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*Full Length Research Paper*

# Outcome of rich farmyard manure and inorganic fertilizers on grain yield and harvest index of hybrid maize (bh-140) at Chiro, eastern Ethiopia

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**Application of farmyard manure (FYM) alone or in combination with inorganic fertilizers helps in proper nutrition and maintenance of soil fertility in maize fields when applied at proper doses replenishing the most deficient macro and micro nutrients which in turn help in getting the highest grain yield and harvest index in hybrid maize varieties. The harvest index determines how many photosynthates are transformed into economic yield. It is the ratio of economic yields to biological yield. A study was conducted at the Haramaya University Chiro Campus to determine the effect of enriched FYM and inorganic fertilizers on grain yield of maize and harvest index. FYM was used either alone or in combination with inorganic fertilizers as follows: control (zero fertilizers and FYM), 10 tons/ha FYM, 8 tons/ha FYM and 25 kg/ha of (Nitrogen (N) + 20 kg/ha Potassium (P), 6 tons/ha FYM, 50 kg/ha N + 40 kg/ha P, 4 tons/ha FYM, 75 kg/ha N + 60 kg/ha P, 2t ons/ha FYM , 100 kg/ha N+80 kg/ha P 100 kg/ha N + 100 kg/ha P. The treatments were arranged in randomized complete block design with four replications from 2008 to 2010. Result from the combined analysis of variance on hybrid maize (BH-140) yield and harvest index over years showed the presence of no significant difference among treatments with 10 tons/ha FYM and 100 kg/ha N +100 kg P/ha ($p < 0.05$). The pooled analysis of variance over years also revealed the existence of no significant differences among Treatments 2, 6, and 7 viz (10 t/ha FYM + 0 N and P, 2 t/ha FYM and 100 kg/ha N + 80 kg/ha P and100 kg/ha N + 100 kg/ha P), respectively at ($p < 0.05$) on grain yield of hybrid maize (BH-140) and the harvest index. But 4 tons/ha FYM and 75 kg/ha N + 60kg/ha P increased maize yield from 5.1 tons/ha in 2009 to 8.15 tons/ha in 2010. Similarly, the harvest index has increased from 0.33 to 0.58 (33 to 58%) at this rate. From this finding it was noted that, enriching FYM with inorganic fertilizers can boost hybrid maize grain yield significantly through improving the physico-chemical properties of the soil and contribute to the highest value of harvest index. Therefore, on the basis of these results, it can be concluded that, enriched FYM could be used for hybrid maize production at western Hararghe in order to get maximum grain yield and the highest value of the harvest index. Thus, it is recommended that, application of 4 tons/ha FYM incorporated with 75 kg of N and 60 kg of P at Chiro can significantly increase hybrid maize (BH-140) yield and sustain its productivity over years. Besides, it also contributes in reducing the cost of inorganic fertilizers which has been a bottle neck to smallholder farmers of eastern Ethiopia. However, profitability of this technology needs to be tested at different locations and in different seasons.**

**Key words:** Farmyard manure, soil fertility, hybrid maize (bh-140), harvest index, inorganic fertilizers, biological yield, photosynthates.

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## INTRODUCTION

Maize (*Zea mays* L.) is both an exciting model organism in plant genetics and also the most important crop worldwide for food, animal feed and bioenergy production (Bello et al., 2010; Randjelovic et al., 2011 and

Christian et al., 2012). It is an important food crop in Africa. For example, it provides over 30% of the dietary calories in East Africa (Salasya et al., 1998). But many African countries experience maize shortages which affect approximately 100 million people (Alexander and Bindiganavile, 2004).

Over 70% of maize in Africa is produced by resource poor small-scale farmers (Salasya et al., 1998) and the average maize yield in Africa stood at 1.3 t/ha compared to 3.0 t/ha elsewhere (FAO, 2006). This low grain yield can be attributed to a number of constraints which include both biotic stress (diseases, pests, and lack of suitable varieties) and abiotic stresses (low soil fertility and lack of capital to purchase farm inputs) (Salasya et al., 1998; Bello et al., 2010: Veigal et al., 2012).

In Africa, maize is used as both human and animal food, eaten directly as grilled cobs or as various products of maize flour. It is easily stored after drying or milling (Polaszek and Khan, 1998). In Eastern Africa, for instance, 3.9% of the cultivated land is under maize production with grain yields of 700 to 1800 kg /ha as opposed to 7437 kg /ha in the USA (Mosisa et al., 2007). In general, maize in Africa is grown on a small-scale by farmers for local consumption, and yields tend to be low, averaging less than half that of Asia and Latin America (Soboksa et al., 2008; Semagn et al., 2012).

Soil fertility management for food and livelihood security is a major concern in the face of persistent poverty and rampant environmental degradation in the Sub Saharan Africa (SSA) including Ethiopia. About 97% of agricultural land in SSA is under rainfed system (Alexander et al., 2004; Bello et al., 2010), which will remain the dominant source of food production in the near future. However, crop yield from rainfed agriculture in the region remains meager around 1 ton/ha (Soboksa et al., 2008; Betran et al., 2003). Due to the widespread nutrient depletion in agricultural soils exacerbated by improper land use, yield and water productivity in the rainfed systems in many SSA countries is decreasing or stagnating (Bello et al., 2010). Mosisa et al. (2007) suggested that, nutrient depletion is the chief biophysical factor limiting small-scale production in Africa.

In Ethiopia maize is a staple food and one of the main sources of calories in the major maize producing regions. It is cultivated on about 1.7 000 000 ha of land. However, maize varieties mostly grown in the highlands altitude (1,700 to 2,400 m.a.s.l) of Ethiopia are local cultivars (Legesse et al., 2007). The national average yield of maize under subsistence production is about 2200 kg/ha (Wonde et al., 2007). This is too much below the world's average yield (Soboksa et al., 2008). This low yield is attributed to foliar diseases and insect pests such as stalk borer, low soil fertility and use of inferior genes (Fininsa, 2001; Dagne et al., 2008).Different reports elucidated that, average grain yield of maize in Ethiopia is about 2 tons/ha (Mosisa et al., 2007; Dagne et al., 2008), which is too much lower than its productivity in industrialized countries such as USA 8 to 9 tons/ha and that of the developing worlds' average 3 tons/ and the yield recorded under demonstration plots in Ethiopia from 5 to 6 tons/ha Dagne et al. (2008).

Chemical fertilizers are used in modern agriculture to correct known plant nutrient deficiencies; to provide high levels of nutrition, which aid plants in withstanding stress conditions; to maintain optimum soil fertility conditions; and to improve crop quality. Adequate fertilization programs supply the amounts of plant nutrients needed to sustain maximum net returns (Leonard, 1986). The broad aim of integrated nutrient management is to utilize available organic and inorganic sources of nutrients in a judicious and efficient manner. Based on the evaluation of soil quality indicators, Dutta et al. (2003) reported that, the use of organic fertilizers together with chemical fertilizers, compared to the addition of organic fertilizers alone, had a higher positive effect on microbial biomass and soil health. Sutanto et al. (1993) in their studies on acid soils for sustainable food crop production noted that, FYM and mineral fertilizer produced excellent responses. Boateng and Oppong (1995) studied the effect of FYM and method of land clearing on soil properties on maize yield and reported that, plots treated with poultry manure and NPK (20-20-0) gave the best yield results.

Application of FYM alone or in combination with inorganic fertilizers helps in proper nutrition and maintenance of soil fertility in maize fields when applied at proper doses replenishing the most deficient macro and micro nutrients which in turn help in getting the highest grain yield and harvest index in hybrid maize varieties. The harvest index determines how many photosynthates are transformed into economic yield. It is the ratio of economic yields to biological yield (Shash et al., 2009; Materechera and Salagae, 2002).

The recycling and the use of nutrients from organic manure have been given more consideration for insuring sustainable land use in agricultural production development (Ararsa, 2012). The positive influence of organic fertilizers on soil fertility, crop yield and quality has been demonstrated in the works of many researchers (Ramamurthy and Shivashankar., 1996; Onasanya et al., 2009; Hoffman, 2001).

Application of animal manures to agricultural fields is a widely used method of increasing soil organic matter and fertility (Debele et al., 2001; Wakene et al., 2005; Heluf et al., 1999; Khaliq et al., 2009). Most solid livestock manures can be applied directly to crop fields or piled for composting. In organic farming, Nitrogen (N) is supplied through organic amendments in the form of manure. Applying organic N fertilizer without prior knowledge of N mineralization and crop needs can result in nitrate-nitrogen (NO3-N) leaching below the root zone and potential groundwater contamination (Debele et al., 2001; Chapagain, 2010).

Soil fertility depletion on smallholder farms is one of the fundamental biophysical root causes responsible for declining food production in eastern part of Ethiopia (Asfaw et al., 1998; Heluf et al., 1999; Ararsa., 2012). Especially, the highlands of Hararghe, eastern Ethiopia, where maize is grown among the major cereals in the high rainfall areas such as (Chiro, Doba, Tullo, Mesela, Gemechis, Kuni, Boke Habro and Daro Labu) soil fertility depletion is the number one problem stagnating crop productivity including maize. Intercropping is widely used in this area by combining maize or sorghum with perennial crops like Chat (*Chata edulis*) which further exposes the soil to rampant nutrient degradation leading to poor crop yield (Heluf et al., 1999; Fininsa, 2001; Ararsa, 2012). In this area maize is grown on soils devoid of basic crop nutrients. Hence the genetic potential of hybrids will not be fully exploited.

Crop residues are used for animal feed and FYM is used for fuel in the region. These and the low rates of NP fertilizers currently being used for maize production under farmers' conditions have aggravated the situation of soil fertility degradation and declining maize production. Consequently, training the farming community on the proper handling and use of FYM together with low rates of inorganic fertilizers could be one alternative solution for fertility management.

Presently BH-140 is widely grown in eastern Ethiopia. However, the response of this hybrid maize cultivar to FYM and inorganic fertilizers and its effect on grain yield and harvest index at western Hararghe zone is not studied. Therefore, the present investigation was carried out to evaluate the effects of FYM and inorganic fertilizers on grain yield of hybrid maize (BH-140) and its harvest index and introduce the culture of integrating FYM and NP fertilizers for maize production at west Hararghe Zone, Oromia Regional State, Ethiopia.

## MATERIALS AND METHODS

### Description of the study area

West Hararghe is located between 7° 55' N to 9° 33' N latitude and 40° 10' E to 41° 39' E longitude. The major crops grown in the study area are sorghum, maize, chat, field beans, potato and tef. The area is characterized by Charcher Highlands having undulating slopes and mountainous in topography. The mean annual rainfall ranges from 850 to 1200 mm/year with minimum and maximum temperatures of 12 and 27° C, respectively.

### Treatment details

The response of hybrid maize variety (BH-140) was used as test crop, to N and Potssium (P) fertilizers. FYM was used either alone or in combination with inorganic fertilizers as follows: control (zero fertilizers and farmyard manure), 10 tons/ha FYM, 8 tons/ha FYM and 25 kg/ha of N + 20 kg/ha P, 6 tons/ha FYM, 50 kg/ha N + 40 kg/ha P, 4 tons/ha FYM, 75 kg/ha N + 60 kg/ha P, 2 tons/ha FYM , 100 kg/ha N + 80 kg/ha P 100 kg/ha N + 100 kg/ha P. The treatments were arranged in randomized complete block design with four replications at the Haramaya University Chiro Campus from 2008 to 2010 cropping seasons.

### Experimental procedures

The experimental field was prepared by using local plough according to farmers' conventional farming practices. The field was ploughed four times each year during the experimental seasons. A plot size of 4 m length by 4.5 m width with six rows per plot was used. Spacing was 0.75 and 0.25 m between rows and plants, respectively. Planting was done in May 2008, 2009, 2010 at a rate of 25 kg/ha. Enriched FYM was prepared by adding 10 kg of urea by pit method in12 $m^3$ pit from cattle manure and subjected to microbial fermentation for 90 days before field application (Debelle et al., 2001; Achieng et al., 2010)

Urea (46-0-0) and DAP (46-18-0) were used as sources of N and P, respectively. All P fertilizer and half dose of N fertilizer as per treatment were applied as basal application at planting and the remainder N was top-dressed at 35 days after planting and FYM was applied each year for one month before the sowing date. Seeds of hybrid maize (BH-140) were sown on 10$^{th}$ of May 2008, at 20$^{th}$ of May 2009 and 15$^{th}$ of May 2010 at the rate of 25 kg/ha. Sowing was completed on the same day. Then after, all necessary cultural practices were employed to raise a successful crop. Comparison of yield data was made between the enriched FYM plots and sole inorganic fertilizers plots (Gomez and Gomez, 1984).

An area of 5.65 $m^2$, corresponding to 32 plants in the central four rows, was harvested immediately after physiological maturity for grain yield and assessment of harvest index. During harvests, border plants at the ends of each row were excluded to avoid border effects. Grain moisture percent (MOI %) was estimated using a Dickey-John multi grain moisture tester. Grain yield (GY t $ha^{-1}$) was calculated using shelled grain and adjusted to12.5% moisture (Mosisa et al., 2007). Harvest index (HI) was calculated as the ratio of grain to total above ground biomass yield multiplied by 100 (Shah et al., 2009).

## RESULT

### Effect on grain yield from the application of FYM and inorganic fertilizers

Combined analysis of variance on grain yield of hybrid maize (BH-140) over years showed the presence of no significant difference between treatments 2 and 7 (10 t/ha FYM and 100 kg/ha N +100 kg /ha P) (Tables 2 and 3) and also the result indicated that, all proportions of FYM and inorganic fertilizer treatments significantly increased maize grain yield as compared to the control treatment (Tables 1 and 2) and the highest grain yield (8158.5 kg/ha) was obtained in the Treatment 5 (4 ton/ha farmyard manure + 75 kg/ha N and 60 kg/ha P) and the lowest grain yield (1647.5 kg/ha) was obtained in the control plots (Table 1). The analysis of variance also elucidated the presence of no significant difference among Treatment 2, 6, and 7(10 t/ha FYM + 0 N and P, 2 t/ha FYM and 100 kg/ha N + 80 kg/ha P and 100 kg/ha N + 100 kg/ha P), respectively (Table 3) at ($p < 0.05$) on grain yield of hybrid maize (BH-140). But 4 ton/ha FYM and 75 kg/ha N + 60 kg/ha P increased maize yield from 5.1 t/ha in 2009 to 8.15 t/ha in 2010 (Tables 1 and 3).

**Table 1**. Effect of enriched FYM and inorganic fertilizers on grain yield of hybrid maize (BH-140) at Chiro, Western Hararghe, Ethiopia from 2008 to 2010.

| Treatment | Mean grain yield of maize (kg/ha) | | | | | |
|---|---|---|---|---|---|---|
| | **$Rep_1$** | **$Rep_2$** | **$Rep_3$** | **$Rep_4$** | **Total** | **Mean** |
| Control(0 FYM and 0 N and P) | 1563 | 1784 | 1586 | 1657 | 6590 | 1647.5 |
| 10 t/ha FYM+0 N and P | 6579 | 6934 | 6601 | 6496 | 26610 | 6652.5 |
| 8 t/ha FYM and 25 kg/ha N + 20 kg/ha P | 5546 | 5955 | 6266 | 5661 | 23428 | 5857 |
| 6 t/ha FYM and 50 kg/ha N + 40 kg/ha P | 5497 | 5353 | 4978 | 4854 | 20682 | 5170.5 |
| 4 t/ha FYM and 75 kg/ha N + 60 kg/ha P | 7601 | 8155 | 8042 | 8836 | 32634 | 8158.5 |
| 2 t/ha FYM and 100 kg/ha N + 80 kg/ha P | 7269 | 6837 | 6228 | 6340 | 26674 | 6668.5 |
| 100 kg/ha N + 100 kg/ha P | 6568 | 6821 | 7343 | 7256 | 27988 | 6997 |
| Total | 4063 | 41839 | 41044 | 41100 | 164606 | 6858.58 |

**Table 2.** Analysis of variance (mean value) for the effect of enriched FYM and inorganic fertilizers on grain yield of hybrid maize (BH-140) at West Hararghe Zone, Oromia, eastern Ethiopia (2008 to 2010).

| Sources of variation | DF | SS | MS | $F_{cal}$ | $F_{tab}$ |
|---|---|---|---|---|---|
| Treatment | 6 | 104302819.7 | 17383803.28 | | |
| Replication | 3 | 109453.84 | | | |
| Error | 18 | 2497295.16 | 138738.62 | 125.29* | 3.26 |
| Total | 27 | 106909568.7 | | | |
| CV(%) | 5.43 | | | | |
| LSD = 0.05 | 571.53 | | | | |

**Table 3**. Mean separation (Duncan's Multiple Range Test) for the effect of enriched FYM and inorganic fertilizers on grain yield of hybrid maize (BH-140) at West Hararghe Zone, Oromia, eastern Ethiopia (2008 to 2010).

| | 1647.5 | 6652.5 | 5857 | 5170.5 | 8158.5 | 6668.5 | 6997 |
|---|---|---|---|---|---|---|---|
| 1647.5 | 0 | -5005* | -4209.5* | -3523* | -6511* | -5021* | -5349.5* |
| 6652.5 | | 0 | $795.5^{ns}$ | $1482^{ns}$ | -1506* | -16* | -344.5* |
| 5857 | | | 0 | $686.5^{ns}$ | -2301.5* | -811.5* | -1140* |
| 5170.5 | | | | 0 | -2988* | -1498* | -1826.5* |
| 8158.5 | | | | | 0 | $1490^{ns}$ | $1161.5^{ns}$ |
| 6668.5 | | | | | | 0 | -328.5* |
| 6997 | | | | | | | 0 |

## Effect on grain yield from sole inorganic fertilizer data

Result from the pooled analysis of variance on grain yield of hybrid maize (BH-140) from the present study significantly varied ($p < 0.05$) over the seasons (Table 1 and 4). This might be due to variation in environmental differences among the growing seasons, the response of cultivar to the environment and G × E interactions. The mean yield of the cultivar across the three seasons ranged from 2.52 t $ha^{-1}$ to 7.62 t $ha^{-1}$. The cultivar gave the highest mean grain yield 8.62 t $ha^{-1}$ in 2009 and the poorest yield was noted in 2010 cropping season (Table 5).

## Effect on Harvest Index of BH-140

The results of this study showed that, the application of different levels of FYM and inorganic fertilizers significantly improved the harvest index of hybrid maize(BH-140) and the combined analysis of variance for the harvest index BH-140 showed that, the effect of different levels of FYM and inorganic fertilizers was highly significant in 2010 (Tables 1 and 6). Comparison of harvest index for maize traits in different levels of FYM, N and P showed that, the highest harvest index (0.58) and the lowest value of the harvest index (0.33) were noted on Treatment 7 and Treatment 1, respectively (Table 4). However, no significant differences were observed on

**Table 4.** Grain yield and Harvest index (mean values of three replications) as influenced by increasing rates of FYM, N and P on hybrid maize (BH-140) 2008 to 2010 at Chiro, western Hararghe, Ethiopia.

| N kg/ha | P kg/ha | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Grain yield(kg/ha) | | | | | | Harvest index | | | | | |
| | 0 | 20 | 40 | 60 | 80 | Total | 0 | 20 | 40 | 60 | 80 | Total |
| 0 | 1501 | 1931 | 2601 | 2896 | 2323 | 11252 | 0.39 | 0.35 | 0.50 | 0.38 | 0.37 | 1.99 |
| 25 | 2541 | 3955 | 4266 | 4961 | 4707 | 20530 | 0.37 | 0.45 | 0.50 | 0.49 | 0.57 | 2.38 |
| 50 | 3497 | 3353 | 4978 | 5854 | 5650 | 23332 | 0.33 | 0.42 | 0.55 | 0.53 | 0.54 | 2.37 |
| 75 | 3601 | 4155 | 6042 | 5836 | 6175 | 26109 | 0.33 | 0.47 | 0.52 | 0.55 | 0.55 | 2.42 |
| 100 | 4269 | 4837 | 5228 | 6940 | 7426 | 28670 | 0.33 | 0.42 | 0.54 | 0.55 | 0.58 | 2.42 |
| Total | 15409 | 18131 | 23115 | 26487 | 26281 | 109423 | 1.75 | 2.11 | 2.61 | 2.50 | 2.61 | 11.58 |
| Gr. Mean | | | | | | 4377 | | | | | | 0.46 |
| CV (%) | 3.38 | | | | | | | | | | 2.45 | |
| LSD = 0.05 | 215.35 | | | | | | | | | | 0.18 | |

**Table 5.** Analysis of Variance for the Effect of N and P Fertilizers on grain yield of maize (BH-140) at Chiro, western Hararghe Ethiopia 2008 to 2010.

| Sources of variation | DF | SS | MS | $F_{cal}$ | $F_{tab}$ |
|---|---|---|---|---|---|
| Treatment | 4 | 40288164.6 | 117832576.2 | | |
| Replication | 4 | 19609442.2 | | | |
| Error | 16 | 394035 | 24627.18 | 70* | |
| Total | 24 | 60291641.8 | | | |

Treatments 2, 4, and 6 (Table 3) but the highest value was noted on Treatment 5 in 2010 (Tables 4 and 5). Consistently, this finding showed significant increase in harvest index in Bh-140 was observed at the highest rates of FYM and in organic fertilizers N and P during the experimental seasons (Tables 3 and 5).

## DISCUSSION

Application of FYM alone or in combination with inorganic fertilizers helps in proper nutrition and maintenance of soil fertility in maize fields when applied at proper doses replenishing the most deficient macro and micro nutrients which in turn help in getting the highest grain yield and harvest index in hybrid maize varieties. The harvest index determines how many photosynthates are transformed into economic yield. It is the ratio of economic yields to biological yield. In this finding the highest yield of 8150 kg/ha and the lowest yield of 5100 kg/ha as well as a significant increase in harvest index (0.33 to 0.58) indicates the combined effect of FYM and inorganic fertilizers contributed in the maximization of the biological activity of BH-140 at Chiro (Tables 3 and 6).

The long term effects of the combined application of organic and inorganic fertilizers in improving soil fertility and crop yield have been demonstrated by many workers (Chen et al., 1988). Wang et al. (2001) reported that, organic and inorganic fertilizers showed great benefits not only for the increase in the N uptake by the plant but also in the improvement of the fodder yield on maize.

Intensive cultivation of high yielding hybrid maize varieties requires application of plant nutrients in large quantities. Supplying these nutrients from chemical fertilizers has got certain limitations and inherent problems. Further, these chemical fertilizers can supply only a few plant nutrients like N, P and potash and also they are becoming very expensive for resource poor farmers. Silvia et al. (2004) reported that, non-inclusion of organic manures such as farmyard manure, compost, green manures, etc. in the manurial schedule have resulted in the depletion of fertility status of the arable soils and their consequent degradation.

Debele et al. (2001) also reported organic manures, especially farmyard manure, have a significant role for maintaining and improving the chemical, physical and biological properties of soils and in sustaining maize yield in western part of Ethiopia. They also reported that 10 ton/ha of farmyard manure is statistically at par with current agronomic recommendation of inorganic fertilizers N and P for maize. In the present finding it is also observed that 10tons/ha of FYM and 100kg/ha N + 100

**Table 6.** Mean Separation (Duncan's Multiple Range Test) for the Effect of N and P Fertilizers on grain yield of maize (BH-140) at Chiro, western Hararghe Ethiopia 2008 to 2010.

| Values | 2250.4 | 4106 | 4666.4 | 5221.8 | 5734 |
|---|---|---|---|---|---|
| 2250.4 | 0 | -1855.6* | -2416* | -2971.4* | -3483.6* |
| 4106 | | 0 | -560.4* | -1115.8* | -1628* |
| 4666.4 | | | 0 | -555.4* | -1067.6* |
| 5221.8 | | | | 0 | -512.2* |
| 5734 | | | | | 0 |

kg/ha P showed no significant difference on yield and harvest index of BH-140 (Tables 1 and 3).

Wakene et al. (2005) indicated that, the urgency of using organic manure has been gaining ground in the wake of increasing cost of fertilizer with every passing year and certain other inherent limitations with the use of chemical fertilizers. FYM is the oldest organic manure used by man ever since he is involved in farming. It has stood the test of time and is still very popular among the poor and marginal farmers. It consists of litter, waste products of crops mixed with animal dung and urine. Therefore, it contains all the nutrient elements present in the plant itself and returns these nutrients to the soil when it is applied to the field for the benefit of succeeding crop.

This study also confirms the role of FYM and chemical fertilizer in combinations increases grain yield of BH-140 and its harvest index. Similarly, Diriba et al. (2011) also reported that, grain yield of hybrid maize varieties BH-540 and BH-660 ranged from 73400 to 8456kg/ha, respectively. In Diriba et al. (2011) it is also reported that, different values of harvest index were noted for hybrid and open pollinated maize varieties at western part of Ethiopia. The highest for BH-540 (52.74%), intermediate for BH-660 (51.96%) and lowest for Kulani (45.66%). In the present finding BH-140 was released by Bako agricultural research center western Ethiopia and adopted at the eastern part of the country showed a range of harvest index values (33 to 58%) this might be due to the variation in the levels of the treatments and seasons.

This result also revealed that, FYM and inorganic fertilizers either in sole or in combination can increase grain yield of BH-140 and harvest index (Tables 3 and 5). But combinations of them have more significant effect on grain yield and harvest index (Tables 1 and 2). In a recent evaluation of the direct effects of cattle manure on corn, it was verified by Silva et al. (2004) that, manure increased green ear yield, grain yield and harvest index in two corn cultivars in Brazil. Dutta et al. (2003) also reported the benefit of organic matter application on soil in enhancing the soil microbial population and soil health in addition to its yield advantage. Khaliq et al. (2009) used partially decomposed cattle and chicken manure amended with wood ash and reported that, higher plant yield of fodder maize was obtained by the use of chicken manure. Manure can supply nutrients required by crops and replenish nutrients removed from soil by crop harvest. In western part of Ethiopia Wakene et al. (2005) and Debele et al. (2001) reported the benefit of FYM in maize production and soil maintenance.

The incorporated use of organic sources of nutrients especially FYM not only supply essential nutrients but also has some positive interaction with chemical fertilizers to increase their efficiency and thereby to improve the soil structure (Elfstrand et al., 2007). Integrated use of chemical fertilizers and organic material may be a good approach for sustainable production of crops. Rautaray et al. (2003) and Zelalem (2012) reported integrated use of organic matter particularly FYM and inorganic fertilizers are beneficial in improving crop yield, soil pH, organic carbon and available N, P and CEC in clay loam soils.

## Conclusion

From this finding it is concluded that, enriching FYM with inorganic fertilizers boost hybrid maize (BH-140) grain yield, and harvest index significantly through improving the physico-chemical properties of the soil. Thus it is recommended that, application of 4 t/ha FYM incorporated with 75 kg of N and 60 kg of P at Chiro can significantly increase hybrid maize (BH-140) yield and its harvest index and sustain its productivity over years. However, profitability of this technology needs to be tested at different locations and in different seasons in the eastern part of Ethiopia.

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