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# Evaluation of Alternative Soil Amendments and Response to Bread Wheat (Triticum aestivum) Productivity in Ada'a District, Central Highlands of Ethiopia

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**Abstract**
Field experiment was conducted during 2014 main cropping season in Ada'a district, central highlands of Ethiopia to evaluate the impacts of soil fertility amendments on the productivity of bread wheat. Relevant agronomic traits were recorded from each plot. The amendments included solo and combined application of compost, bio slurry and inorganic fertilizers including control field with three replication. The wheat variety used for the study was Kekeba. The design was randomized complete block and to compute the numerical data, SPSS software was used. The agronomic analysis results revealed that there was a significant difference ($P<0.001$) in all the agronomic traits. The highest plant height, spike length, spikelet spike$^{-1}$ and 1000 grain weight were obtained from the application of compost at the rate of 64.4 N & 46 kg P ha$^{-1}$ along with inorganic fertilizer at the rate of 98.5 N & 46 kg P ha$^{-1}$ while the highest grain yield and biomass yield were obtained from the application of 96 N & 69 kg P ha$^{-1}$ inorganic fertilizers. The lowest grain yield and biomass yield were obtained from control field. Therefore, it can be concluded that combined application of dry matter compost along with inorganic fertilizers can be an option for wheat production in the study area.
**Keywords:** Dry matter compost, Dry matter bio Slurry, Inorganic Fertilizers, Amendments, Wheat Productivity, Vertisols, Ada'a district, Central Ethiopia

## 1. Introduction

Agriculture contributes for more than 46% of the GDP and 90% of the export earnings, and supports 85% of the labor force of Ethiopia (MOFED, 2005). The current development strategy of Ethiopia is Agricultural Development Led Industrialization (ADLI). This strategy has been adopted since 1994/95 and focuses on productivity improvement of smallholder's agriculture through diffusion of fertilizers, improved seeds and setting up credit schemes. However, soil fertility decline and accompanied low level of agricultural production have been voiced to be still among the serious challenges of the strategy (MOARD, 2008).

Wheat (*Triticum aestivum L.*) is one of the important grain crops produced worldwide. Wheat is one of the most important cereals cultivated in Ethiopia. It ranks 4$^{th}$ after Tef (*Eragrostis tef*), Maize (Zea mays) and Sorghum (Sorghum bicolor) in area coverage and 3$^{rd}$ in total production (CSA, 2007).

In Ethiopia, it is largely grown in the mid and highlands of the country and constitutes roughly 10% of the annual cereal production and plays an appreciable role in supplying the population with carbohydrates, protein and minerals (Schulthess *et al.,* 1997). The crop is grown well at an altitude ranging from 1500 to 3000 masl while the most suitable agro ecological zones falls between 1900 and 2700 masl. Accordingly, the major wheat producing areas in Ethiopia are located in Arsi, Bale, Shewa, Ilubabor, Western Hareghe, Sidamo, Tigray, Northern Gonder and Gojam zones (Bekele *et al.,* 2000). Wheat in the study area is the 3$^{rd}$ important crop in terms of total production after *tef* and chickpea (Bogale, 2014).

At a country level, wheat shows an increasing trend in terms of area coverage which is about 2.56 million ha (CSA, 2008). However, its productivity (1.17 tons ha$^{-1}$) is very low due to poor soil fertility and crop management practices. Moreover, farmers who have the experience and resources to prepare compost and bio slurry often manage to have much less than the amount required (Getachew and Taye, 2005).

Dry matter compost and bio slurry are valuable organic amendments for agricultural soils. The most common inorganic fertilizers used in Ethiopia for cereal production are Urea and DAP. Continuous application of these fertilizers may intensify the depletion of important soil nutrients that may not appear with these inorganic fertilizers and may increase soil acidy. Inorganic fertilizers are also costly for farmers to apply as much as the required amount for optimum level of production. In contrast, sole application of compost and bio slurry may be constrained because of lack of access to these amendments, low nutrient content and high labor demand for preparation and transportation to farming field. Thus, the integrated use of inorganic fertilizers and locally available soil amendments are assumed to be the best approach for achieving higher fertilizer-use efficiency, improve crop yield and economic feasibility (Getachew *et al.,* 2012).

Recent studies indicated that the interaction effect between combined inputs and practices can provide almost double the crop yield benefits compared to fertilizers applied separately (Getachew and Taye, 2005; Våje, 2007; Dercon and Hill, 2009). It is often believed that ISFM based crop production systems plays an important roles in restoring soil fertility, availability of plant nutrients, enhancing crop growth and productivity (Vanlauwe *et al.,* 2010; Gete *et al.,* 2010).

The objectives of the paper are: (1) to compare the effect of solo and combined application of compost, bio slurry, Nitrogen and P fertilizers on the production of bread wheat, and (2) to determine the optimum rates of fertilizer application from the perspectives of increased bread wheat production in Ada'a district of central highlands of Ethiopia.

## 2. Materials and methods

### 2.1 The study area

On farm experiment was conducted in the 2014 cropping season on a vertisols of Ada'a district of central highlands of Ethiopia which is situated $8^0$ 32' 30"- $8^o$ 57' 30" N & $38^o$ 47' 30"- $39^o$ 12' 30" E (Fig.1). The study area covers 89,430 ha and its altitude ranges from 1780 - 2804 masl. The district is characterized by Dega and Weyena dega agro climatic zone. In the period of 50 years (1964-2014), the study area has witnessed wet season from March to September with mean monthly rainfall varying from 2.5 to 209.8 mm with a total annual average of 818.3 mm. The mean annual temperature of the district ranges from 16.4 $^0$C to 19.8 $^0$C and the hottest months are April and May (Fig. 2).

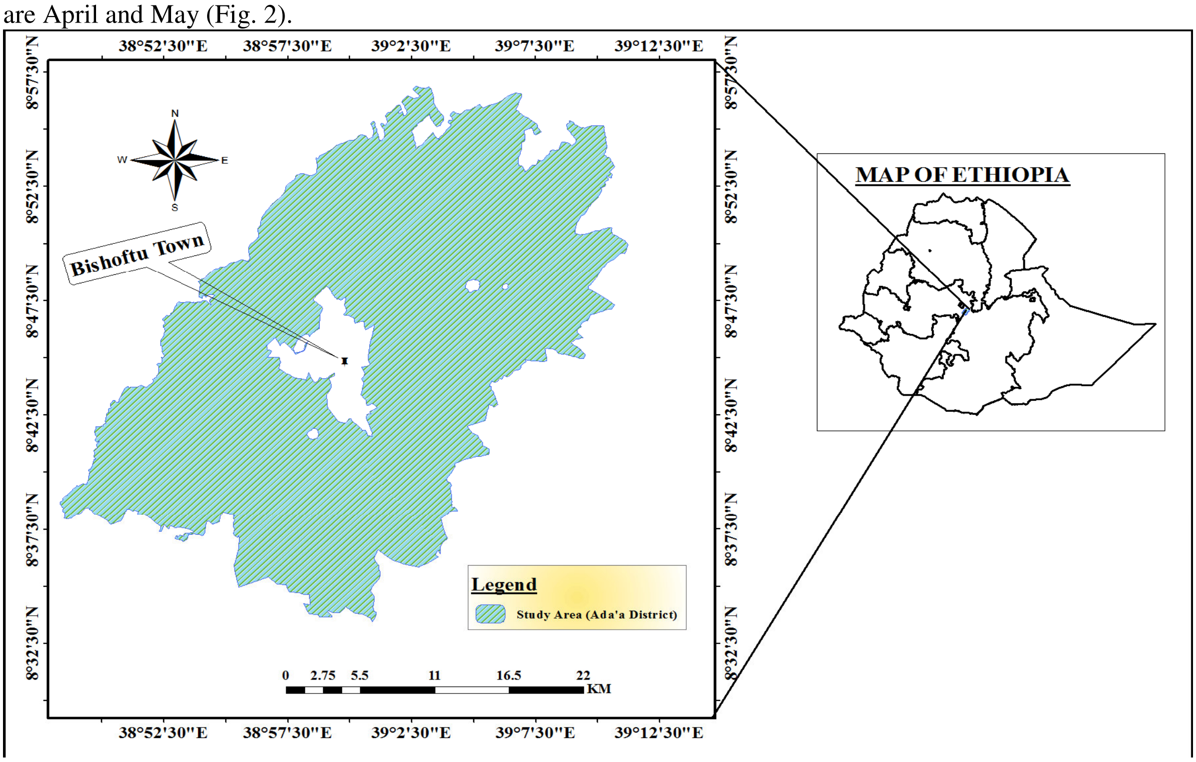



Fig. 1. Location map of Ada'a district, Ethiopia

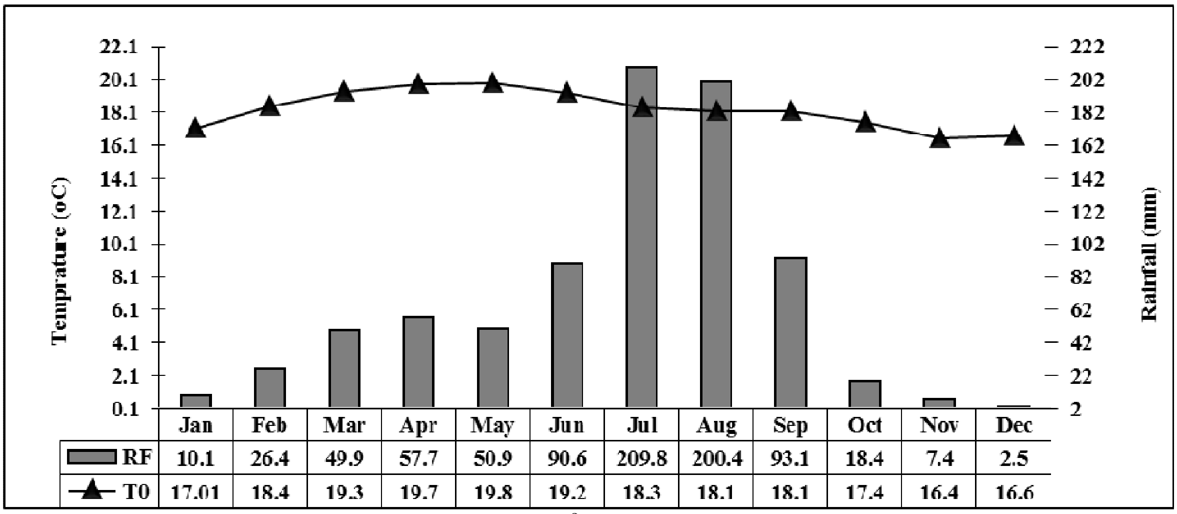
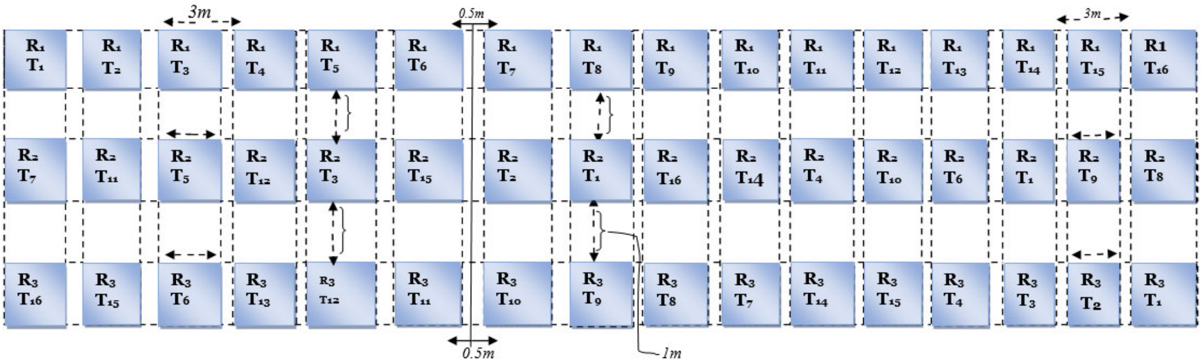


Fig. 2. Mean monthly rainfall (mm) and temperatures (°C) of the study area, 2015

## 2.2 Experimental Design and Field layout

The experiment was laid out in Randomized Complete Block Design (RCBD) having 3 replication and each replication has 16 plots with a total numbers of 48 plots. The net plot area measured 3.0 m x 3.0 m (9.0 $m^2$). Spacing between replication was 1.0 m with 0.5 m between plots. The experiment comprised 6 amendments; dry matter bio slurry, dry matter compost, inorganic fertilizer, dry matter bio slurry + inorganic fertilizer, dry matter compost + inorganic fertilizer and control. The amendment combinations and the field layout are shown in Fig.3.




T1-T3= Bio slurry; T4-T6= Compost; T7-T9= inorganic Fertilizer; T10-T12= Bio slurry + Inorganic Fertilizer; T13-T15= Compost + Inorganic Fertilizer; T16= Control
Fig. 3. Amendment combinations and field layout

**Table 18. Amendments and their rates of application**

| Treatments | Replicates | Rate of application |
|---|---|---|
| $T_1$ | 3 | 9800 kg $ha^{-1}$ dry matter bio Slurry[1] (64 N & 46 P kg $ha^{-1}$) |
| $T_2$ | 3 | 4900 kg $ha^{-1}$ dry matter bio Slurry (32 N & 23 P kg $ha^{-1}$) |
| $T_3$ | 3 | 14300 kg $ha^{-1}$ dry matter bio Slurry (96 N & 69 P kg $ha^{-1}$) |
| $T_4$ | 3 | 9200 kg $ha^{-1}$ dry matter compost[2] (64 N & 46 P kg $ha^{-1}$) |
| $T_5$ | 3 | 4600 kg $ha^{-1}$ dry matter compost (32 N & 23 P kg $ha^{-1}$) |
| $T_6$ | 3 | 13800 kg $ha^{-1}$ dry matter compost (96 N & 69 P kg $ha^{-1}$) |
| $T_7$ | 3 | 100 kg Urea and 100 kg DAP fertilizer (64 N & 46 P kg $ha^{-1}$) |
| $T_8$ | 3 | 50 kg Urea & 50 Kg DAP fertilizer (32 N & 23 P kg $ha^{-1}$) |
| $T_9$ | 3 | 150 kg Urea & 150 kg DAP fertilizer (96 N & 69 P kg $ha^{-1}$) |
| $T_{10}$ | 3 | 4900 $kg^{-1}$ dry matter bio slurry (32 N & 23 P kg $ha^{-1}$) + inorganic fertilizer (32 N & 23 P kg $ha^{-1}$) |
| $T_{11}$ | 3 | 7350 kg $ha^{-1}$ dry matter bio slurry (48 N & 34.5 P kg $ha^{-1}$) + inorganic fertilizer (145 N & 82.5 P kg $ha^{-1}$) |
| $T_{12}$ | 3 | 9800 kg $ha^{-1}$ dry matter bio slurry (63.7 N & 46 P kg $ha^{-1}$) + inorganic fertilizer (93 N & 46 P kg $ha^{-1}$) |
| $T_{13}$ | 3 | 4600 kg $ha^{-1}$ dry matter compost (32 N & 23 P kg $ha^{-1}$) + inorganic fertilizer (48.6 N & 23 P kg $ha^{-1}$) |
| $T_{14}$ | 3 | 6900 kg $ha^{-1}$ dry matter compost (34.5 N & 34.5 P kg $ha^{-1}$) + inorganic fertilizer (73 N & 34.5 P kg $ha^{-1}$) |
| $T_{15}$ | 3 | 9200 kg $ha^{-1}$ dry matter compost (64.4 N & 46 P kg $ha^{-1}$) + inorganic fertilizer (98.5 N & 46 P kg $ha^{-1}$) |
| $T_{16}$ | 3 | 0 kg $ha^{-1}$ (Control) |

## 2.3 Land preparation, sowing and harvesting

The experimental field was prepared by using local plough called *Maresha*. Accordingly, the field was plowed

[1] *Dry matter bio-slurry with 0.0065 and 0.0047, N & P-contents respectively.*
[2] *Dry matter compost with 0.0070 and 0.0050, N & P-contents respectively.*

four times; the 1st ploughing was done at the beginning of May, the 2nd plowing was at the middle of May, the 3rd ploughing was at the middle of June and the final was accompanied on 23 July 2014 and amendment was conducted within the same date. Harvesting was undertaken on 12 November 2014 and finally threshing time was on 26 November 2014.

The seed was bought from the surrounding smallholder farmers of Adana district. The tested variety used in the study was improved bread wheat variety (Kekeba); widely grown by smallholder's farmers of the study area.

Dry matter bio slurry was obtained through the outlet of biogas digesters of cattle dung which was already installed in Kumbursa village of Ada'a district. Fine grained compost was obtained from the surrounding farmers. Then, both bio slurry and compost were weighed according to the treatment plan and applied before five days sowing of wheat seed (Fig. 4).

Fig. 4. Application of compost (left) and bio slurry (right) before five days sowing of wheat seed

**2.4 Data collection**

Yield and yield components of bread wheat were collected from each plot using the following procedures:

**Plant height (PH):** For the experiment on wheat, plant height was measured at maturity stage, from ten random plant samples of the harvestable rows, from the ground level to the tip of the spike including the awns using a measuring tape.

**Spike length (SL):** Spike length was measured by calculating the average spike length of ten random plant samples in the harvestable rows, following the measurement from its base to the tip excluding awns.

**Number of spikelet's per spike (NSPS):** The number of spikelet in each spike of the ten randomly selected plants of each plots was counted at the crop maturity and average was calculated.

**Number of tillers per plant (NTPP)**: Total tillers for randomly selected plants were counted at the time of maturity and averaged plant$^{-1}$ was calculated.

**Thousand Grain Weight (TGW):** Grain weight of thousand seeds sampled at random from total grain harvest of the experimental plot was recorded on analytical balance expressed in gram/kg.

**Total Biomass yield (TBY) (kg ha$^{-1}$):** Biomass or biological yield was measured by weighing the total above ground plant biomass within each central rows of 1m$^2$.

**Grain yield (kg ha$^{-1}$):** All the grain received from each plot was weighed and on the basis of grain yield plot$^{-1}$, grain yield ha$^{-1}$ was calculated in kilograms as per the following formula:

$$\frac{\text{Grain yield plot (kg)}}{\text{Plot size } (m^2)} * 10{,}000$$

**Harvest Index (HI):** was calculated by dividing the weight of dry grain yield by the total dry biomass weight (TBY) (TBY = weight of harvested grain and residue);

$$HI = \frac{GY}{TBY} * 100$$

**2.5 Statistical analysis**

Data were subjected to analysis of variance (ANOVA) using Statistical Package for Social Science (SPSS Version-20) to evaluate the impact of amendment options and response to bread wheat production of the study area. Results were presented as means with LSD at 5% probability level (Steel *et al,* 1997). Pearson's simple linear correlation coefficient values were computed to examine the magnitude and direction of relationships among agronomic genotypes using the mean values.

## 3. Results and discussion

The major yield and yield components measured were plant height, spike length, number of productive tillers plant$^{-1}$, number of spikelet's spikes$^{-1}$, grain yield m$^{-2}$ or ha$^{-1}$, total biomass yield, 1000 grain weight and harvest index. Results showed all genotypes of wheat were significantly ($p<0.001$) affected by the application of different amendment options.

### Plant height

Plant height is not a yield component especially in grain crops but it indicates the influence of various nutrients on plant metabolism. For the experimental plots, plant height was measured at maturity stage, from ten random plant samples of the harvestable rows, from the ground level to the tip of the spike including the awns using a measuring tape. Plant height was significantly influenced ($P<0.001$) due to the application of soil fertility amendment levels.

All amendments containing dry matter bio slurry caused an increase in plant height ranging from 2 to 9 % over control at maturity stage. The maximum plant height (87 cm) was observed on the application of dry matter bio slurry at the rate of 14300 kg ha$^{-1}$ (96 N & 69 kg P ha$^{-1}$) in T3 while in the application of dry matter compost, the maximum plant height (87.6 cm) at the maturity stage was obtained from 13800 kg ha$^{-1}$ (96 N & 69 kg P ha$^{-1}$) compost in T6. With regarding of inorganic fertilizer application, the lowest (80 cm) plant height was recorded from inorganic fertilizer at the rate of 50 kg urea and 50 kg DAP (32 N & 23 kg P ha$^{-1}$) in T8 and the highest plant height (96 cm) was recorded from the application of inorganic fertilizer at the rate of 150 kg urea and 150 kg DAP (96 N & 69 P kg ha$^{-1}$) in T9.

Across all rates of amendment, the tallest plant height (103.3 cm) of wheat at the maturity stage was recorded from the application rate of 9200 kg ha$^{-1}$ compost (64.4 N & 46 kg P ha$^{-1)}$ plus fertilizer (98.5 N & 46 kg P ha$^{-1}$) in T15 as compared with other applications. Tallest plant might be due to the application of balanced application of amendments with improved methods, while other application may be the more wastage of amendments with decreased availability to crops plant.

Comparative analysis of dry matter compost and bio slurry indicates that effect of compost with fertilizer showed better results on plant height than control and even than bio slurry plus inorganic fertilizer amendment.

Thus, the application of dry matter compost along with inorganic fertilizer is the recommended option in the trial plots followed by application of dry matter bio slurry along with inorganic fertilizer, solo inorganic fertilizer, dry matter compost and bio slurry, respectively. The increase in plant height on the application of dry matter compost in combination with inorganic fertilizer was in line with the results reported by Sarwar *et al.* (2007).

Similarly, the findings of Getachew *et al*. (2008) indicated that wheat plant height tended to increase in the mixed application of organic and inorganic fertilizers as compared to sole application of inorganic fertilizer. Jagadeeswari and Kumaraswamy (2000) also noted that the use of composts along with inorganic fertilizer increased yield and production of wheat. The second largest plant height (102 cm) was recorded with the application dry matter bio slurry along with inorganic fertilizer in T12 while the shortest plant height (78 cm) was recorded from the control plots in T16 (Fig. 5). This indicates that dry matter compost along with inorganic fertilizer in T15 showed a remarkable impact on the plant height of bread wheat in the study area.

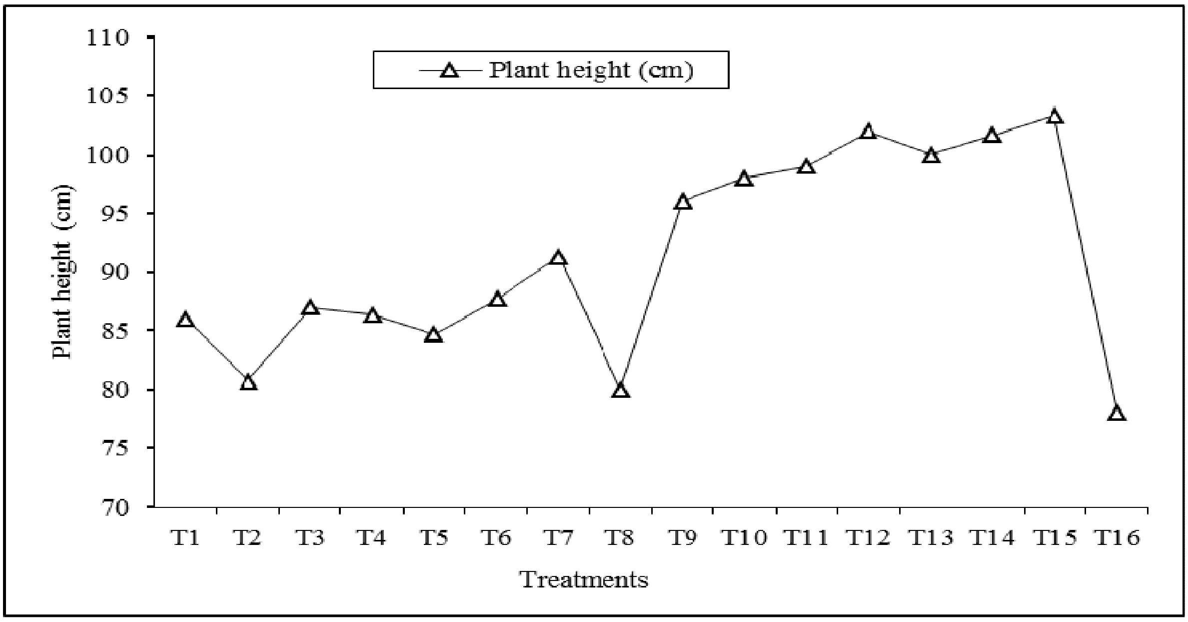



Fig. 5. Effects of amendments on the plant height of wheat

**Spike Length**

Spike length or ear size is among the major yield components of wheat that can affect its productivity. Ear size is considered as a yield contributing factor because larger spikes have more grains as compared to shorter ones which ultimately leads towards better grain yield. Spike length was measured by calculating the average spike length of ten random plant samples in the harvestable rows, following the measurement from its base to the tip excluding awns. Spike length of the tested crop was statistically significantly at 0.01% probability level (P<0.001) with the application of soil fertility amendment options. Accordingly, the largest spike length resulted from dry matter bio slurry was 8 cm followed by 7.67 and 7.33 cm that obtained from 64 N & 46 kg P ha$^{-1}$, 96 N & 69 kg P ha$^{-1}$ and 32 N & 23 kg P ha$^{-1}$ in T1, T2, and T3, respectively while the largest spike length as a result of dry matter compost application was 8 cm in T4 and T6.

In the application of inorganic fertilizer, the largest spike length was 9 cm in T7, 8.33 cm in T9 and 7.33 cm in T8. Similarly, the largest spike length (9 cm) as a result of inorganic fertilizer was obtained in T7 with the application of 100 kg urea and 100 kg DAP fertilizer (64 N & 46 kg P ha$^{-1}$) followed by 8.33 and 7.33 cm with the application of 150 kg urea and 150 kg DAP (96-69 kg ha$^{-1}$ inorganic) and 50 kg urea and DAP fertilizer (32 N & 23 kg P ha$^{-1}$ inorganic) in T9 and T8 respectively.

The evident from the data that numerically the largest average spike length (9.67 cm) was produced from the application of dry matter compost along with inorganic fertilizer in T15. However, the smallest spike length (6.67 cm) was recorded in T16 (control plot). Almost similar findings were described by Alam *et al.,* 2003. This indicated that compost gave outstanding results when applied along with inorganic fertilizer (Fig. 6).

**Number of productive tillers**

Number of tillers m$^{-2}$ in wheat crop is one of the most important agronomic component that can be considered for enhancing wheat productivity. Total tillers for randomly selected plants were counted at the time of maturity and averaged plant$^{-1}$ was calculated. The response of bio slurry, compost and different levels of inorganic fertilizer on number of productive tillers per plant is shown in Fig. 6. The data clearly showed that application of bio slurry and compost with different level of inorganic fertilizer statistically significantly affected the number of productive tillers per plant at significant level of 0.1 (p<0.001). Experimental results showed that the highest number of tillers (9.0) was produced with the solo application of inorganic fertilizer in T9, combined application of dry matter bio slurry along with inorganic fertilizers at all rates of T10, T11, T12 and application of dry matter compost with inorganic fertilizer in T13 and T14 while the second highest number of tillers (8.67) was produced by the application of dry matter bio slurry in T1. The smallest productive tiller (5.0) was recorded from the control plot in T16 (Fig. 6).

Therefore, application of dry matter bio slurry plus inorganic fertilizers in all three levels, inorganic fertilizer at the maximum rate (Table 1) and application of dry matter compost along with inorganic fertilizer in T13 and T14 are the recommended rate of amendment options that produce maximum numbers of tillers per plant in the study area. These results are directly in line with the finding of Hussain *et al,* (2008). Similarly, dry matter bio slurry along with inorganic fertilizer overall showed better results than other amendments in number of productive tillers. Rehman *et al.* (2008) also reported that application of compost along with inorganic fertilizer leads maximum productive tillers. Muhammad (2011) also reported that application of dry matter bio slurry along with inorganic fertilizer resulted maximum numbers of productive tillers than any other amendments.

**Number of Spikelet's per spike**

The number of spikelet per spike of the ten randomly selected plants of each plot was counted at the crop maturity and average was calculated. Effect of dry matter bio slurry and compost in the presence of variable rates of inorganic fertilizers and its integration on number of spikelet per spike is shown in Fig. 6. The data clearly indicated that the application of dry matter bio slurry and compost with different levels of inorganic fertilizer significantly ($p<0.001$) affected the number of spikelet per spike per plot.

From the applied dry matter bio slurry rate, the highest spikelet per spike (16.33) was obtained from the application dry matter bio slurry at the rate of 96 N & 69 kg P $ha^{-1}$ in T3 followed by 32 N & 23 P kg $ha^{-1}$ in T2 that resulted the second number of spikelet per spike (16) while in the application of dry matter compost, the largest spikelet per spike was 16.33 followed by 16 and 14.33 that resulted from the application of compost at the rate of 96 N & 69 kg P $ha^{-1}$ in T6, 64 N & 46 kg P $ha^{-1}$ in T4 and 32 N & 23 kg P $ha^{-1}$ in T5, respectively. Similarly, the highest number of spikelet per spike (17) was obtained from the application of inorganic fertilizer at the rate of 64 N & 46 kg P $ha^{-1}$ in T7 followed by 16.67 and 14.67 numbers of spikelet per spike under the application rate of 96 N & 69 kg P $ha^{-1}$ and 32 N & 23 kg P $ha^{-1}$ in T9 and T8, respectively. Here, it can be recapped that, instead of using 96 N & 69 P kg $ha^{-1}$ to increase the number of spikelet per spike in the study area, it is better to use 64 N & 46 kg P $ha^{-1}$ otherwise, wastage of nutrient will happen.

From the observed result, the influence of dry matter compost application along with various levels of inorganic fertilizers on the number of spikelet's $spike^{-1}$ was significantly higher than other amendment options. The inorganic fertilizers application along with dry matter compost in T14 and T15 resulted in the highest number of spikelet's $spike^{-1}$ (18) while relatively the number of spikelet's $spike^{-1}$ was lower (13.67) under control plot in T16. The findings of Muhammad (2011) outsmarted this study in such a way that the application of compost along with inorganic fertilizer leads to maximum numbers of spikelet per spike.

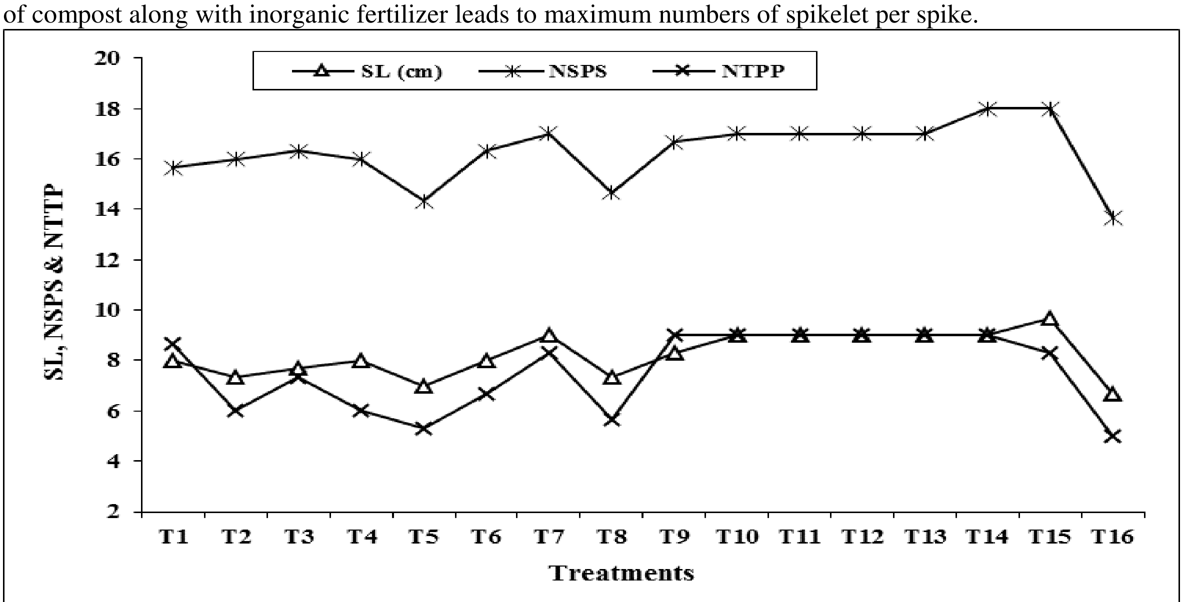



Fig. 6. Effects of amendments on the spike length, no. of spikelet $spike^{-1}$ and productive tillers $plant^{-1}$.

**Grain yield**

Grain yield is the final result that can be studied through its yield components. All the grain obtained from each plot was weighed and on the basis of grain yield $plot^{-1}$, grain yield $ha^{-1}$ was calculated in kg $ha^{-1}$ or Qt $ha^{-1}$. The effect of various amendment levels applied on grain yield $gm^{-2}$ was significant at 0.1% probability level ($p<0.001$). The highest grain yield under the application of dry matter bio slurry was 59.67 that obtained from 64 N & 46 kg P $ha^{-1}$ in T1 followed by 57.67 and 48.67 Qt/ha that obtained 96 N & 69 kg P $ha^{-1}$ in T3 and 32 N & 23 kg P $ha^{-1}$ in T2, respectively. Regarding to the effect of dry matter compost, the highest grain yield was 57 Qt/ha in T6 followed by 51.33 in T4 and 39.33 in T5. Under the inorganic fertilizers application, the highest grain (69.67 Qt/ha) was registered from the application of 96 N & 69 P kg $ha^{-1}$ in T9 followed by 56.67 Qt/ha in T7 and 43.3 Qt/ha from T8. The grain yield value of bread wheat under 96 N & 69 P kg $ha^{-1}$ in T9 was the highest (696.67 $gm^{-2}$ which is 69.67 Qt/ha) among the applications and followed by grain yield of 666.67 $gm^{-2}$

or 66.67 Qt/ha recorded in the application of dry matter compost along with inorganic fertilizers in T15. Similar findings of Getachew *et al* (2012) revealed that inorganic fertilizer has an immediate benefit, but from a natural resource management point of view, efficient management and utilization of organic nutrient sources and the required inorganic fertilizers in correct balance may contribute to longer-term sustainability of agricultural productivity and an integrated farming system in the highlands of Ethiopia.

However, the lowest grain yield (260 $gm^{-2}$ or 26 Qt/ha) was obtained under control field in T16 (Fig.7). In the experiment, grain yield in control plots were low and steadily declined (Bationo *et al.,* 1993).

**Total biomass yield**

Biomass or biological yield was measured by weighing the total above ground plant biomass within each central rows of $1m^2$. The total above ground biomass of the crop was statistically significance at 0.1% probability level (P<0.001). The highest total biomass yield as a result of dry matter bio slurry application was 135.00 Qt/ha in T1 followed by 130.67 and 120 Qt/ha in T3 and T2 respectively while with the application of dry matter compost, the highest biomass yield was 136.67 Qt/ha in T6 followed by 122.33 and 89.67 Qt/ha in T4 and T5 respectively. Similarly, with the application of inorganic fertilizer, the highest total biomass yield was 158 Qt/ha in T9 followed by 137 and 120 Qt/ha in T7 and T8 respectively. Relatively the highest dry biomass yield (1580 $gm^{-2}$) was obtained due to the application of inorganic fertilizer in T9 followed by the application of dry matter compost along with inorganic fertilizer in T15 that resulted 1576.7 $gm^{-2}$ or 157.67 Qt/ha while the lowest dry biomass yield (880 $gm^{-2}$ or 88 Qt/ha) was obtained from the control field in T16 (Fig. 7).

Increased biomass production with increasing rates of dry matter compost and inorganic fertilizers was observed. Highly significant and positive correlations of total above ground biomass with grain yield (r =0. $952^{**}$), spike length (r = $0.819^{**}$), number of spikelet $spike^{-1}$ (r = $0.877^{**}$), plant height (r = 0. $832^{**}$), numbers of tillers (r = $0.853^{**}$), TGW (r =0. $468^{**}$) and harvest index (r = 0. $496^{**}$) were recorded (Table 4).

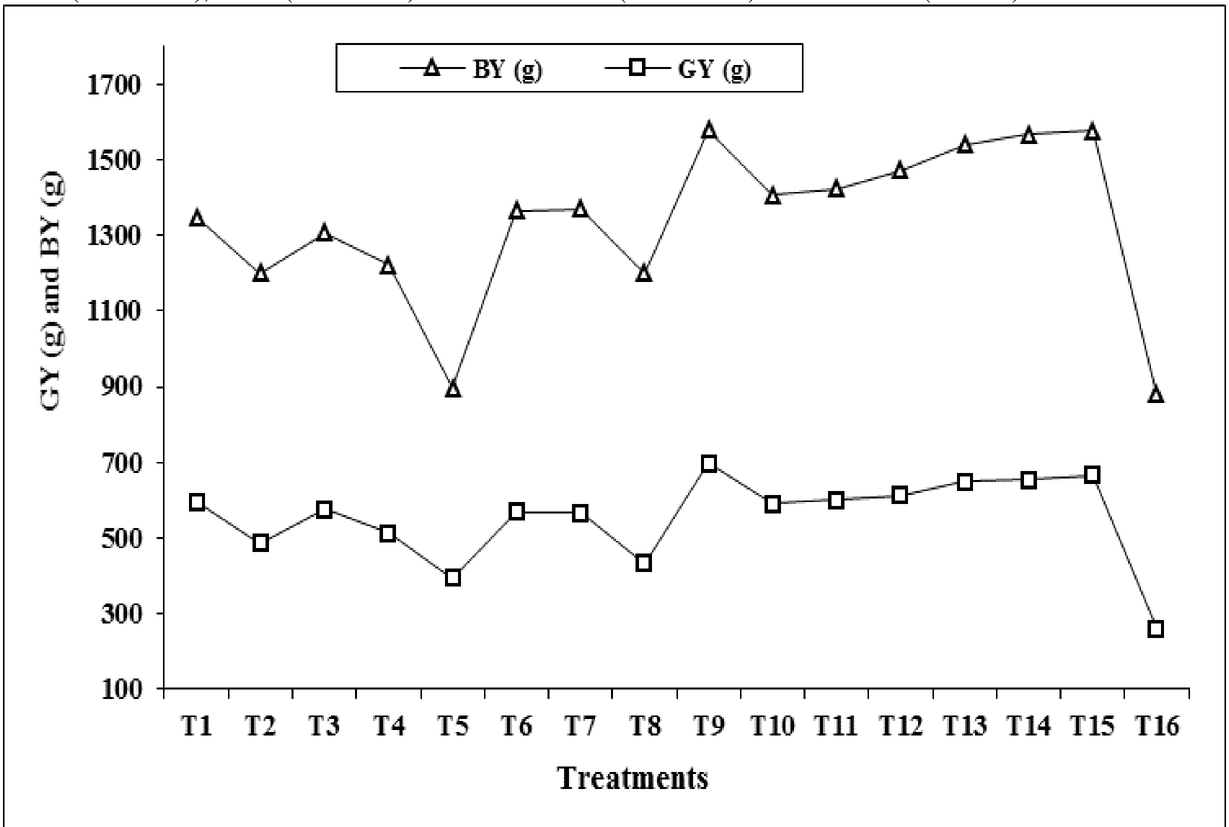



Fig. 7. Effects of treatments on the biomass yield (BY) and grain yield (GY) of Wheat

**Thousand Grain Weight**

Grain weight of thousand seeds sampled at random from total grain harvest of the experimental plot was recorded on analytical balance expressed in gram. TGW is an important agronomic trait of which have positive correlation with grain yield. More the TGW ultimately enhanced grain yield will be obtained. Means concerning the comparative effect of bio slurry and compost with different levels of inorganic fertilizer on TGW is presented in Fig. 8.

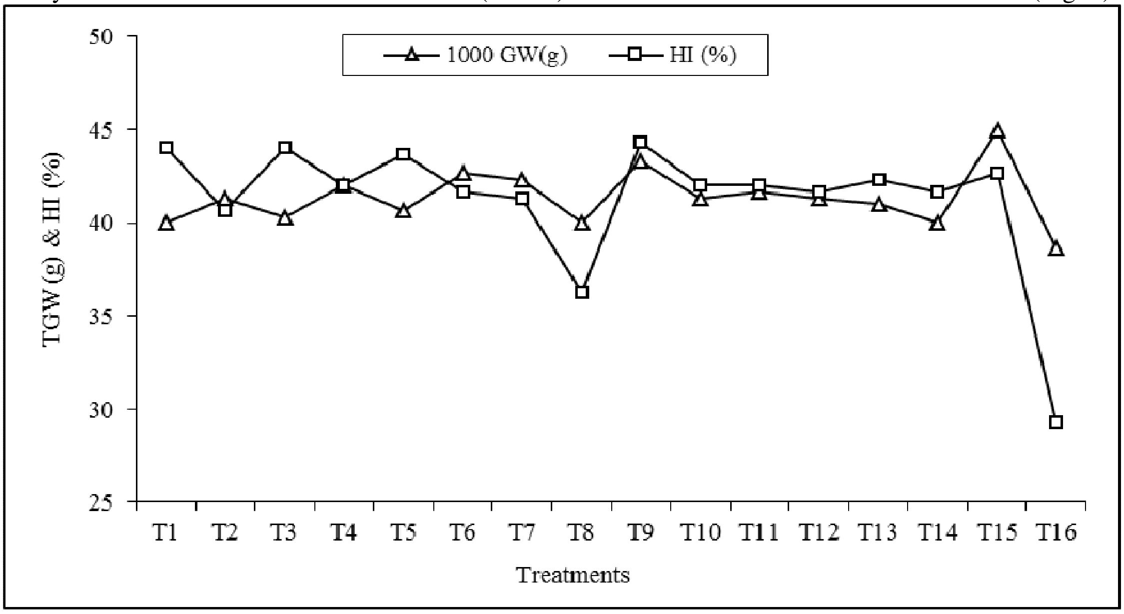
Means concerning the comparative effect of bio slurry and compost along with different levels of inorganic fertilizers on TGW is explored by Fig. 8. Based on the result of variance analysis, 1000 grain weight of the tested crop was significant at 0.1 % probability level (P<0.001). In the application of dry matter bio slurry options, the highest TGW (41.33 $gm^{-2}$) was obtained from the rate of 32 N & 23 kg P $ha^{-1}$ in T2 followed by 40.33 and 40.0 $gm^{-2}$ TGW resulted from 96 N & 69 kg P $ha^{-1}$ in T3 and 64 N & 46 kg P $ha^{-1}$ in T1, respectively. Here, it can be concluded that using the minimum rate is better than the other two options to improve TGW of wheat in the study area otherwise, using the two indicated dry matter bio slurry option is not economical. Regarding the effect of dry matter compost application on the TGW, the highest TGW was registered from the application of compost 96 N & 69 kg P $ha^{-1}$ in T6 that resulted 42.67 $gm^{-2}$ followed by 42 and 40.67 $gm^{-2}$ obtained from the application of compost 64 N & 46 P kg $ha^{-1}$ and 32 N & 23 kg P $ha^{-1}$ in T4 and T5, respectively. Concerning, the application of inorganic fertilizers, the maximum TGW (43.33 $gm^{-2}$) was obtained from the 96 N & 69 kg P $ha^{-1}$ in T9 followed by 42.33 and 40 $gm^{-2}$ that obtained from 64 N & 46 kg P $ha^{-1}$ and 32 N & 23 kg P $ha^{-1}$ in T7 and T8 respectively. Therefore, using the maximum rate of inorganic fertilizer to increase TGW of the wheat in the study area is the best option.

Relatively, the application of inorganic fertilizers along with dry matter compost in T15 resulted in the maximum TGW ( 45 $gm^{-2}$) followed by 43 $gm^{-2}$ observed under T9 of inorganic fertilizers rate while 1000 grain weight value was comparatively lower (40 $gm^{-2}$) under T1, T8 and T14. However, the lowest TGW value (38.67 $gm^{-2}$) was observed under the control field in T16 (Fig. 8).

**Harvest index**

Harvest index (HI) was calculated as the ratio of grain yield to above ground dry biomass and significantly (p<0.001) affected by the amendments applied. The maximum HI that obtained with the application of dry matter bio slurry was 44% in both T1 and T2 while the minimum HI was recorded in T3. This result indicates that using the minimum rate of dry matter bio slurry as indicated in Table 1 is recommended to get more HI value in the study area. The maximum value of HI gained as a result of compost application was 43.67 % in T5 followed by 42 and 41.67 in T4 and T6 respectively.

Comparatively, the application of inorganic fertilizers at the rate of 96 N & 69 kg P $ha^{-1}$ in T9 resulted in the maximum HI (44.3 %) and the second HI value (44%) was recorded with the application of dry matter bio slurry in T1 while the minimum value of HI (29.3%) was obtained from the control field in T16 (Fig. 8).




Most of the indices obtained due to different combinations of organic and inorganic fertilizers rates ranged from 36 to 42%, which was in line with that of Mengel and Kirkby (1996), who reported that harvest indices of modern wheat cultivars normally range from 35 to 40 %.

Fig. 8. Effects of amendments on the 1000 grain weight and harvest index of Wheat

**Correlation among agronomic traits of bread wheat**

Correlation analysis between yield related traits and grain yield is presented in Table 4. The correlation analyses revealed that, there was a significant (P < 0.001) positive correlation between grain yield and yield related traits of bread wheat. Grain yield was significantly and positively correlated with plant height (r = 0.808**), spike length (r = 0.779**), numbers of spikelet $spike^{-1}$ (r = 0.871**), numbers of tillers (r= 0.850**), biomass yield (r = 0.952**), 1000 grain weight (r = 0.496**) and harvest index (r = 0.731**).

Similar research findings also indicated that grain yield is positively correlated with biomass, spike length, number of productive tillers and plant heights of barley and wheat (Getachew and Taye, 2005).

Table 4. Pearson's correlation matrix among yield traits and grain yield of bread wheat

| | PH (cm) | SL (cm) | SPS (No.) | TPP (No.) | BY (Qt/ha)) | GY (Qt/ha) | TGW (g) | HI (%) |
|---|---|---|---|---|---|---|---|---|
| PH (cm) | **1.00** | | | | | | | |
| SL (cm) | .879** | **1.00** | | | | | | |
| SPS (No.) | .839** | .821** | **1.00** | | | | | |
| TPP (No.) | .838** | .796** | .783** | **1.00** | | | | |
| BY (Qt/ha) | .832** | .819** | .877** | .853** | **1.00** | | | |
| GY (Qt/ha) | .808** | .779** | .871** | .850** | .952** | **1.00** | | |
| TGW (g) | .430** | .520** | .488** | .316* | .468** | .496** | **1.00** | |
| HI (%) | .449** | .408** | .554** | .496** | .496** | .731** | .389** | **1.00** |

*PH= Plant Height; SL= Spike Length; NSPS= Spikelet per Spikes; TPP= Tillers per Plant; BY= Biomass Yield; GY= Grain Yield; TGW= 1000 Grain Weight; HI= Harvest Index; Qt/ha: Quintal per hectare; ** and * indicate significant at P < 0.01 and P < 0.05 level, respectively*

## 4. Conclusions

The test crop used in the experimental plots was improved wheat variety (Pica flora), which was widely adopted and produced by the smallholder's farmers in the study area. Solo and combined application of dry matter bio slurry, compost and inorganic fertilizers were applied as integrated soil fertility amendment options. The design was randomized complete block with three replication. Surface soil samples (0-20 cm depth) were collected before and after amendment to determine the soil fertility status of the study area.

The lowest value of bulk density (1.40 g/cm$^3$), the highest organic carbon (1.41 %), total N (0.13 %), available P (41.82 mg kg$^{-1}$), available K (3.13 mg kg$^{-1}$) and exchangeable Ca (19.65 cmol (+) kg$^{-1}$), were obtained from the solo application of dry matter compost at the rate of 96 N & 69 P kg ha$^{-1}$ in T6. Exchangeable Mg (13.2 cmol (+) kg$^{-1}$) was obtained from solo application of dry matter compost at the rate of 64 N & 46 P kg ha$^{-1}$ in T4 while the highest values of exchangeable Na (0.34 cmol (+) kg$^{-1}$) was observed in the combined application of dry matter compost along with inorganic fertilizers at the rate of 63.7 N & 46 kg P ha$^{-1}$ plus 93 N & 46 kg P ha$^{-1}$ in T12 respectively. From the observed results, it can be concluded that, application of dry matter compost showed a remarkable result as a means of integrated soil fertility management option but the difference was statistically insignificant.

Therefore, it can be concluded that solo application of dry matter compost can be an alternative to soil fertility improvement while combined application of dry matter compost along with inorganic fertilizers can be an option for wheat production in the study area. The results of this experiment are expected to be reproducible in similar agro-ecologies and farming systems of the country.

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