International Journal of Home Science 2021; 7(2): 78-85

International Journal of Home Science

ISSN: 2395-7476
IJHS 2021; 7(2): 78-85

www.homesciencejournal.com
Received: 07-04-2021
Accepted: 09-05-2021

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Response of tef (*Eragrostis tef* (Zucc). Trotter) to organic and inorganic fertilizers in Ethiopia: Review

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Abstract
Tef [*Eragrostis tef* (Zucc.) Trotter] is a highly valued crop in the national diet of Ethiopians. It is major crops grown in Central highlands of Ethiopia under wide range of Agro ecological condition. Integrated nutrient management is the best approach to supply adequate and balanced nutrients to increase crop productivity in an efficient and environmentally benign manner, without sacrificing soil productivity of future generations. The objective of this review was to investigate the effect of organic and inorganic fertilizers as well as their combination on growth, yield and yield components of tef. Applications of chemical fertilizers mainly Urea and DAP have been started some four decades ago to improve soil fertility for enhanced crop production. Untenable increases in the price of fertilizers coupled with their adverse effects on the soil and reduced recovery efficiency of fertilizers by crops are the bottlenecks that prohibit the indiscriminate use of this technology. On farm using of organic fertilizers is inadequate due to some parts of the country us it as source of energy. Though ISFM is the notably preferred option in replenishing soil fertility and enhancing productivity, it is not yet widely taken up by farmers due to access or availability of inputs, use of organic resources for other purposes in place of soil fertility, transporting and management of organic inputs and economic returns of investments. Therefore, research needs to conduct detailed study on the best combinations of inputs that can boost crop yield in different farming systems and soil types.

Keywords: tef, organic and in organic fertilizers, integrated soil fertility management, yield

1. Introduction

Tef [*Eragrostis tef* (Zucc.) Trotter] is a cereal crop that belongs to the grass family Poaceae, which is endemic to Ethiopia and has been widely cultivated in the country for centuries (Teklu and Tefera, 2005). Tef is adaptable to a wide range of ecological conditions in altitudes ranging from near sea level to 3000 m.a.s.l and even it can be grown in an environment unfavorable for most cereal, while the best performance occurs between 1100 and 2950 m.a.s.l in Ethiopia (Hailu and Seyfu, 2000) [41]. It is resistant to extreme water conditions, as it is able to grow under both drought and waterlogged conditions (Minten *et al*. 2013). In Ethiopia, tef is mainly produced in Amhara and Oromia, with smaller quantities in the Tigray and SNNP regions. East and West Gojam of Amhara and East and West Shoa of Oromia are particularly known tef producing areas in the country (Demeke and Marcantonio, 2013) [18]. During the 2017 meher rains, more than 6.77 million farmers allocated 23.85 percent of the national grain area to tef. The national average tef yield at 2017 reached 1.75 tons ha^{-1} (CSA, 2017) [16].

Tef is the country's most important staple crop in terms of both production and consumption, at least in value terms. It is considered as an economically superior good, relatively more consumed by urban and richer consumers (Berhane *et al*. 2011; Minten *et al*. 2013). Growth in average incomes and faster urbanization in Ethiopia are likely to increase the demand for tef over time (Berhane *et al*. 2011). Tef is used to produce the nation's staple dish enjera, to brew local beer. It has high protein, fiber and complex carbohydrates content, relatively low-calorie content, and is gluten free (Berhane *et al*. 2011; ATA 2013).

Even though, Ethiopia is a center of origin and diversity of tef and has the above-mentioned importance and coverage of large area, its productivity is very low to feed the demand of its people and market. These is due to low in productivity compared to the potential yield due to lack of adequate synthetic-fertilizer input, limited return of organic residues and manure, and high biomass removal, erosion, and leaching rates, low soil fertility and suboptimal use of mineral fertilizers. Although organic inputs, such as farmyard manure and crop residues, are potential sources of plant nutrients and have beneficial effects on soil fertility, there is competition from alternative uses of these resources; both manure and crop residues are used for fuel and crop residues are also used as animal feed and for construction (Abegaz and van Keulen, 2009; Haileselassie *et al*., 2005) [3, 40]. The continuous removal of biomass (grain and crop residues) from crop land without adequate nutrient replenishment can rapidly deplete the soil nutrient reserves and jeopardize the sustainability of agricultural production (Gete *et al*., 2010; Getachew *et al*., 2015) [29, 33]. Nutrients like N, K and P are removed by livestock through grazing and crop residue collection. It is known that among the essential nutrients, both nitrogen and phosphorous are required in large quantities for optimum growth and yield of crop plants. Since Orga-P has lower N concentration (1%) in relation to other nutrients, therefore, there is need to find out the right combination of inorganic N and Orga- P as sources of N and P for optimum yields of tef.

Soil nutrient status is widely constrained by the limited use of inorganic and organic fertilizers and by loss of nutrients mainly due to erosion and leaching (Balesh *et al*., 2007; Gete *et al*., 2010; Getachew *et al*., 2014) [11, 30, 33]. The principle of green revolution in Ethiopia under the blanket recommendation is not successful under most conditions, then more researches has to be done under farmers condition with his own participation in such a manner that the research is able to minimize the different sorts of local problems, by reducing the soil fertility loss and decline in productivity, under what is called the integrated soil fertility management (Abera and Belachew, 2011). Integrated use of 23/20 kg N/P ha^{-1} with 20 t FYM ha^{-1} or 46/40 kg N/P ha^{-1} with 10 t FYM ha^{-1} are recommended for wheat around Hagerselam, and barley and potato producers around Chencha. The integrated use of 4.53 t FYM ha^{-1} and 37 kg N ha^{-1} were recommended for tef production on Vertisols of central highlands (Teklu and Haile Mariam, 2009) [66].

1.1 Objective

To review the effect of compost, farmyard manure, Nitrogen, Phosphorus fertilizers and their interactions in terms of grain yield harvested and to determine the economically optimum inorganic and organic fertilizers rates for tef production.

2. Response of Tef (*Eragrostis tef*) to organic and inorganic fertilizers

2.1 Growth, yield and yield components of tef in response to organic fertilizers

Organic fertilizers are natural materials of either plant or animal source, including livestock manure, green manures, crop residues, household waste, compost, and works directly as a source of plant nutrients and indirectly influences the physical, biological and chemical properties of soil (Ngoc Son *et al*; 2004; Basel and Sami, 2014) [12, 54]. Soils fertilized with compost or manure have higher contents of SOM and soil microorganisms than mineral fertilized soils, and are more enriched in P, K, Ca and Mg in the top soil and NO3-N, Ca and Mg in the sub soils (Edmeades, 2003) [19].

2.1.1 Effects of compost on growth, yield and yield components

The use of organic matter such as animal manures, human waste, food wastes, backyard wastes, sewage sludge and composts has long been recognized in agriculture as beneficial source for plant nutrients and thereby improving, yield of crops. Organic soil amendments (OSA) such as compost produced higher yield of crops because they are the sources of multiple nutrients required by plants or crops for their growth and developments. Organic fertilizers are relatively cheap, technically easy to apply and accessible to all famers irrespective of their financial capacities (Wassie and Abebe, 2013). Compost is another alternative source of plant nutrients (Ngwira *et al*., 2013; Odlare *et al*., 2011; Vanlauwe *et al*., 2011) [55, 56]. Well-made compost is known to improve soil structure, resulting in improved air exchange, water infiltration and retention (Fischer and Glaser, 2012) [24]. According to Balesh *et al*. (2007) [11], tef was most responsive to compost on Vertisols and Nitisols. Similarly, Edwards (2006) [6] studied the effects of compost and fertilizer on the yields of seven crops grown in thirty fields in Tigray reported that grain and straw yields of all crops in all fields treated with compost were higher than in control (check) fields Table (1). Accordingly, compost increased the grain yield of crops by 110 and 43% over the control and fertilizer treatments. In addition to higher yield, there is also higher profitability with compost than with fertilizers (Minale *et al*., 2010).

Table 1: Average yields for seven crops in Tigray, 2001-2005 (Edwards, 2006) [6]

Crop type	Average yield (kg/ha)					
	Check (no input)		Compost		Chemical fertilizer	
	Grain	straw	Grain	Straw	Grain	Straw
Faba bean	1544	7199	3535	13998	2696	11350
Barley	1661	6927	3535	13670	1832	8269
Wheat (Durum)	1313	6464	2374	10740	1760	8453
Tef	1179	7384	2791	12193	1774	11096
Maize	1843	13545	2401	17840	3013	14363
Mixture of Barley and Durum	858	6706	3895	10187	1199	6712
Finger millet	898	4177	2496	12148	1297	6665

Adapted from Edwards (2006) [6]

2.1.2 Effects of manure on growth, yield and yield components

In the mixed farming systems of the Ethiopia highlands, farm yard manure (M) is probably the most important soil amendment to which farmers have a better access (Powell *et al*. 1995) [59]. In addition to its nutrient supply, farmyard manure improves the physicochemical conditions of soils. The beneficial effects of M on crop production through improved soil fertility and physical properties of soil is an established fact. However, unlike the western parts of the country where it is the major means of soil amendment (Teklu *et al*. 2004), manure is largely used as a source of household energy in the central and the northern parts. Wheat yields are highest (9.4 tons ha^{-1}) when farmyard manure is applied, (Gruhn *et al*., 2000) [35] and the highest grain yield of wheat was obtained with the application of 6 t M ha^{-1} and 30 kg N ha^{-1}.

Yield increase due to 60 kg N ha^{-1} was 300% as compared to the control under no application of manure, but it was only 12.8% when 6 t M ha^{-1} was applied. This implies that the contribution of 6 t FYM ha^{-1} to grain yield was comparable to that of 60 kg N ha^{-1}, indicating the possibility of complete substitution of the urea through organic sources (Teklu and Hailemariam 2009) [66]. The marginal rate of return (1-387%) obtained from adopting optimum rate of M and N was higher than the minimum acceptable rate, estimated to be about 50-100% by several studies for farmers already use fertilizers

(Hailemariam and Gezahegne 2000; Hailemariam *et al*. 2006; CIMMYT 1988) [38, 39]. According to Teklu and Hailemariam (2009) [66], the economic optimum rate of M and N for wheat (6.85 t M ha^{-1} and 44 kg N ha^{-1}) and tef (4.53 t M ha^{-1} and 37 kg N ha^{-1}) is less than the agronomic optimum.

2.2 Growth, yield and yield components of tef in response to inorganic fertilizers

2.2.1 Effects of nitrogen on growth, yield and yield components

Tef responds to fertilizers especially to N highly in all its yield components. N is essential for carbohydrate use within plants and stimulates root growth and development as well as uptake of other nutrients (Tisdale *et al*., 1993; Brady and Weil, 2002) [13, 70]. The acceleration of emergence of the crop in response to N application might be due to the possibility that N supply may have triggered faster germination because of its positive influence on the internal factors regulating the germination process such as increased contents of gibberellic acid in the seed (Taiz and Zeiger, 2006) [64]. A similar result was reported by Temesgen (2012) [68]. On other hand, this finding is in contrast to Haftom *et al*. (2009) [37] and Mitiku (2008) [75] who reported that increased application of N delayed crop emergence in tef. Tef grown at the rate of 46 kg N ha^{-1} had significantly hastened days to panicle emergence than those grown at the other two higher rates of nitrogen. Similarly, according to finding of Getachew (2004) [31] and Mekonnen (2005) [51], heading was significantly delayed at the highest N fertilizer rate compared to the lowest rate on wheat and barley crops, respectively.

According to Fenta Assefa (2018) [23] report, Days to the maturity of tef plants hastened under lower N rates (about 66.5 days by mean at controlled and 66 days at 46 kgha^{-1} fertilizer rate than under the higher N (about 70 days treated with 92 kgha^{-1} followed by 66.2 days by mean at 69 kgha^{-1} N fertilizer rates. Thus, increasing the rate of N from 46 kgha^{-1} to 69 kg N ha^{-1} prolonged days to maturity by about relative shorten days as compared to that of 92 kgha^{-1} N rate, which was very prolonged maturation. This result is in line with the finding of Getachew (2004) [31] and Mekonen (2005) who reported that the heading was significantly delayed at the highest N fertilizer rate compared to the lowest rate on wheat and barley crops, respectively.

Table 2: Main effects of nitrogen fertilizer rates on the phenology of tef

Nitrogen (kg/ha)	Days to panicle emergence (days)	Days to maturity (days)
0kg\ha	44.5b	66.5b
46kg\ha	43.8b	66.0b
69kg\ha	44.7b	66.2b
92kg\ha	48.0a	70.0a
LSD ($p<0.05$)	1.6	1.7

Adapted from Fenta Assefa (2018) [23]

Many studies revealed significant influence of N on plant height as it plays vital role in Vegetative growth of plants. For instance, result reported by Haftom *et al*. (2009) [37] showed that tef plants with higher plant height (92 cm) and panicle length (38 cm) were found by applying a high amount of N fertilizer (92 kg N ha^{-1}). This may be attributed to the fact that N usually favors vegetative growth of tef, resulting in higher stature of the plants with greater panicle length. The plant height obtained from the all treated plots was significantly higher than the unfertilized plot. This is because nitrogen fertilizer has a great role in plant growth. Findings of Legesse (2004) [45]; Mitiku (2008) [75] and Haftamu *et al*. (2009) confirm that panicle length exhibited positive and highly significant correlation with culm length, plant height, number of internodes, and grain yield. Increased application of N caused increased panicle length and hence crops with higher panicle length produced significantly higher total biomass yield, grain yield and straw yield than those with shorter panicles (Giday, 2014) [34].

The number of effective tillers was significantly increased in response to increasing rate of nitrogen fertilizer. The maximum number of effective tillers was recorded in response to nitrogen applied at the rate of 69 kg N ha^{-1} is more effective tillers, but from plots treated with 46 kg N ha^{-1} the lowest number of effective tillers was obtained. Similarly Legesse (2004) [45]; Haftamu *et al*. (2009) reported significantly higher number of tillers in response to the application of high N rate in tef.

Table 3: Main effects of nitrogen fertilizer rates on the growth parameter of Tef

Factors N-fertilizer rate	Plant height (cm)	Panicle length (cm)	Effective tillers
0 kgN/ha	57.73d	27.42d	2.28
46 kgN/ha	81.82c	35.10c	2.5
69 kgN/ha	87.16b	36.80b	2.67
92 kgN/ha	92.16a*	37.75a	2.4
LSD	1.58	0.95	NS
CV (%)	5.39	7.46	18.77

Adapted from Haftamu *et al.* (2009)

Nitrogen application significantly enhanced biomass yield agrees with the result of Amanuel *et al*. (1991) [5] who reported a significant increase in biomass yield of wheat because of increased rate of nitrogen application. The application of highest level of nitrogen resulted in less biomass yield (614.8g per plot) compared to 69 kg N ha^{-1} rate applied in Quncho variety. This might be due to the effect of lodging resulted from too high amount of nitrogen fertilizer that encourage vegetative growth and height leading to lodging before the translocation of dry matter to economic yield since biomass includes the economic yield. According to Mitiku (2008) [75] days to physiological maturity of tef found to be positively correlated with fertilizer application. Studies by Legesse (2004) [45]; Mitiku (2008) [75] and Haftamu *et al*. (2009) similarly revealed that, further increases in N application resulted in higher total biomass yield.

Table 4: Effect of N rate on yield of teff in vertisols of Gondar Zuria woreda

N Kg/ha	Year 2014		Year 2015		Two years' combined	
	Biomass yield (kg/ha)	Grain yield (kg/ha)	Biomass yield (kg/ha)	Grain yield (kg/ha)	Biomass yield (kg/ha)	Grain yield (kg/ha)
0	1343	421	5404	1615	3374	1018
46	6080	1440	9019	1816	7550	1789
69	6837	1559	9561	1944	8199	1751
92	7102	1411	9576	2139	8340	1613
Mean	6673	1208	8390	1879	6866	1543
LSD	855	198	1116	186	625	141

***Source*:** International center for agricultural research in the dry areas (ICARDA) www.icarda.org

2.2.2 Effects of phosphorous on growth, yield and yield components

Phosphorus is the main element involved in energy transfer for cellular metabolism in addition to its structural role (Wiedenhoeft, 2006). The number of days required to heading varied among P fertilizer rates. According to result of Getahun *et al.* (2013) [32], the control (0 P) treatment significantly delayed heading (96.7) while higher levels of P (10, 20 and 30 kg ha^{-1}), significantly enhanced heading. The reason might be that applied P fertilizer played an essential role in plant growth and development. Assefa *et al*. (2016) [8] also reported a similar result. Application of P fertilizer also significantly affected panicle length. The highest panicle length (39.6 cm) was recorded from the application of 20 kg P ha^{-1} while the shortest was obtained from the control treatment.

The increase in panicle length with increasing P rate could be due to sufficient uptake of P by plants, which encourages plant growth. The result was in agreement with the findings of Giday (2014) [34]. Higher panicle length may have also positive contribution to the grain and straw yields since it has a positive correlation to grain yield. In line with this result, Asefa (2014) [7] reported that the application of balanced fertilizer and efficient utilization of nutrients leads to high photosynthetic productivity and accumulation of high dry matter, which ultimately increases panicle length and grain yield. Onasanya *et al*. (2009) [57] showed that phosphorus plays an important part in many physiological processes that occur within a developing and maturing plants. It is involved in enzymatic reactions in the plant and hastens the maturity, thus counteracting the effect of excess nitrogen application to the soil. According to Getahun *et al.* (2018), the shortest days (91.2) to physiological maturity were obtained from the application of 30 kg P ha^{-1} and the longest days (96.7) from the control. This was due to phosphorus application could possibly shorten maturity date since it promotes rapid cell division and maturity of plants.

Table 5: The main effects of P fertilizer rates on phenology of tef in Asosa and Bambasi 2012-2013

Treat phosphorus (kg ha^{-1})	Days to 50% emergency	Days to 50% heading	Days to 90% physiol maturity	Panicle length (cm)
0	4.2	51.7a	96.7a	32.4b
10	4.3	47.2b	92.8b	38.2a
20	3.9	46.1bc	91.4b	39.6a
30	4.0	45.3c	91.2b	38.9a
LSD (5%)	Ns	0.92	1.83	0.92
CV (%)	25.7	9.2	9.4	11.8

Adapted Getahun *et al.* 2018

According to Fissehaye *et al*. ((2009) [25] N and P significantly (P<0.01) improved grain yield, biomass yield, height and lodging of plants but not harvest index. The biomass yield of tef was also positively and significantly correlated with P. Although the interaction of N and P was not statistically significant, yet, it was observed that a mixture of N and P gave the highest biomass yield of 3.82 t ha^{-1} when 69 kg of each of N and P ha^{-1} was applied. The respective individual yields were 2.45 t ha^{-1} for N and 1.83 t ha^{-1} for P at the same rates.

Table 6: Effect of P2O5 rate on yield of teff in vertisols of Gondar Zuria woreda

P205 Kg/ha	Year 2014		Year 2015		Two years combined	
	Biomass yield (kg/ha)	Grain yield (kg/ha)	Biomass yield (kg/ha)	Grain yield (kg/ha)	Biomass yield (kg/ha)	Grain yield (kg/ha)
0	3972	860	7508	1674	5740	1267
46	5653	1263	8223	1891	6938	1577
69	5568	1328	8871	1947	7219	1637
92	6170	1680	8958	2001	7564	1691
Mean	5341	1283	8390	1878	7240	1543
LSD	855	198	1025	186	625	141

Source: Technical report of experimental activities June 2016, International center for agricultural research in the dry areas (ICARDA) www.icarda.org

Table 7: The effect of different levels of P and N fertilizers on tef grain yield (t/ha) and biomass yields (t/ha)

P kg/ha	N (kg/ha)				
	0	23	46	69	Mean
0	0.51^{j}	0.80^{h}	1.053^{e}	1.125^{c}	0.872
23	0.7^{j}	0.991^{f}	1.125^{d}	1.21^{c}	1.007
46	0.83^{h}	1.213^{c}	1.541^{b}	1.619^{a}	1.299
69	0.91^{g}	1.235^{c}	1.548^{ba}	1.631^{a}	1.329
Mean	0.737	1.06	1.317	1.395dd	1.127
LSD		0.109	0.029	0.645	
CV		6.50			

Adapted Fissehaye *et al*. (2009) [25]

2.3 Effect of integrated nutrient application on yield and yield components of tef

A combination of mineral and organic fertilizers is necessary to sustain and improve crop production on depleted soils (Bationo *et al*., 2006). For sustainable productivity, mixed use of chemical with organic fertilizer has proved to be highly beneficial in terms of balanced nutrient supply (Ali *et al*; 2009) (Ayeni and Adetunji, 2010) [10] and significantly higher than yields from sole organic fertilizer application (Efthimiadou *et al*; 2010) [20]. The integrated use of 4.53 t ha^{-1}

FYM and 37 kg N ha^{-1} were recommended for tef production on Vertisols of central highlands (Teklu and Hailemariam, 2009) [66]. The use of 5 t ha^{-1} of compost either with 55/10 or 25/11 kg of N/P ha^{-1} is economical for maize production in Bako Tibe district. In another study conducted at Hawassa, Southern Ethiopia, combined use of 23/20 kg N/P ha^{-1} with 20 t FYM ha^{-1} or 46/40 kg N /P ha^{-1} with 10 t FYM ha^{-1} are recommended for wheat around Hagerselam, and barley and potato producers around Chencha.

According to Girma and Gebreyesus (2013-2014) field experiment conducted for two consecutive cropping seasons on farmers' fields in Dendi district of Oromia Regional State the highest tef grain and biomass yield 3144.8 kg ha^{-1} and 12562 kg ha^{-1} respectively were obtained from the application of 50% VC and half the recommended rate of N and P followed by full dose of recommended rate of N and P from inorganic fertilizer resulting in 2846 kg ha^{-1} grain and 11833 kg ha^{-1} biomass yields respectively, where there is no significance differences between the two treatment effects. The application of 50% CC with 50% N and P has also given comparable grain and biomass yield as compared to application of full dose of N and P from inorganic fertilizer. Therefore, the result of study has clearly indicated that it is possible to fairly produce tef through integrated nutrient application approach, rather than applying nutrient from one source. In line with the current result, research findings of Tekalign Ayalew (2011) and Getachew *et al*. (2012) [27] indicated that tef has showed significance response to the ISFM treatments containing both organic and inorganic forms under farmers' field condition that they could be considered as alternative options for sustainable soil and crop productivity in the degraded highlands of Ethiopia.

Table 8: Effects of organic and inorganic fertilizers application on tef yield and yield components

Treatments	PHT (cm)	PL (cm)	BY ($kgha^{-1}$)	GY ($kgha^{-1}$)
Recommended NP	114.17	42a	11833.3ab	2846ab
Conventional Compost (CC)	98.3	39.7abc	7979.2d	1941de
Farmyard manure (FYM)	92.67	38.3c	8250d	1920e
50% VC + 50% CC	101.5	40abc	8500cd	2027.3de
50% VC + 50% FYM	103.17	40.5abc	8750cd	1933.5de
33% VC + 33% CC + 33% FYM	100.83	39.17bc	9145.8cd	2293cd
50% VC + 50% NP	111.5	41.17ab	12562.5a	3144.8a
50% CC + 50% NP	108	41ab	10208.3bc	2516.7bc
50% FYM + 50% NP	103.5	38.17c	9687.5cd	2420c
CV (%)	5.12	5.6	16.6	13.9

Adapted from Girma and Gurmu (2013-2014)

Work on ISFM has suggested that integrated use of inorganic and organic fertilizers can increase crop yields. Five-year study conducted in the central highlands of Ethiopia found consistently higher yields for treatments that combine half dose of inorganic fertilizer and half dose of organic fertilizer compared to full dose of inorganic or organic fertilizer alone (Workineh *et al*. 2012). By contrast, in a two-year study on wheat and tef in the highland Nitisol area of Ethiopia, Agegnehu, Vanbeek, and Bird (2014) [30] observed that yields were maintained, but not significantly increased, when 50% of the inorganic fertilizer application was replaced by an N equivalent rate of organic fertilizer.

The use of organic fertilizers together with appropriate chemical fertilizers, had a higher positive effect on microbial biomass and hence soil health (Elkholy *et al.* 2010, Abedi *et al.* 2010, Salehi *et al.* 2017) [2, 22, 76]. Research findings of Tekalign *et al*. (2001), Ayalew (2011) [9] and Getachew *et al*. (2012) [27] indicated that tef has showed significance response to the ISFM treatments containing both organic and inorganic forms under farmers' field condition that they could be considered as alternative options for sustainable soil and crop productivity in the degraded highlands of Ethiopia.

Table 9: Response of teff grain yield (GY), total biomass (TB), straw yield (SY) and harvest index (HI) to ISFM treatments on Nitisols of central Ethiopian highlands

Treatments	GY (kg ha^{-1})	TB (kg ha^{-1})	SY(kg ha^{-1})	HI (%)
Control	853d	3232d	2379d	26.4
Farmers NPK rate (23/10/0)	1427c	5250c	3824c	27.2
Recommended NPK rate (60/20/0)	2057a	8050a	5993a	25.6
50% RNPK (30/10/0) + 50% compost/manure (3.25 t ha^{-1})	1896ab	6895b	4998b	27.5
50% manure + 50% compost (6.5 t ha^{-1})	1795b	6567b	4773b	27.3
LSD 0.05	233	1077	900	3.4
CV (%)	14.2	17.5	19.9	12

Adapted from Getachew Agegnehu (2018)

3. Summery and Conclusion

Ethiopia is one of the 14 sub-Saharan countries with highest rates of nutrient in which, Supplying food for the rapidly increasing population is one of the major problems of today in sub-Ethiopian due to low soil fertility. Soil erosion, continuous cultivation and low nutrient application are the major cause of decline soil fertility in Ethiopia. The continuous removal of biomass (grain and crop residues) from crop land without adequate nutrient replenishment can rapidly deplete the soil nutrient reserves and jeopardize the sustainability of agricultural production. Organic soil amendments (OSA) such as compost produced higher yield of crops because they are the sources of multiple nutrients required by plants or crops for their growth and developments and are relatively cheap, technically easy to apply and accessible to all famers irrespective of their financial capacities. Inorganic fertilizer is usually immediately and fast containing all necessary nutrients that are ready for plants. The excess use of inorganic fertilizers in agriculture can lead to soil deterioration, soil acidification and environment pollution. The blanket recommendation is not successful under most conditions. So, the ISFM system is an alternative approach for the sustainable and cost-effective management of soil fertility and is characterized by reduced input of inorganic fertilizers. The added benefits obtained from the combined use of compost and NP fertilizer at a reduced application rate suggest that fertilizer and compost should be seen as complementing rather than substituting each other. The integration of organic and inorganic sources can improve and sustain different crop yields without degrading soil fertility status. In this regard, integrated use of N and P and FYM are better than application of either N and P or FYM alone for crop production.

Generally, using organic fertilizers in combination with inorganic fertilizers has shortened days to maturity, which is a good strategy to enable the plant to escape terminal moisture stress in rain-fed crop production. Integrated soil fertility management plays a critical role in both short-term nutrient availability and longer-term maintenance of soil organic matter and sustainability of crop productivity in most smallholder farming systems in the tropics.

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