bouyoucos Hydrometre Method (Bouyouces, 1962)

- Soil reaction (pH): pH meter, (Jackson,1958)
- Organic carbon: Walkely and Blank (1934)
- Electrical conductivity (ECe): conductivity meter ,
- Cation exchange capacity (CEC): NH_4^+-acetate method

Statistical Analysis

The data collected from the field study and soil laboratory analysis were subjected for analysis of variance (ANOVA) using SAS software. Whenever treatment effects were significant, mean separations were made using least significant difference (LSD).

Results and Discussions

Soil physical and chemical properties

The mean soil pH was 5.66 which is moderately acidic (Landon, 1991; Tekalign, 1991) with a mean CEC of 25.0. The mean soil organic matter content was 1.88% which is very low due to continuous cultivation, high rate of soil erosion and high temperature with moist and drained soil environment favoring organic matter decomposition than deposition (Table 1). The result is in agreement with Wakene *et al.* (2001) who reported a wide variation among the analyzed samples for organic matter.

Table 1: General selected soil chemical properties of the study areas.

Parameter	mean	mean square	CV %	F value	Pr>F
pH	5.66	0.0433	5.287	0.48	0.75
CEC	25.01	1.866	5.501	0.99	0.49
OM	1.88	1.166	17.21	11.12	0.0105

A significant improvement of organic matter was observed at Dahana wereda with the application of sole recommended N and P fertilizers over the other treatments which are attributed to high root biomass production and addition of organic matter from root decomposition (Table 2).

The overall analysis of variance indicated that there was a significant improvement of soil organic matter after the application of different rates of compost combined with inorganic fertilizers that basically differ from place to place (Table 2). Application of 5 tonnes compost ha^{-1} improved the organic matter status of the soil by 80% and 58% over the unfertilized plots at Lalibela and Dahana, respectively. This organic matter has advantage for CEC, water holding capacity and improvement in nutrient supply.

Table 2: Overall Treatment Effect on selected chemical property Status after the Crop Harvest

Location	Treatment	Depth (cm)	Texture	Mean value of chemical properties				
				pH	EC	CEC	%OC	%OM
Dahana	No fertilizer	0-20	Clay Loam	5.78	45.8	24.2	0.726	1.251
	41 N+ 46 P_2O_5	0-20	Clay Loam	5.60	53.3	26.6	1.265	2.181
	1t compost + 20.5 N+23 P_2O_5	0-20	Clay Loam	5.58	56.6	23	2.478	4.272
	13.7 N + 15.3 P_2O_5 + 3 ton compost	0-20	Clay Loam	5.46	74.5	26.4	1.257	2.168
	5ton compost	0-20	Clay Loam	5.11	139.4	25.6	0.880	1.517
Lalibela	No fertilizer	0-20	sandy clay loam	5.86	29.30	27	0.3235	0.557
	41 N+ 46 P_2O_5	0-20	sandy clay loam	5.79	46.70	25.4	0.7413	1.278
	1t compost + 20.5 N+23 P_2O_5	0-20	sandy clay loam	5.98	16.58	24	0.9357	1.613
	13.7 N + 15.3 P_2O_5 + 3 ton compost	0-20	sandy clay loam	5.53	55.90	24.2	1.5249	2.629
	5ton compost	0-20	sandy clay loam	5.94	43.00	23.8	1.6212	2.794

Responses to yield and yield components

There were treatment effects on barley yield across the years and locations (Table 3 and 4). One tonne compost + 20.5 kg ha^{-1} N + 23 kg ha^{-1} P_2O_5 gave significantly higher grain yields next to the recommended N and P (46 kg ha^{-1} P_2O_5 and 41 kg ha^{-1}N) compared to the other treatments in 2008 cropping season which is in consent with the result reported by Fanuel and Gifole (2012) and Edwards *et.al.* (2007). At Lalibela, the recommended nitrogen and phosphorus fertilizers gave the highest grain yield (1244.44 kg ha^{-1}), biomass (3458.33 kg ha^{-1}) and plant height (91.99 cm) compared to the treatments. Integrating compost with N and P had resulted in 48.6% yield penalty at Lalibela indicating that the combination effects vary from place to place. In similar year at Dahana, reverse results were obtained and the grain yield appreciated combined use of compost and inorganic fertilizers. 1 tonne compost with 20.5 kg ha^{-1} N + 23 kg ha^{-1} P_2O_5 gave a grain yield of 1694.44 kg ha^{-1}. On the other hand, biomass yield (6512.5kg ha^{-1}) and plant height at maturity (108.32cm) were favored by recommended N and P fertilizers (Table 3).

Table 3: Mean biomass and grain yield of five combinations evaluated at Lalibela and Dahana in 2007 cropping season.

Treatments	Lalibela			Dahana		
	Plant height at maturity	Biomass yield in kg^{-1}	Grain yield in kg ha^{-1}	Plant height at maturity	Biomass yield in kg ha^{-1}	Grain yield in kg ha^{-1}
41 kg N+ 46 kg P_2O_5	91.99[a]	3458.33[a]	1244.44[a]	108.32[a]	6512.5b[a]	1527.77[b]
1 t compost + 20.5 kg N+23 kg P_2O_5	70.50[cb]	1920[b]	597.22[b]	98.39[c]	6841.7[a]	1694.44[a]
13.7kg N + 15.3 kg P_2O_5 + 3 t compost	70.50[c]b	1690.06[c]	638.89[b]	105.92[b]	5908.3[c]	1524.44[b]
5 t compost	68.97[c]	1072.78[d]	447.22[c]	105.59[b]	6491.7[b]	1267.22[c]
No fertilizer	73.39[b]	795.28[e]	399.44[c]	93.09[d]	4908.3[d]	1205.00[d]
Mean	75.07	1788.89	665.44	102.26	6132.17	1443.78
CV	2.98	1.84	4.68	0.64	2.87	0.82

The second year results showed similar trend with that of the first year. At Lalibela the recommended N and P favored the plant height at maturity (73.62 cm), biomass yield (6316.39 kg ha^{-1}) and grain yield (2295 kg ha^{-1}) (Table 4). Relatively higher yield increments were observed as compared to year one by applying 1 tonne compost with half recommended N and P fertilizers (Table 4). In Dahana, the recommended N and P resulted in the highest grain yield (1508.33 kg ha^{-1}), biomass yield (5152.78 kg ha^{-1}) and plant height at maturity (91.49cm), followed by 1 tonne compost with half recommended N and P (Table 4).

Table 4: Mean biomass and grain yield of five combinations evaluated at Lalibela and Dahana in 2009 cropping season.

Treatments	Lalibela			Dahana		
	Plant height at maturity	Biomass yield in kg ha^{-1}	Grain yield in kg ha^{-1}	Plant height at maturity	Biomass yield in kg ha^{-1}	Grain yield in kg ha^{-1}
41 N+ 46 P2O5	73.62[a]	6316.39[a]	2295[a]	91.49[a]	5152.78[a]	1508.33[a]
1t compost + 20.5N+23 P2O5	54.62[b]	4579.44[b]	1545[b]	76.44[c]	3383.33[c]	989.72[b]
13.7N + 15.3 P2O5 + 3 ton	52.52[b]	2023.89[c]	727.78[c]	73.14[d]	4111.11[b]	903.61[b]
5tonne compost	51.72[b]	1945.83[c]	544.44[d]	80.74[b]	3444.44[c]	955.56[b]
No fertilizer	55.77[b]	1213.61[d]	336.67[e]	65.84[e]	1911.11[d]	675.00[c]
Mean	57.65	3215.83	1089.78	77.53	3600.55	1006.44
CV	8.57	1.32	3.30	0.70	1.67	6.03

The two years combined analysis over location indicated that using recommended N and P maximized the grain and biomass yields of barley (Table 5). Significant differences were observed among the treatments ($P < 0.05$) in plant height at maturity, biomass and grain yields (Table 5 and 6). From the combination, it was observed that one tonne compost + ½ recommended N and P gave significantly higher grain yield, biomass yield, and plant height at maturity (Table 5 and 6).

Table 5: Mean biomass and grain yield at Lalibela and Dahana combined over years (2007 and 2009) cropping season.

Treatments	Lalibela			Dahana		
	Plant height at maturity	Biomass yield in kg	Grain yield in kg	Plant height at maturity	Biomass yield in kg	Grain yield in kg
41 N+ 46 P2O5	82.80[a]	4887.36[a]	1769.72[a]	99.91[a]	5832.6[a]	1518.06[a]
1t compost + 20.5N+23 P2O5	62.56[b]	3249.72[b]	1071.11[b]	87.42[d]	5112.5[b]	1342.08[b]
13.7N + 15.3 P2O5 + 3 ton	61.51[b]	1860.97[c]	683.33[c]	89.53[c]	5008.9[b]	1214.03c[b]
5tonne compost	60.34[b]	1509.31[d]	495.83[d]	93.16[b]	4968.1[b]	1111.39[c]
No fertilizer	64.56[b]	1004.44[e]	368.06[e]	79.46[e]	3409.7[c]	940.00[d]
Mean	66.36	2502.36	877.61	89.80	4866.36	1225.11
CV	6.62	2.61	8.60	1.53	4.57	9.80

Table 6: Mean biomass and grain yield of five combinations evaluated at Lalibela and Dahana combined over years and locations.

Treatments	Plant height at maturity	Biomass yield kg/ha	Grain yield kg/ha
41 N+ 46 P2O5	91.36[a]	5360.0[a]	1643.89[a]
1t compost + 20.5N+23 P2O5	74.98[b]	4181.1[b]	1206.6[b]
13.7N + 15.3 P2O5 + 3 tonne	76.75[b]	3238.7[c]	803.61[d]
5tonne compost	75.52[b]	3134.7[c]	948.68[c]
No fertilizer	72.02[c]	2207.1[d]	654.03[e]
Mean	78.12	3684.36	1051.36
CV	3.33	7.93	10.66

Conclusions and Recommendations

In general, recommended nitrogen and phosphorus rates gave higher yield as compared to the combinations of compost with N and P fertilizers. However, compost has additional advantage to yield increment i.e. it builds up the physical and chemical properties of soils. The rainfall in the dry land areas is erratic, unpredictable and crop failures were common. Due to the low moisture, application of N and P fertilizers alone is a risk enterprise. Hence, combination of compost and N and P fertilizers was the best option. One tonne compost with half recommended N and P gave a comparable grain and biomass yields to the full recommended N and P in addition to improving soil physical and chemical properties through time. Hence, based on the economic background of the farmers (their poor fertilizer purchasing capacity), half recommended N and P (20.5 N and 23 P_2O_5) + 1 tonne compost is recommended for Wag and Lasta highland area and similar agro-ecologies growing barley.

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