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Response of Wheat to Integrated Nutrient Management: A Review

Review Article

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Abstract

Ethiopia is the only country in sub-Saharan Africa where smallholder wheat production meets more than 70% of the national consumption demand. The two common varieties of wheat grown in Ethiopia are bread wheat and durum Wheat; and 95% of consumed wheat is bread wheat. Wheat ranked second in calories intake from total cereals consumption next to maize. In Ethiopia, based on recent trends, increasing number of poor consumers in low and middle income resolve to eat wheat based food at an affordable price as a result of the high cost of teff. Wheat ranks third after sorghum and maize in area coverage. Despite the large area under wheat, the national average yield of wheat in Ethiopia is very low. That is mainly due to using chemical fertilizer alone, unbalanced use of mineral fertilizers and method of application. On the other hands, the majority of previous researches carried out on wheat in Ethiopia were confined on the effect of N and P fertilizers alone. The results obtained from this review revealed that, to ensure sustainable wheat production, managing soil fertility by using integrated nutrients involving the use of chemical fertilizers in combination with organic fertilizers like; compost, FYM and manures together with input through biological processes were very important. Therefore, the integration of organic sources and synthetic sources of nutrients not only supply essential nutrients but also have some positive interactions leading to increase efficiency and thereby, reduce environmental hazards.

Keywords: Chemical fertilizer; Compost; FYM; Integrated nutrients; Manures; Wheat

Introduction

Wheat is a key staple food that provides around 20 percent of protein and calories consumed worldwide [1]. Demand for wheat is projected to continue to grow over the coming decades, particularly in the developing world to feed an increasing population, and with wheat being a preferred food, continuing to account for a substantial share of human energy needs in 2050 [2]. In Ethiopia, based on recent trends, an increasing number of poor consumers in low and middle-income resolve to eat wheat based food at an affordable price as a result of the high cost of teff. Maize contributes about 29% of the calorie intake from total cereal consumption, followed by wheat and teff contributing about 21% and 17%, respectively [3,4]. Ethiopia is the only country in sub-Saharan Africa where smallholder wheat production meets more than 70% of the national consumption demand [5]. However, despite the periodic variability, wheat production in 2013 has gone up by 60% over 2009 and imports of wheat have declined by 53% [4]. The improvements in wheat production in Ethiopia are primarily due to development and dissemination of improved wheat varieties by the CIMMYT in collaboration with Ethiopian Institute of Agricultural Research (EIAR) [6].

The two common varieties of wheat grown Ethiopia are: bread wheat (*Triticum aestivum* L.), accounting for 60% of production and durum Wheat (*Triticum turgidum*), accounting for the remaining 40% and 95% of consumed wheat is bread wheat [7,8]. Wheat is mainly grown in the highlands of Ethiopia, which lie between 6°N and 16°N and between 35°E and 42°E, at altitudes ranging from 1,500 to 2,800 m above sea level and with mean minimum temperatures of 6°C to 11°C [9,10]. The region of Oromia accounts for more than half of national wheat production (54 percent), followed by Amhara (32 percent); Southern Nations, Nationalities, and Peoples (SNNP)

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(9 percent); and Tigray (7 percent) [11]. Of the current total wheat production area, about 75% is located in the Arsi, Bale, and Shewa wheat belts (MOA, 2012) [10].

In Ethiopia, wheat ranks third after sorghum (*Sorghum bicolor*) and maize (*Zea mays*) in area coverage, while second in total production after maize [12]. Despite the large area under wheat, the national average yield of wheat in Ethiopia is about 2.1 t ha^{-1}, which is well below the experimental yield of above 5 t ha^{-1} and definitely below the world's average which is about 3 t ha^{-1} [9,13,14]. This is because of soil fertility depletion and soil fertility decline, low levels of chemical fertilizer usage like use of fertilizers that contain only N and P , limited knowledge on time and rate of fertilizer application, extensive agriculture that leaves behind little Organic Matter (OM) or complete removal of plant residues including Farm Yard Manure (FYM), low levels of fertilizer application, use of manure and crop residue as a source of fodder and fuel in place of soil fertility maintenance, lack of appropriate soil conservation practices, cropping systems, imbalanced use of mineral fertilizers such as un affordability and cost of blended fertilizer, lack of laboratories to analysis more nutrients except nitrogen and phosphorus and inappropriate method of their application that culminated in low efficiency [15-18]. Due to this reason, Ethiopia is still deficient in terms of wheat production to meet the national requirements. Although wheat production has significantly increased over the past 15 years, domestic production consistently falls short of consumption requirements, making the country a net importer of wheat [18]. However, to ensure sustainable crops production including wheat, healthy soils is important i.e. soils with good physical, chemical and biological fertility [19]. In contrast, poor healthy soils exhibit various worthless attributes like deficiencies in nutrients, easily eroded and various other constraints. Soil nutrients are a key components of soil healthy and are good, if present in adequate, but if not, the means of replenishing them must be understood. Using of chemical fertilizers alone cannot meet the requirement of crops and cropping systems, because of their high cost and less residual effects of chemicals, hence there is increasing trend towards use of organic manures [20]. Incorporation of organic matter either in the form of crop residues or farmyard manure/ vermin compost/ compost are vital for supplementing plant nutrients and maintenance of soil fertility, as it is an important soil component which influences the physical, chemical and biological properties of soil [21]. In modern agriculture, keeping in mind status of the soil health, it is well recognized that neither organic manures nor chemical fertilizers individually can supplement the balanced amount of nutrients required by the plant to sustain production [22]. Therefore, the primary purpose of this paper is to review different components of integrated nutrient managements and its effect on growth and yield of wheat crop production.

Integrated nutrient management

Integrated Nutrient Management (INM) was defined as a set of soil fertility management practices that necessarily include the use of fertilizer, organic inputs, and improved germplasm combined with the knowledge on how to adapt these practices to local conditions, aiming at maximizing agronomic use efficiency of the applied nutrients and improving crop productivity. All inputs need to be managed following sound agronomic principles [23]. Application of imbalanced and/or excessive nutrients led to declining nutrient use efficiency making fertilizer consumption uneconomical and producing adverse effects on atmosphere and groundwater quality causing health hazards and climate change [24,25].

On other hand, nutrient mining has occurred in many soils due to lack of affordable fertilizer sources and where fewer or no organic residues are returned to the soils. INM entails the maintenance/ adjustment of soil fertility to an optimum level for crop productivity to obtain the maximum benefit from all possible sources of plant nutrients; organics as well as inorganic in an integrated manner and is an essential step to address the twin concerns of nutrient excess and nutrient depletion [26].

Effect of mineral fertilizers on wheat productivity

Mineral fertilizers defined as the types of fertilizer which is composed of systemic chemicals on mineral or is a chemical fertilizer produced by chemical fertilizer industry through chemical reactions of different elements or products. Nitrogen, phosphate and potash fertilizers are primary mineral fertilizers produced by the fertilizer industry. Mineral fertilizers are required to supplement the nutrients recycled or added in the form of crop residues and animal manures. Fertilizers are concentrated sources of essential nutrients in a form that is readily available for plant uptake [27].

Influences of nitrogen fertilizer on wheat productivity

Influences of nitrogen fertilizer on wheat yield: Nitrogen is the most limiting nutrient for wheat production that affects the rapid plant growth and improves grain yield. It is quite normal that many researches showed that increasing levels of applied N increased grain yield of wheat [28,29]. Similarly [30], indicated that the different N rates (120, 240 and 360 kg ha^{-1}) have a significant effect on grain yield increment (46% at N120, 72% at N240, and 78% at N360) compared to control. In the same way [30], reported that higher grain yield (8230 kg ha^{-1}) was produced in treatment receiving 240 kg N ha^{-1} than in control (3930 kg ha^{-1}), 120 kg N ha^{-1} (4400 kg ha^{-1}), and 360 kg N ha^{-1} (6530 kg ha^{-1}). The increased in grain yield would be due to increase in the yield attributes as the level of nitrogen was increased. Abebe, et al. also reported that grain yield of wheat was highly significantly influenced by the rate of N fertilizer (0, 23, 46, 69 and 92 kg ha^{-1}) application [31]. Among these treatments, fertilizer applied with rate of 46 kg ha^{-1} had 5.4% less and 36.1% more grain yield than fertilizer applied 69 kg ha^{-1} and control, respectively (Table 1). According to this study to maximizing the grain yield of wheat, applying of 69 kg ha^{-1} N is appropriate because proper rate and time of application are critical for meeting crop needs. In agreement with the results of this study, split N application 69 kg ha^{-1} is effective in attaining higher grain yield of wheat [32,33].

Several studies on N rate and time of application on different soil types in our country, Ethiopia, also indicated that wheat yields, N uptake and efficiency were significantly affected. Aleminew, et al. obtained that the highest grain yield (3992 kg ha^{-1}) at Kone and (2685 kg ha^{-1}) at Geregera was obtained with the application time of urea fertilizer 1/2 at planting and 1/2 at tillering stage of bread wheat in Eastern Amhara Region [34]. Likewise, experiments Conducted on

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Vertisols of Bale Zone, Southeastern Ethiopia showed that increasing the applied levels of N from 0 to 92 kg ha^{-1} linearly increased grain yield of durum wheat and the grain yield (730 kg ha^{-1}) obtained at the highest N levels [35]. Therefore, nitrogen is a key factor in achieving optimum wheat grain yield.

Effect of fertilizer nitrogen on yield components of wheat: Different studies showed that, positive and linear response of wheat to applied N fertilizers were evident in selected agronomic parameters such as plant height, number of fertile tiller per unit area, Thousand Grain Weight (TGW) and number of grain spike^{-1} [36,37]. Research conducted at Chencha, Southern Ethiopia indicated that N applied with the rate of 23, 46, 69 and 92 kg ha^{-1} had significantly affected days to heading and maturity, plant height, number of tillers, panicle, thousand seed weight, grain, straw and total biomass yields and minimizes the date of heading by 9 days compared with control [31]. Meantime N applied 69 kg ha^{-1} had contributed for 18.9% in increments in height than no fertilizer applied. Fertilizer applied at the rate of 46 kg ha^{-1} was contributed for 27.12% increment in spike length than N applied 92 kg ha^{-1}, but resulted for 19.7% reduction compared with N applied 46 kg ha^{-1} and the rate of N fertilizer had not significantly affected harvest index. Generally N applied with the rate of 69 kg ha^{-1} had more tillers, thousand seed weight, biomass, straw and grain yield than fertilizer applied 0, 23, 46 and 120 kg ha^{-1} (Table 1). In line with this result, Abedi, et al. concluded that spikes number m^{-2} [30], number of seeds spike^{-1} and harvest index significantly enhanced with increasing nitrogen levels from 46% at N120, 72% at N240, but the increments of spikes number m^{-2} and 1000 seed weight were non- significant from 240 to 360 kg N ha^{-1}. The result was conformity with that of who stated with increasing levels of nitrogen from 0 to 130 kg ha^{-1} [38], number of tillers unit area^{-1}, spike length, number of grains spike^{-1} and TGW were significantly increased. However, plant height was linearly increased with increasing N rates and the highest value (82.4 cm) recorded at the highest N rate (180 kg ha^{-1}) (Table 2). These results were quite in line with that of [39,40].

The same letter in a column of each factor shows a non-significant difference at 5% probability level.

Effect of fertilizer nitrogen on quality: Nitrogen occupies a conspicuous place in plant metabolism. All vital processes in plant are associated with protein, of which nitrogen is an essential constituent

Table 1: Effect of the rate of N-fertilizer application on growth and yield of wheat.

Treatment	NT (cm)	TBM (kg ha^{-1})	SY (kg ha^{-1})	TGW (g)	GY (Qt ha^{-1})	HI
Nitrogen rates (kg ha^{-1})						
0	2.00^{d}	10821.50^{ab}	8835.70^{a}	46.79^{e}	17.83^{e}	0.25
23	3.10^{c}	9600.80^{bc}	6975.80^{bc}	53.17^{c}	26.25^{c}	0.27
46	4.00^{b}	10414.90^{abc}	7623.20^{abc}	55.17^{b}	27.92^{b}	0.27
69	5.00^{a}	11770.60^{a}	8445.60^{ab}	57.00^{a}	29.50^{a}	0.29
92	2.67^{cd}	8908.30^{c}	6689.70^{c}	50.66^{d}	23.85^{d}	0.27
LSD (%)	0.84	1818.10	1726.50	1.40	1.54	0.06
CV (%)	21.50	22.96	19.25	2.29	5.29	17.85

Source: [31]

NT = Number of Tillers; TBM = Total Bio Mass; SY = Straw Yield; GY = Grain Yield; TGW = Thousand Grain Weight; HI = Harvest Index; the same letter in a column of each factor shows a non-significant difference at 5% probability level.

Table 2: Effect of nitrogen on wheat growth and yield components.

Nitrogen (kg ha^{-1})	Number of tillers unit area^{-1}	Plant height (cm)	Spike length (cm)	Grain number spike^{-1}	1000 grain weight (g)
0	303.5^{c}	69.3^{d}	9.1^{c}	39.5^{c}	39.7^{c}
80	351.2^{b}	77.9^{c}	10.7^{b}	40.5^{b}	40.4^{b}
130	375.8^{a}	80.4^{b}	11.3^{a}	40.9^{a}	41.9^{a}
180	369.0^{ab}	82.4^{a}	10.0^{bc}	40.8^{bc}	40.5^{b}

Source: [38]

[41]. Wheat protein content and baking quality highly depend on genetic background and environmental factors, especially influence of drought and heat stress, during the grain filling period and nitrogen availability (soil N, rate and time of N application) [42]. In line with the results found that protein concentration and hectoliter weight in the wheat grain increased linearly increased with increasing N rate [43]. Nitrogen rate, type of nitrogen, and timing of its application are useful to enhance the baking quality parameters such as protein content and protein quality [44]. Some studies also showed that N fertilization increases the total quantity of flour proteins, resulting in an increase in both gliadins and glutenins [45]. Therefore, proper management of N fertilizer is essential to ensure high quality wheat production by designing of fertilizer application regimes which used to combine rate, timing, splitting, and source of application, with a view to optimizing wheat yield and its quality [46,47]. Corresponding to this finding, numerous studies have been done in order to determine the optimum rate and time of N application as they are a decisive factor in the obtaining of high yields, increased protein content and improved grain quality [48-50]. Studies conducted on N rate and time of application on protein and gluten content showed that N rate significantly affected protein content whereas gluten content was affected by time of N application [30]. Application of 240 kg N ha^{-1} resulted in the maximum amount of seed protein content in all timing treatments (Figure 1). The influence of N rates on the gluten showed non-significant (Figure 2). On the other hand, N timing has a significant effect on gluten content and the maximum amounts of gluten were obtained from T2 (no fertilizing in sowing time), and T1 (no fertilizing in grain filling period) had significant negative effects on gluten (Figure 2).

Role of phosphorus fertilizer in wheat

Next to nitrogen, phosphorus is the most important nutrient needed by a wheat crop. Phosphorus (P) is vital for plant development starting when wheat is just a seedling and continuing all the way to maturity. Besides playing a role in the quality and formation of seeds, this nutrient helps ensure uniform heading, faster maturity and strengthens the plant to help survive the winter [51]. Studies revealed that mild P deficiency in wheat causes stunting while severe deficiency darkens leaves, causes older leaves to brown and die off and reduces tillering, head and grain numbers [52,53].

Study conducted on Kulumsa Agricultural Research Center (KARC), Ethiopia, showed application of 30 kg P ha^{-1} increased the grain yield and biomass yield of wheat by 6.5 qt ha^{-1} (23.73%) and 11.27 qt ha^{-1} (15.17%), respectively when compared with the no phosphorus (P) application. On the other hand, N and P uptakes by wheat ranged from 42.01 kg N ha^{-1} with no P to 52.28 kg N ha^{-1} at

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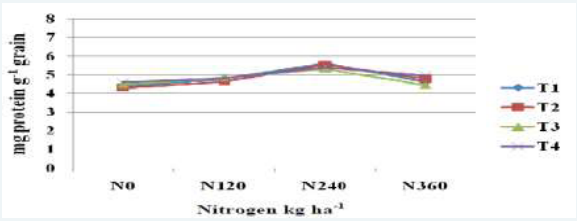

Figure 1: Effect of N fertilization rate and its timing on seed water soluble protein.

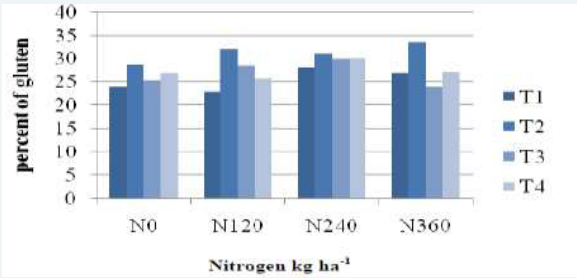

Figure 2: Effect of N fertilization rate and its timing on seed gluten content.

the rate of 30 kg P ha^{-1}, and 20.08 kg P ha^{-1} with no P to 29.06 kg P ha^{-1} at rate of 30 kg P ha^{-1}, respectively [54]. The response to the increased application of P might be associated with improvement in the concentration and uptakes of P and N that could account for the increase in yield. An experiment carried at Enderta, North Ethiopia also indicated that application of different rates of phosphorus fertilizers had significantly increased both grain and straw yield of wheat [55]. According to this report increased application rates of 10 and 20 kg P ha^{-1}, increased the grain yields of wheat by 4 and 11% respectively over the control. Further more research conducted on Samre, North Ethiopia indicated that grain yield, plant height, above ground dry matter yield and panicle length of wheat HAR250 variety increased significantly with increasing P rates and the highest grain yield, plant height, above ground dry matter yield, panicle length and 1000 seed weight were found at 20 kg P ha^{-1} [56]. He also indicated that the highest grain yield of wheat (3.435 t), and above ground dry matter yield (9.200 t) were found at 46 kg ha^{-1} P with interaction of 75 kg ha^{-1} of urea. Recently another research conducted in northern Ethiopia Hawzen district to investigate effect of phosphorus fertilizer level on the growth and yield of wheat also indicated Phosphorus application at a rate of 46 kg P2O5 ha^{-1} increased significantly grain and straw yields by 38% and 46%, respectively than control [55]. On the other hand, Bashir S, et al. observed that maximum grain yield was recorded for 100 kg P2O5 ha^{-1} when applied through double band application method as compared to control. Similar results were also obtained by and who found that grain yield of wheat significantly increased with phosphorus application [57-59].

Interaction of nitrogen with phosphorus

Nitrogen and phosphorus are considered as the most deficient nutrients in soils of Ethiopia [60]. This indicates that nitrogen and phosphorus are the most yield limiting factors of cereals including wheat production in Ethiopia. Grain and straw yields of wheat were not affected significantly due to the interaction effect of nitrogen and phosphorus fertilization [56,61]. In contrast to this findings stated that the maximum yield of 3557 kg ha^{-1} by the application of 128-128 kg ha^{-1} (NP) ratio 1:1 which was indicating importance of phosphorus at its highest dose in achieving maximum wheat productivity [58]. Maximum dose of phosphorus combined with fixed N, yielded maximum number of grains $spike^{-1}$ i.e. 26 in plots treated with 128-128 kg NP ha^{-1} (Table 3). On the other hand, maximum germination count and fertile tillers m^{-2} were obtained in plots treated with NP 128-84 kg ha^{-1}. It might be due to at germination stage seed uses its internal resources and does not depend largely upon external material. The authors also indicated that application of the highest dose of phosphorus in combination with fixed nitrogen, i.e. in 1:1 ratio contributed maximum to translocate dry matter and physiological attributes towards the yield attributes in wheat variety, Inqlab-91 and therefore maximum phosphorus dose helped in achieving highest number of grains $spike^{-1}$, 1000 grain weight and ultimately wheat yield. Molla A noticed that [62], the application of N92 P10 (200/50 of Urea/DAP) and N 130.5 P 30 (225/150 of Urea/DAP) kg ha^{-1} was recommended for bread wheat production on relatively fertile and infertile black soils, respectively, in the central highlands of Ethiopia. Asargew, et al. also reported that among the different N and P amounts combined the combined application of 276 kg/ha N and 90 P2O5 kg/ha is recommended for those farmers with better financial capacity and access to credit to buy fertilizer [63]; however, resource poor farmers can alternatively use 184 kg/ha of N and 90 kg/ha P2O5 followed by 184 kg/ha N and 60 kg/ha P2O5 in Womberema and Debre Elias districts, northwestern Ethiopia.

The same letter in a column of each factor shows a non-significant difference at 5% probability level.

Influence of organic fertilizers on wheat

Farmer's awareness is increasing towards organic farming due to high cost of synthetic fertilizers and nutrient composition in wheat grain all over the world. The continued use of chemical fertilizers causes health and environmental hazards such as ground and surface water pollution by nitrate leaching [64,65]. So, reducing the amount of nitrogen fertilizers applied to the field without a nitrogen deficiency will be the main challenge in field management. One of the possible options to reduce the use of chemical fertilizer could be recycling of organic wastes. Compost as the organic waste can be a valuable and

Table 3: Mean yield and yield components of wheat variety Inqlab-91 as affected by different levels of NP fertilizers.

Treatments	NP (kg ha^{-1})	Germination count m^{-2}	Fertile tillers m^{-2}	Grain $spike^{-1}$	100 grains wt. (g)	Yield (kg ha^{-1})
T1	128-32	148.5	292.5	24.0	40.0	3142.0^{c}
T2	128-42	156.0	304.0	25.5	40.8	3286.0^{b}
T3	128-84	176.5	328.0	22.5	42.5	3251.0^{b}
T4	128-96	155.0	302.5	25.5	40.3	3204.0^{b}
T5	128-128	162.5	319.5	26.0	44.0	3558.0^{a}
		NS	NS	NS	NS	

Source: [58]

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inexpensive fertilizer and source of plant nutrients. Positive effects of organic waste on soil structure, aggregate stability and water-holding capacity were reported in several studies. Gopinath KA, et al. have been reported positive changes in the quality of wheat flour, because of increasing the amount of gluten after compost treatment [66]. Furthermore, compost has high concentrations of NPK, while the contamination by heavy metals and other toxic substances are very low [67,68]. The results of present experiments revealed a significant increase in grain yield when compost was applied. However, there was no significant difference between 30 and 60 Mg compost ha^{-1} application (Table 4). Organic fertilizers have a two-fold effect. The indirect effect consists of the beneficial effect of soil parameters, such as, earthworm abundance and soil organic matter [69,70]. The direct effect consists of the slow provision of nutrients. Pratt, et al. published that 35, 10 and 5% of the total manure nitrogen was available to crops during the first, second and third year respectively [71]. Conversely, a combination of mineral and organic fertilizers can cause environmental damage, as many farmers do not consider organic fertilizers, pig slurry specifically, as fertilizer, but as waste products and so they do not reduce the total amount of mineral nutrients [46]. Another researchers showed that the combination of Green Manure Crop (GM), Farm Yard Manure (FYM), Poultry Manure (PM), Press Mud (PM) and Sewage Sludge (SS) green manure crop + poultry litter + sewage sludge each at 10 t ha^{-1} gave maximum productive tillers, number of grain per spike and 1000-grain weight as a result this combination gave highest wheat grain yield [68].

Means in the same column followed by the same letters are not significantly different ($P < 0.05$), according to Duncan's test.

Combined effect of organic and chemical fertilizers on wheat

Integration of both organic and inorganic forms has significant effect on crop production. For instance experiment conducted in northern western Ethiopia using treatments of manuring, liming and inorganic fertilizers significantly affected the growth of Wheat. The present study indicated that the effect of interaction between manure, lime and P fertilizer were higher than the main effect (Table 5). A combination of 10 t ha^{-1} manure and 2.2 t ha^{-1} limes produced greater yield and from the combination of P and Manure 10 t ha^{-1} and 30 kg P ha^{-1} produced more grain yield in Wheat. On the other hand, the experiment conducted in central highlands of Ethiopia on integrated soil fertility in Wheat and Teff showed that the organic carbon content increase under Organic and combination of organic and in organic condition. Application of inorganic or organic nutrient sources alone or mixed has significant effect on wheat grain yield, total biomass and harvest index but didn't affect the thousand grain weight. Higher yield, total biomass and straw yield was obtained from the combination of organic and inorganic compounds yield increase was over 100 % [17]. The same is true that grain yield, total biomass, straw yield has also responded for combined use of organic and in organic plant nutrients.

Table 4: Effect of compost on wheat yield and yield components.

Compost (Mg ha^{-1})	grain yield (kg ha^{-1})	Spike number m^{-2}	Seed number m^{-2}	1000 grain weight (g)
0	3025.80^{b}	479.20^{b}	15.21^{b}	39.42^{b}
30	5110.60^{a}	735.60^{a}	17.90^{ab}	38.69^{c}
60	5360.90^{a}	841.30^{a}	19.96^{a}	40.23^{a}

Source: [72]

Table 5: Main and two-way interactions of manure effects on grain yield (t ha^{-1}).

Manure t ha^{-1}	Lime t ha^{-1}			Phosphorus (kg ha^{-1})			Manuring
	0	2.2	3.3	0	20	30	
0	0.898	1.980	1.787	1.191	1.654	1.820	1.560
5	1.741	2.689	2.170	1.466	2.501	2.619	2.200
10	2.215	2.736	2.212	1.958	2.515	2.704	2.390
Lime and P	1.618	2.468	2.056	1.538	2.223	2.381	

Source: [76]

The experiment conducted by on the effects of different levels of inorganic (0, 80, 160 and 240 kg N ha^{-1}) and organic (0, 30 and 60 Mg municipal waste compost ha^{-1}) fertilizers on wheat grain yield [72], gluten content, protein variability and protein banding pattern on polyacrylamide gel in different growth stages of irrigated wheat and concluded all in all, it is possible to obtain maximum grain yield, protein and gluten, just in 160 kg ha^{-1} nitrogen level. This shows the positive impact of compost application on reduction of chemical fertilizer use. Imbalanced fertilization practiced over a long period of time and replacement of recycling of organic materials and application of organic manures raised concerns about the potential long-term adverse impacts on soil productivity and environmental quality [73]. Addition of Farm Yard Manure (FYM) with inorganic fertilizers to soil has been reported to increase the efficiency of applied fertilizers moreover; addition of FYM with inorganic fertilizers improves organic matter content of soil and consequently water holding capacity of soil [74]. Nutrient replenishment by merely adding chemical fertilizers is often not economically feasible and even in the technically, it may not be in balance with the supply of organic matter. Study in Nitisols of South Ethiopia by the Awasa Agricultural Research Center indicate that using *Erythrina bruice* as a green manure crop either its biomass alone or in combination with mineral fertilizer is found to increase the yield and yield components of bread wheat [75]. The author also reported that *Erythrina bruice* is a nitrogen fixing plant, which fix's the nitrogen through its leaves; this tree is endemic to Ethiopia and is a fast growing nutrient rich plant particularly high with nutrient contents on NPK.

An integrated use of chemical and organic fertilizer has proved to be highly beneficial for sustainable crop production. Several researchers have demonstrated the beneficial effect of combined use of chemical and organic fertilizers to mitigate the deficiency of many secondary and micronutrients in fields that continuously received only N, P and K fertilizers [76,77]. The rapid increase in the world population demands parallel increases in food production, particularly of wheat. In order to preserve the environment and the present natural resources, further increases in global wheat production must be along with a proper management of fertilization. Integrated use of organic wastes and chemical fertilizers is beneficial in improving crop yield, soil pH, organic carbon and available N, P and K in soil [78]. The results of present experiments indicated that wheat grain yield and yield components increased significantly with the application of compost (Table 6). However, there were no significant enhancements in these parameters under last two levels of N and compost applications (160 and 240 kg N ha^{-1}) or (30 and 60 Mg

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Table 6: Interaction effects of nitrogen and compost on wheat grain yield (kg ha $^{-1}$).

Treatment	Compost (Mg ha^{-1})			
Nitrogen (kg ha^{-1})	0	30	60	Mean
0	1274.19^{f}	3600.90^{de}	3312.65^{de}	2720.20^{c}
80	2893.58^{e}	4206.67^{cde}	5274.42^{bc}	4124.80^{b}
160	3439.00^{de}	7546.19^{a}	6548.55^{ab}	5844.59^{a}
240	4507.00^{cd}	6089.94^{b}	5307.09^{bc}	5301.00^{a}
Mean	3021.70^{b}	5110.60^{a}	5360.90^{a}	

Source: [72]

ha^{-1} compost). Additionally, results showed that the use of chemical fertilizer, N, in combination with organic materials, compost, further enhanced the grains yield.

Besides the positive effect of organic fertilizer on soil structure that lead to better root development that result in more nutrient uptake, compost not only slowly releases nutrients but also prevents the losses of chemical fertilizers through denitrification, volatilization and leaching by binding to nutrients and releasing with the passage of time [79]. Rational use of organic and mineral fertilizers, based on the knowledge of their chemical composition, can lead to the same results as using mineral forms alone, thus reducing financial costs and not endangering the environment [46]. Hence; it is very likely that when we apply enriched compost along with chemical fertilizers, compost prevents nutrient losses. Consequently, integrated use of chemical fertilizers and recycled organic waste may improve the efficiency of chemical fertilizers and reduce their use in order to improve crop productivity as well as sustain soil health and fertility. Increasing yield potential without negative effect on the quality of the grain is difficult, mainly because increases in grain yield are generally accompanied by a decrease in the seed protein content, which is strongly associated with bread making quality.

Means in the same column and the last row followed by the same letters are not significantly different ($P < 0.05$), according to Duncan's test.

Summary and Conclusion

Despite the large area under wheat, the national average yield of wheat in Ethiopia is definitely below the world's average. Soil fertility depletion, low levels of chemical and organic fertilizer usage, imbalanced use of mineral fertilizers, and limited knowledge on time and rate of fertilizer application and the unavailability of other modern crop management inputs are some of the constraints. Therefore, managing of soil fertility is decisive for improving wheat productivity. The rapid increase in the world population demands parallel increases in food production, particularly of wheat. In order to preserve the environment and the present natural resources, further increases in global wheat production must be along with a proper management of fertilization. Integrated use of organic wastes and chemical fertilizers is beneficial in improving crop yield, yield components and quality, soil pH, organic carbon and available N, P and K in soil. The continued use of chemical fertilizers alone causes health and environmental hazards such as ground and surface water pollution by nitrate leaching. One of the possible options to reduce the use of chemical fertilizer could be recycling of organic wastes like compost, green manure and farm yard manure. Hence, the future research should be focused on integrated nutrient management includes combination of both organic and inorganic source in a sustainable way to improve soil fertility as well as crop productivity which is in turn vital to feed the alarm rate increments of human populations.

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