academicJournals

Vol. 12(5), pp. 114-121, May 2018
DOI: 10.5897/AJPS2018.1637
Article Number: AAD58D456949
ISSN 1996-0824

http://www.academicjournals.org/AJPS

African Journal of Plant Science

Full Length Research Paper

Comparative effects of newly introduced and adopted chemical N and P fertilizers on wheat growth, yield and yield components

Tarekegn Yoseph[1*], Tewodros Ayalew[1], Xinzhu Li[2], He Jigang[2] and Tingshuai Yan[2]

[1]School of Plant and Horticultural Sciences, College of Agriculture, Hawassa University, P. O. Box 05, Ethiopia.
[2]Kingenta Ecological Engineering Group Co., Ltd, Linyi, P. R. China.

Received 3 January, 2018; Accepted 5 April, 2018

Soil fertility decline is one of the prime factors contributing to low productivity of crops and food insecurity in Ethiopia. To alleviate this problem and achieve maximum yield, identifying suitable agronomic inputs such as N and P types in wheat production systems is very important. The aim of this study was therefore, to estimate the effects of different N and P fertilizer types and rates on growth, yield and yield components of wheat at Hawassa, southern Ethiopia. For this purpose a treatments consisting of seven N and P sources (F1=Control, F2=Local recommended Urea 100 kg ha^{-1} and DAP 100 kg ha^{-1}, F3=Urea 100 kg ha^{-1} and Enhanced DAP 100 kg ha^{-1}, F4=Black Urea 103.3 kg ha^{-1}and Enhanced DAP 100 kg ha^{-1}, F5=100 kg ha-^{1} Enhanced Urea-1 and Enhanced DAP 100 kg ha^{-1}, F6=Enhanced Urea-2 100 kg ha^{-1}and Enhanced DAP 100 kg ha^{-1} and F7=Compound fertilizer 256.25 kg ha^{-1}) were studied using a randomized complete block design with three replications. Analysis of the data recorded from the combined application of different N and P treatments revealed that maximum grain yield (3.67 t.ha^{-1}) was obtained from the plots which were supplied with Enhanced Urea-2 and Enhanced DAP at the rate of 100-100 kg ha^{-1}. It can be concluded from the result that wheat crop performed better when fertilized with this treatment. Therefore, the application of enhanced DAP 100 kg ha^{-1} with Enhanced Urea-2 100 kg ha^{-1} is recommended to optimize the growth and yield performance of wheat.

Key words: Enhanced DAP (diammonium phosphate), enhanced urea, growth, yield components, wheat.

INTRODUCTION

Ethiopia is one of the largest cereal crop producers in Africa, and the second largest wheat producer in sub-Saharan Africa, following South Africa (GAIN, 2012). Most wheat production in the country comes from small holder farmers. Wheat is primarily grown in the Southeast central and Northwest parts of the country. Small amount is produced in the rest of the North and South regions. At the national level currently 1,453,817 ha of land is covered by bread and durum wheat and over 25,376,39.8 tones are produced from this land annually (Crop Variety

*Corresponding author. E-mail: tareyoseph@gmail.com. Tel: +251929479195.

Register, 2010). Nutritionally, the crop provides an excellent source of carbohydrates, proteins (20 to 25%), fates (20 to 25%), vitamins such as:- thiamine, niacin, pantothenic acid, riboflavin and folate and minerals such as iron, magnesium, zinc and phosphate (Kumar et al., 2011). In addition to this, inclusion of wheat in the daily diet has several health benefits and can be used for different liver ailments, to help prevent cancer, tooth decay, skin problems such as eczema and psoriasis (www.organicauthority.com/benefits-of-wheatgrass.html).
It is also claimed to reduce hair from greying, improves digestion, reduces high blood pressure as it enhances the capillaries, support the growth of *lactobacilli* and can remove heavy metals from the body (Meyerowitz, 1999). It is found to improve hematological toxicity related to chemotherapy in breast cancer patients, it reduces the frequency and requirement of blood transfusions in thalassemia major (Singh et al., 2010; Arya and Kumar, 2011).

Despite, the importance of wheat and its many useful characteristics, its production is low in Ethiopia. Its average yield for example is about 2.1 t ha^{-1} which is much lower than the potential yield of 5.0 t ha^{-1} (Hailu, 1991; MoA, 2012; 2011). The low yields of wheat is partly attributed by biological and environmental factors, such as frequent occurrence of drought, declining of soil fertility, poor agronomic practice, limited and suboptimal use of production inputs, insufficient technology generation, lack of credit facilities, poor seed quality and weak supply, disease, insect, pests and weeds particularly, Striga (Spielman et al., 2011; MoA, 2012; 2011). The most important constraint that threatens wheat production in Ethiopia is poor soil fertility (CSA, 2012). Particularly, the deficiency of nitrogen (N) and phosphorus (P) is the main factor that severely reduces the growth and yield of most cereals including wheat. In order to alleviate the soil fertility problem in the area, the Bureau of Agriculture and Natural Resources of the Region has introduced chemical fertilizers particularly DAP (diammonium phosphate) and urea fertilizers in each district of the zone. However the fertilizer types and the rate which is being used by farmers are very limited and recommended in blanket basis throughout the region. Fertilizer is the most important agricultural input which contributes markedly towards final grain yield of wheat and to exploit the inherited potential of a cultivar. N is an essential component of deoxyribonucleic acid (DNA), ribonucleic acid (RNA), and proteins, the building blocks of life (Harrison, 2010). All organisms require N to live and grow. Even though N is among the most abundant elements on earth, it is the critical limiting element for growth of most plants due to its unavailability (Graham and Vance, 2000).

Several investigators (Khursheed and Mahammad, 2015; Solomon and Anjulo, 2017) reported a beneficial effect of N application on wheat. They reported that plant height, numbers of tillers, spike length, number of spikelet's and grains per spike, grain and straw yields of wheat increased with increasing N to the optimum level. P has great importance in plant nutrition. It involves in the processes of energy transformations, genetic inheritance, protein synthesis and cell division. Moreover P enhances root development and strengthening of straw, affects flowering, fruiting, seed formation and crop maturation (Gebreslassie and Demoz, 2016). Many researches reported the beneficial effect of P fertilization on growth and grain yield of cereal crops including wheat (Harfe, 2017). Kaleem et al. (2009) has also shown that the application of P fertilizer to wheat crop has significantly increased the plant height, number of tillers plant^{-1}, straw and grain yield over the control treatment. So far, little information is available on the wheat growth and yield enhancing effects of N and P fertilization in Ethiopia in general and in Southern region in particular. Therefore, the present study was aimed to evaluate the effects of newly introduced and adopted chemical N and P fertilizers on wheat growth, yield and yield components.

MATERIALS AND METHODS

Site description

The field experiment was conducted in Hawassa University research field which is located at 273 km Southwest of the capital Addis Ababa in the South Nation Nationalities and People Regional State (SNNPR). The site is located at 7^0 4'N latitude and 38^0 31'E longitude and at an altitude of 1969 m.a.s.l. The soil type of the area is sandy loam with a pH of 7.9. The average annual rainfall of the area is 800 to 1100 mm, with the average annual maximum, minimum and mean temperature of 27, 12, and 20°C, respectively (Agro-Meteorology Department, Hawassa Agricultural Research Center).

Source of inputs, plant material, treatments, experimental design and procedures

Except treatment F2 (locally used Urea and DAP fertilizers) all fertilizers were imported and obtained from the Kingenta Fertilizer Company of China. These different fertilizers were known to enhance growth and yield performances of cereals including wheat in different provinces of China. A high yielding wheat variety Jonsen, which is adapted to the agro-ecology of the area, was used for the study. Seeds were obtained from the Hawassa Agricultural Research Centre, Hawassa, Ethiopia. The variety was chosen based on its high yield ability, acceptability by farmers and seed availability. The treatments consisted of seven N and P types (F1=Control, F2=Local recommended Urea 100 kg ha^{-1} and DAP 100 kg ha^{-1}, F3= Urea 100 kg ha^{-1} and Enhanced DAP 100 kg ha^{-1}, F4=Black Urea 103. 3 kg ha^{-1}and Enhanced DAP 100 kg ha^{-1}, F5=Enhanced Urea-1 100 kg ha^{-1}and Enhanced DAP 100 kg ha^{-1}, F6=Enhanced Urea-2 100 kg ha^{-1}and Enhanced DAP 100 kg ha^{-1} and F7=Compound fertilizer 256.25 kg ha^{-1}. The size of each plot was 3 m × 4 m (12 m^2) and the distance between adjacent plots and blocks kept at 1.0 m and 1.0 m apart, respectively. Seeds were sown by drilling using a row spacing of 20 cm. The experiment was laid out using a factorial randomized complete block design (RCBD) with three replicate plots. Weeding was done manually by hoe at two weeks after seedling emergence, and three weeks later. Finally, wheat plants were harvested from the three central rows to determine yield and yield components of wheat on 27 September, 2017.

Data collected

Plant height

This was measured at mid-head setting stage by measuring ten randomly selected plants from ground level to the top of the spike termination node and averaged for a single reading.

Root length

The same sample was taken and root length was measured through measuring tape and averaged for a single mean root length in each experimental unit.

Number of tiller per plant

Tiller number was counted by ten randomly selected plants and values averaged for a single reading.

Shoot dry weight per plant

This was measured at harvest by measuring ten randomly selected plants and averaged for a single reading.

Spike length

This was measured from ten randomly selected spikes at harvest from each plot through measuring tape.

1000-grains weight (g)

This was measured at harvest and weighed on top loading digital balance and its averaged was taken as 1000-grain weight.

Grain and biological yield

Grain and biological yield were recorded at three central rows harvested in each experimental unit. Subsequent sample was oven dried at 70°C for maximum 48 h to estimate dry matter yield.

Harvest index

This was calculated as a ratio of grain yield to total biological yield.

Statistical analysis

The obtained data were subjected to analysis of variance (ANOVA) using the General Linear Model (GLM) of the Statistical Analysis System (SAS, 2002) version 9.0. Mean separation was done using Least Significant Difference (LSD) test at 5% probability level. Plants grown in non-N and P amended soil served as control.

Soil sampling and analysis

Before planting soil samples were randomly taken from the experimental site at a depth of 30 cm using an auger and the samples were mixed thoroughly to produce one representative composite sample of 1 kg. The composite soil sample was air-dried and ground to pass 2 and 0.5 mm (for total N) sieves. Then the processed sample was analyzed following standard laboratory procedures as outlined by Sahlemedhin and Taye (2000) at Hawassa University College of Agriculture soil laboratory. Organic carbon (OC) and total N contents of the soil were determined following the wet combustion method of Walkley and Black, and wet digestion procedure of Kjeldahl method, respectively. The available P content of the soil was determined following Olsen method. Soil texture was analyzed by Bouyoucos hydrometer method. The cations exchange capacity (CEC) of the soil was determined following the 1N ammonium acetate (pH 7) method. The pH (1:2.5 solid: liquid ratio) of the soils was measured in water using pH meter with glass-calomel combination electrode.

RESULTS AND DISCUSSION

Soil physico-chemical properties

The results of pre-planting soil analysis revealed that, the experimental soil is sandy loam in texture (38.0% sand, 24.0% silt and 38.0% clay). Soil texture is a fundamental soil property which in practice the farmer can do little to modify. It is also closely related to the water-holding capacity of soils, since loams and clays hold more water than sandy soils (Brady, 2002). Thus, the experimental soil has good water holding capacity, which creates a suitable growing media for cereal crops. Wheat is characteristically grown on such soils which holds sufficient amount of residual soil moisture. The soil was slightly acidic in reaction with the pH (H_2O 1:2.5) value of 6.4, which is within the range of optimum soil pH for cereal production including wheat (Havlin et al., 1999). The total N, available P, OC and CEC of the soil before planting were 0.15%, 7.6 mg kg^{-1}, 5.9%, and 24.3 cmol (+) kg^{-1}, respectively (Table 1). According to Havlin et al. (1999) soils are classified depending on their total N content in percentage (%), as very low (<0.1), low (0.1 to 0.15), medium (0.15 to 0.25), and high (>0.25). Thus, the soil of the study site has low total N content. Olsen et al. (1954) classified available P content of the range <5 as very low, 5 to 15 as low, 15 to 25 as medium and >25 mg kg^{-1} as high. According to Landon (1991) the soil organic carbon content ranges from 1 to 2, 2 to 4, and 4 to 6% are rated as low, medium and high, respectively. Thus, the OC content of the soil is considered as low before planting. The CEC ranges from 5 to 15, 15 to 25 and 25 to 40 cmol kg^{-1} are rated as low, medium and high, respectively. Based on these ratings, the cation exchange capacity (24.3 cmol kg^{-1}) before planting of the experimental field was in the medium range.

Generally the soil analysis result indicated that, the soil is nutrient deficient to support the potential crop production. This may be associated with poor farm management practices and continuous cropping with little or no fertilizers input which resulted in a decline in soil fertility. It may be because of this that growth, yield and yield components of wheat responded to supplied N and

Table 1. Physico-chemical properties of the experimental soil before planting.

pH	Organic carbon (%)	Total N (%)	Available Phosphorus (mg kg^{-1})	CEC (cmol kg^{-1})	Sand (%)	Silt (%)	Clay (%)	Textural Class
6.4	1.81	0.15	7.6	24.3	38.0	24.0	38.0	Sandy loam

Table 2. Analysis of variance for plant height, root length, number of tillers, shoot dry weight of wheat grown at Hawassa, in 2017.

Source of variation	Degree of freedom	Plant height (cm)	Root length (cm)	Number of tillers	Shoot dry weight (g)
Replication	2	2.30	1.94	0.12	0.55
Treatment	6	39.98***	9.46***	5.15***	2.82***
Error	12	4.58	0.66	0.53	0.28

*** Significant at 0.1% levels.

Table 3. Effect of different types of N and P application on plant height, root length, number of tillers and shoot dry weight of wheat grown at Hawassa, in 2017.

Treatment	Plant height (cm)	Root length (cm)	Number of tillers	Shoot dry Weight (g)
F1	34.8±0.53^{d}	6.3±0.24^{d}	5.1±0.07^{c}	8.2±0.30^{c}
F2	40.5±1.73^{bc}	9.6±0.23^{bc}	6.4±0.12^{b}	9.8±0.44^{b}
F3	39.3±0.53^{c}	9.4±0.70^{c}	6.7±0.18^{b}	9.4±0.07^{b}
F4	40.3±1.71^{c}	10.0±0.20^{bc}	8.5±0.29^{a}	10.1±0.49^{ab}
F5	41.4±0.12^{bc}	10.4±0.53^{bc}	8.1±0.87^{a}	10.1±0.32^{ab}
F6	44.1±1.67^{ab}	11.9±0.87^{a}	8.6±0.42^{a}	11.1±0.22^{a}
F7	46.3±0.79^{a}	10.9±0.53^{ab}	6.6±0.20^{b}	11.0±0.26^{a}
CV%	5.2	8.2	10.2	5.3
LSD%	3.8	1.4	1.3	0.94

Means with the same letter(s) within a column are not significantly different at p<0.05. F1 = Control, F2 = Local recommended Urea 100 kg ha-^{1} and DAP 100 kg ha-^{1}, F3= Urea 100 kg ha-^{1} and Enhanced DAP 100 kg ha-^{1}, F4 = Black Urea 103. 3 kg ha-^{1}and Enhanced DAP 100 kg ha-^{1}, F5 = 100 kg ha-^{1} Enhanced Urea-1 and Enhanced DAP 100 kg ha-^{1}, F6 = Enhanced Urea-2 100 kg ha-^{1} and Enhanced DAP 100 kg ha-^{1} and F7= compound fertilizer 256.25 kg ha-^{1}.

P fertilizers in the present experiment.

Plant height

Different types of N and P fertilizer had highly significant effects on the plant height (Table 2). The highest mean plant height was obtained from plots supplied with treatment F7 (compound fertilizer) (46.3 cm) which was significantly different from the other treatments, except F6 (Table 3). The lowest plant height (34.8 cm) was recorded from the treatment F1 (control), which was significantly inferior to all other treatments. Plant height increment of 87.5% was obtained from F7 as compared to the F2 (locally used urea and DAP) fertilizers. The reasons for the increased plant height under different N fertilizer types could be due to the increased vegetative growth with applied N. In line with this, Razaq et al. (2017) obtained increased plant height of wheat fertilized with N. Similarly, Abera (2013) reported that applied N at different rates resulted in increased vegetative growth period of maize that increases photosynthetic assimilate production and its partitioning to stems that might have favorable impacts on heights of maize. On the other hands, increase in plant height due to application of P might be attributed to more availability of nutrients due to increased levels of P, which exerted beneficial effect on vegetative growth of plant. Increase in plant height with supplied N and P levels has also been observed by Khan et al. (2014). This may be due to increased root growth, which strengthened the stem against lodging during prolonged vegetative growth. Furthermore, Khalil et al. (1988) and Umeri et al. (2016) reported that marked increase in plant height of maize due to combined application of NP fertilizers.

Root length plant^{-1}

Statistical analysis of data revealed significant effects of

Table 4. Analysis of variance for yield and yield components of wheat grown at Hawassa, in 2017

Source of variation	Degree of freedom	Spike length (cm)	1000 grain weight (g)	Grain yield (t. ha^{-1})	Biological yield (t. ha^{-1})	Harvest index
Replication	2	3.53	22.33	0.17	0.08	0.006
Treatment	6	21.06***	166.89**	2.09***	2.92***	0.03**
Error	12	1.87	31.39	0.15	0.19	0.004

*** and ** Significant at 0.1 and 1% levels, respectively.

different N and P fertilizer types on root length plant^{-1} (Table 2). Maximum mean root length plant^{-1} was obtained from the F6 (11.9 cm) and it was significantly different from all other treatments except treatment F7 which in turn was not significantly different from treatments F2, F4 and F5 (Table 3). The lowest root length plant^{-1} (6.3) was recorded from F1 (control). All other N and P fertilizer treatments increased root length plant^{-1} to a variable extent over the control, indicating that the need of N and P sources for better root growth in nutrient deficient soils. The increased root growth beneficially increases the potential soil water and nutrient reservoirs of the growing crops (Gajri et al., 1989). Studies in wheat have reported that applications of N fertilize, typically increase water use efficiency in both irrigated (Hussain and Al-Jaloud, 1995) and rain-fed systems (Belford et al., 1987). P also plays an important role in lateral root morphology and root branching and influences not only root development, but also the availability of N nutrients (Lopez-Bucio et al., 2003; Jin et al., 2005). Similar to these results Razaq et al. (2017) reported an increased root growth due to supplied N and P fertilizers.

Number of tillers plant^{-1}

Analysis of variance on tiller number plant^{-1} revealed the existence of highly significant difference among the combined application of N and P fertilizers (Table 2). Maximum mean number of tillers plant^{-1} was obtained from the treatment F6 and it was significantly at par with treatments F3 and F4 (Table 3). The lowest tiller number per plant (5.1) was recorded from the control treatment. This study is supported by Tabar (2013) where application of N and P fertilizers found to favor tillering in rice. Wakene et al. (2014) also reported an increased number of fertile tillers, total biomass and straw yield of barley due to addition of P.

Shoot dry weight plant^{-1}

Plant growth measured as shoot dry matter was significantly (P<0.001) affected by combined application of N and P fertilizers (Table 2). The highest (11.1 g plant^{-1}) shoot dry matter was recorded from treatment F6, but statistically parity between this treatment and treatments F7, F4 and F5 (Table 3). However, the lowest shoot dry weight (8.2 g) was recorded from treatment F1 (control). This is in agreement with the findings of Elgharably (2011) who stated an increased shoot dry matter of wheat due to individual and combined application of N and P in a saline sandy loam soil.

Spike length plant^{-1}

Application of different types of N and P fertilizers significantly increased spike length (Table 4). The highest spike length (14.5 cm) was recorded from the application of treatment F6 (Enhanced Urea-2 100 kg ha^{-1}and Enhanced DAP 100 kg ha^{-1}). However, statistically significant variation in spike length was not detected between this treatment and treatment F7 (Table 5). However, these treatments were significantly higher over the control. These results are similar with the findings of Kaleem et al. (2009) who reported maximum NP fertilizer utilization recorded the highest yield effects due to maximum accumulation of photosynthates. The length of spikelets per spike plays a paramount role towards the grain per spike and final yield of wheat crop (Shahzad et al., 2007).

1000- grains weight

The data given in Table-4 showed that there were highly significant (P<0.01) variations in fertilized and non-fertilized treatments for 1000-grain weight. Maximum 1000 grain weight (55.7 g) was obtained from plots treated with enhanced urea and DAP at 100-100 kg ha^{-1}. However, the minimum (30.7 g) 1000-grain weight was obtained from the treatment where NP was not supplied (Table 5). All the other treatments fall in between these treatments. The relatively heavier seed weight in N and P treated plots was obtained possibly due to increased assimilates production and photosynthesis efficiency at the grain filling stage of the plant because of improved plant mineral nutrition. Furthermore, it may be due to greater contribution of N and P by producing healthy grains which have well filled and bigger grains than the

Table 5. Effect of different types of N and P application on yield and yield components of wheat grown at Hawassa, in 2017.

Treatment	Spike length (cm)	1000grain weight (g)	Grain yield (t. ha^{-1})	Biological yield (t. ha^{-1})	Harvest index
F1	6.0±0.40^{d}	30.7±1.86^{c}	0.92±0.17^{c}	2.67±0.26^{d}	0.34±0.03^{b}
F2	10.9±0.73^{bc}	42.0±1.53^{b}	2.37±0.32^{b}	4.25±0.11^{c}	0.55±0.06^{a}
F3	10.2±0.70^{c}	41.7±2.19^{b}	2.41±0.04^{b}	4.33±0.19^{bc}	0.56±0.03^{a}
F4	11.7±0.55^{bc}	44.3±3.28^{b}	2.78±0.21^{b}	5.07±0.19^{ab}	0.55±0.05^{a}
F5	11.3±1.54^{bc}	44.0±4.00^{b}	2.94±0.02^{b}	5.07±0.19^{ab}	0.58±0.02^{a}
F6	14.5±0.94^{a}	55.7±3.28^{a}	3.67±0.37^{a}	5.81±0.32^{a}	0.63±0.04^{a}
F7	12.9±0.44^{ab}	47.3±4.70^{ab}	2.74±0.18^{b}	4.66±0.36^{bc}	0.59±0.02^{a}
CV%	12.4	12.8	15.0	9.7	12.3
LSD%	2.4	10.0	0.7	0.78	0.12

Means with the same letter(s) within a column are not significantly different at $p<0.05$. F1 = Control, F2 = Local recommended Urea 100 kg ha-^{1} and DAP 100 kg ha-^{1}, F3= Urea 100 kg ha-^{1} and Enhanced DAP 100 kg ha-^{1}, F4 = Black Urea 103. 3 kg ha-^{1}and Enhanced DAP 100 kg ha-^{1}, F5 = 100 kg ha-^{1} Enhanced Urea-1 and Enhanced DAP 100 kg ha-^{1}, F6 = Enhanced Urea-2 100 kg ha-^{1} and Enhanced DAP 100 kg ha-^{1} and F7= compound fertilizer 256.25 kg ha-^{1}.

control treatments. These results are similar with the findings of Khan et al. (2014) who reported improved seed weight due to combined application of NP fertilizers on maize.

Grain yield

The fertilizer treatments significantly affected the grain yield of wheat (Table 4). The yield was highest in the F6 treatment, followed by treatments F5, F7, F3 and F2, respectively. In the F1 (control), the yields of wheat was significantly lower than those other treatments. On the other hands, it was visually observed that wheat plants in the control plots were very thin with small spike size, short and light in color. Whereas, plants in the N and P fertilized plots had thick and strong stems, green in color, large spike size. The increased grain yield due to applied N and P might be attributed to low nutrient contents of study site (Table 1). Thus, the availability of these nutrients enables the plant to develop more extensive root system to extract water and nutrients, from more depth. This could enhance the plants to produce more assimilates, which was reflected in higher biomass (Gobarah et al., 2006). Furthermore, the increases in yield due to P fertilizer may be attributed to the activation of metabolic process, where its role in building phospholipids and nucleic acid is known (Gentili and Huss-Danell, 2003). This result is in agreement with the findings of Bereket et al. (2014) who reported that application of N and P fertilizers increase grain yield of wheat. These results do not agree with the findings of Kulhare et al. (1991) who studied NP doses effect on late sown wheat crop and reported that application of NP, does not increased wheat yield.

Biological yield

Application of different types of N and P fertilizer had highly significant effects on the biological yield of wheat (Table 4). Highest biological yield of (5.81 t. ha^{-1}) was obtained from treatment F6 but was not statistically different than the treatments F4 and F5 (Table 5). The lowest biological yield (2.67 t ha^{-1}) was recorded from the control, which was significantly inferior to all other treatments. Greater plant height, yield and yield components might have contributed to the differences observed in biological yield among the different types of N and P application. These results are in confirmation with the findings of Islam and Baten (1987) and Patel et al. (1991) who recorded maximum biological yield by the application of optimum N and P fertilizer rates when compared to the treatments receiving no N and P fertilizers.

Harvest index

Harvest index was influenced significantly by different N and P fertilizers treatments (Table 4). The highest harvest index (0.63) was recorded in F6 and it was at par with all the treatments except the control. The lowest harvest index (0.34) was recorded from the control treatment (Table 5). The physiological ability of a crop plant to convert proportion of dry matter into economic yield is measured in terms of harvest index. The results indicated that adequate supply of N and P fertilizers in combination enhanced dry matter partitioning in favor of grain showing a greater harvest index. This is illustrated by the lower harvest indices observed under the treatments that received no N and P treatments. These results corroborate the findings of Mesfin and Zemach (2015), who reported similar results.

Conclusion

In this study it was found that, the combined application of N and P fertilizers had significant effect on growth, yield and yield components of wheat. Among the treatments studied, Enhanced Urea-2 and enhanced DAP 100 kg ha^{-1}, respectively gave greater grain yield. Furthermore, this treatment enhanced growth and yield related parameters compared to the control treatment. Thus, it is possible to recommend the combined application of Enhanced Urea-2 and Enhanced DAP at the rate of 100 kg $ha\text{-}^{1}$ each to attain greater grain yield of wheat in the study area. However, it is advisable to undertake further research across soil type, years and locations to draw sound recommendation on a wider scale.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

ACKNOWLEDGMENTS

The authors are grateful to Kingenta Fertilizer Company for supplying enhanced N and P fertilizers and for financial support to conduct this experiment.

REFERENCES

Abera K (2013). Growth, productivity and nitrogen use efficiency of maize (*Zea mays* L.) as influenced by rate and time of nitrogen fertilizer application in Haramaya District, Eastern Ethiopia and extension needs. Field Crops Res. 65:93-106.

Arya P, Kumar M (2011). Chemoprevention by (*Triticum aestivum* L.) of mouse skin carcinogenesis induced by DMBA and croton oil-association with oxidative status. Asian Pac. J. Cancer Prev. 12:143-148.

Belford RK, Klepper B, Rickman RW (1987). Studies of intact root-shoot systems of field grown winter wheat-II. Root and shoot developmental patterns as related to nitrogen fertilizer. Agron. J. 79:310-319.

Bereket H, Dawit H, Mehretab H, Gebremedhin G (2014). Effects of Mineral Nitrogen and Phosphorus Fertilizers on Yield and Nutrient Utilization of Bread Wheat (*Tritcum aestivum*) on the Sandy Soils of Hawzen District, Northern Ethiopia. Agric. Forest. Fish. 3(3):189-198.

Brady NC (2002). Phosphorus and potassium. In. Brady, N.C. and Weil, R.R. (eds.) The Nature and Properties of Soils. Dehli, India: Prentice-Hall. pp. 261-272.

Crop Variety Register (2010). Animal and plant health regulatory directorate. Issue No. 12, Addis Ababa, Ethiopia.

Central Statistical Agency (CSA) (2012). Agricultural sample survey: area and production of major crops, meher season. Vol. I. Addis Ababa, Ethiopia.

Elgharably A (2011). Wheat Response to Combined Application of Nitrogen and Phosphorus in a Saline Sandy Loam Soil. Soil Sci. Plant Nutr. 57:396-402.

Global Agricultural Information Network (GAIN) (2012). Assessments of commodity and trade issues made by USDA staff and not necessarily statements of official U.S. government policy. Report number ET 1201.

Gajri PR, Prihar SS, Arora VK (1989). Effects of nitrogen and early irrigation on root development and water use by wheat on two soils. Field Crops Res. 21(2):103-114.

Gebreslassie HB, Demoz HA (2016). A Review on: Effect of Phosphorus Fertilizer on Crop Production in Ethiopia. J. Biol. Agric. Healthc. 6(7):117-120.

Gentili F, Huss-Danell K (2003). Local and systemic effects of phosphorus and nitrogen on nodulation and nodule function in Alnus incana. J. Exp. Bot. 54:2757-2767.

Gobarah ME, Mohamed MH, Tawfik MM (2006). Effect of phosphorus fertilizer and foliar spraying with zinc on growth, yield and quality of groundnut under reclaimed sandy soils. J. Appl. Sci. Res. 2(80):491-496.

Graham PH, Vance CP (2000). Nitrogen fixation in perspective: an overview of research and extension needs. Field Crops Res. 65(2-3):93-106.

Hailu GM (1991). Wheat productions and research in Ethiopia. IAR, Addis Ababa.

Harfe M (2017). Response of bread wheat (*Triticum aestivum* L.) varieties to N and P fertilizer rates in Ofla district, Southern Tigray, Ethiopia. Afr. J. Agric. Res.12(19):1646-1660.

Harrison JA (2010). The Nitrogen Cycle.Visionlearning Vol. EAS-2 (4).

Havlin JE, Beaton JD, Nelson, WL, Tisdal SL (1999). Soil Fertility and Fertilizers. An Introduction to Soil Management, 6th ed. Prentice Hall, Inc. 634p.

Hussain G and Al-Jaloud AA (1995). "Effect of irrigation and nitrogen on water use efficiency of wheat in Saudi Arabia," Agricultural Water Management, 27(2): 143–153.

Islam MA and Baten MA (1987). Growth and yield of wheat as affected by different levels of N and P. Thai J. Agri. Scie. 20 (3) Absts. 42(6): 3886-1989.

Jin J, Wang GH, Liu, X, Pan X, Herbert SJ (2005). Phosphorus application affects the soybean root response to water deficit at the initial flowering and full pod stages. Soil Sci. Plant Nutr.51(7):953-960.

Kaleem S, Ansar M, Ali MA, Sher A, Ahmad G and Rashid M (2009). Effect of phosphorus on the yield and yield components of wheat variety "inqlab-91" under rainfed conditions. Sarhad J. Agri. 25(1): 21-24.

Khalil SK, Afridi MS and Iqbal M (1988). Plant height, weeds weight and hay yield of maize and Mungbean in mono and associated culture as affected by NPK application. Sarhad J. Agri. 4: 377-85.

Khan F, Khan S, Fahad S, Faisal S, Hussain S, Ali S, Ali A (2014). Effect of Different Levels of Nitrogen and Phosphorus on the Phenology and Yield of Maize Varieties. Am. J. Plant Sci. 5:2582-2590

Khursheed MQ, Mahammad MQ (2015). Effect of different nitrogen fertilizers on growth and yield of wheat. Zanco J. Pure Appl. Sci. 27(5):19-28.

Kulhare PS, Agarwal KK and Padihar SK (1991). Response of N. P. and Zn by late sown wheat in deep vertisoles. Curreny Res. Univ. Agric. Sci. Banglor. 20(10):217-218.

Kumar P, Yadava RK, Gollen B, Kumar S, Verma RK, Yadav S (2011). Nutritional Contents and Medicinal Properties of Wheat: A Review. pp. 1-9.

Landon JR (1991). Booker tropical soil manual: a handbook for soil survey and Agricultural land evaluation in the tropics and subtropics. Long man scientific and technical. Booker Tate Ltd. John Wiley and Sons, Inc., New York.

Lopez-Bucio J, Cruz-Ramirez A, Herrera-Estrella L (2003). The role of nutrient availability in regulating root architecture. Curr. Opin. Plant Biol. 6(3):280-287.

Mesfin K, Zemach S (2015). Effect of Nitrogen and Phosphorus Fertilizer Rates on Yield and Yield Components of Barley (*Hordeum Vugarae* L.) Varieties at Damot Gale District, Wolaita Zone, Ethiopia. Am. J. Agric. Forest. 3(6):271-275.

Meyerowitz S (1999). Wheat Grass: Nature's Finest Medicine, Edition 6, Sproutman Publications, pp. 31-33.

MoA-Ministry of Agriculture (2011). Ministry of Agriculture. Animal and Plant Health Regulatory Directorate. Crop variety register, Issue No. 14. Addis Ababa, Ethiopia.

Ministry of Agriculture (MoA) (2012). Ministry of Agriculture. Animal and Plant Health Regulatory Directorate. Crop variety register, Issue No. 15. Addis Ababa, Ethiopia.

Olsen SR, Cole CV, Wantanabe FS and Dean LA (1954). Estimation of available phosphorous in soils by extraction with sodium bicarbonate, U.S. Dep. of Agriculture circular 939. U.S.D.A, Washington DC., USA. P 23.

Patel NM, Patel RB, Patel KK (1991). Response of wheat varieties to N and P. Indian J. Agron. 36:255-256.
Razaq M, Zhang P, Shen H-l, Salahuddin (2017). Influence of nitrogen and phosphorous on the growth and root morphology of *Acer mono*. PLoS ONE 12(2):e0171321.
Sahlemedhin S, Taye B (2000). Procedures for soil and plant analysis. National Soil Research Center, Ethiopian Agricultural Research Organization, Addis Ababa, Ethiopia.
SAS Institute Inc. (2002). SAS User's Guide, Statistics Version 9.0 ed. SAS Institute, Cary, NC, USA.
Shahzad MA, Din WU, Sahi ST, Khan MM, Ehsanullah and Ahmad M (2007). Effect of sowing dates and seed treatment on grain yield and quality of wheat. Pak. J. Agric. Sci. 44(4):581-583.
Singh K, Pannu MS, Singh P, Singh J (2010). Effect of Wheatgrass tablets on the frequency of blood transfusions in Thalassemia major. Indian J. Pediatr. 77(1):90-91.
Solomon W, Anjulo A (2017). Response of bread wheat varieties to different levels of nitrogen at Doyogena, Southern Ethiopia. Int. J. Sci. Res. Publ. 7(2):452-459.
Spielman DJ, Kelemwork D, Alemu D (2011). Seed, fertilizer, and agricultural extension in Ethiopia. ESSP II Working Paper 020. International Food Policy Research Institute (IFPRI).
Tabar (2013). Effect of Nitrogen and Phosphorus FertilizerManagement on Growth and Yield of Rice. Int. J. Agric. Crop Sci. 5(15):1659-1662.
Umeri C, Moseri H, Onyemekonwu RC (2016). Effects of Nitrogen and Phosphorus on the Growth Performance of Maize (*Zea mays*) in Selected Soils of Delta State, Nigeria. Adv. Crop Sci. Technol. 4: 207.
Wakene T, Walelign W, Wassie H (2014). Effects of Nitrogen and Phosphorus Fertilizer Levels on Growth and Development of (*Hordeum vulgare* L.) at Bore District, Southern Oromia, Ethiopia. Am. J. Life Sci. 2(5): 260-266.
www.organicauthority.com/benefits-of-wheatgrass.html. Accessed on October 23, 2017.