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Nitrogen and Phosphorus Fertilizers and Tillage Effects on Growth and Yield of Maize (*Zea mays* L.) at Dugda District in the Central Rift Valley of Ethiopia

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ABSTRACT

An experiment was conducted at Dugda district in the Central Rift Valley of Ethiopia under field conditions to determine the impacts of tillage levels, N and P fertilizers on growth and yield of maize (*Zea mays* L.). Two tillage levels; (1) Conventional and (2) Minimum tillage and four N and P fertilizer levels; (1) No fertilizer (control treatment), (2) 64 kg N ha^{-1} (139 kg urea ha^{-1}), (3) 20 kg P ha^{-1} (100 kg TSP ha^{-1}) and (4) 64 kg N ha^{-1}+20 kg P ha^{-1} (100 kg DAP ha^{-1}+ 100 kg urea ha^{-1}) were laid out in split plot design by assigning tillage levels to the main plots and fertilizers to the subplots and replicating three times. Data collected on growth and yield parameters was analyzed using the GLM procedure of SAS Version 9.2. N and P fertilizers had highly significant effects on growth parameters: plant height and leaf area. They also significantly affected yield parameters: biomass yield and grain yield of maize but the effects of tillage levels as well as the interaction between tillage levels and fertilizers were not significant. For the majority of the growth and yield parameters, the treatment with 64 kg N ha^{-1}+20 kg P ha^{-1} (100 kg DAP ha^{-1}+ 100 kg urea ha^{-1}) outperformed the remaining three treatments. Accordingly, significant and highest plant height (178.24 cm), leaf area (431 cm^2), biomass yield (11925 kg ha^{-1}) and grain yield (3678.8 kg ha^{-1}) were obtained from the application of fertilizer treatment with 64 kg N ha^{-1}+ 20 kg P ha^{-1} (100 kg DAP ha^{-1}+100 kg urea ha^{-1}). The results of the correlation analysis also indicated that biomass yield was significantly and positively correlated with grain yield and grain yield was also significantly and positively correlated with harvest index. This indicated that N and P fertilizer treatments with higher biomass yield and harvest index could result in higher grain yield of maize. According to the current results, it can be concluded that N and P fertilizers significantly affected the growth and yield of maize but tillage levels have no significant effect. Therefore, the use of 64 kg N ha^{-1}+20 kg P ha^{-1} (100 kg DAP ha^{-1} +100 kg urea ha^{-1}) and minimum tillage could be recommended for optimum growth and yield of maize and also save the precious soil, money and time of resource poor small holder farmers, of the study area.

Key words: N and P fertilizers, minimum tillage, growth, yield, *Zea mays* L.

INTRODUCTION

Maize (*Zea mays* L.) is an important cereal crop ranking third after wheat and rice in the world (Gibbon and Pain, 1985; FAO., 2011). In Africa, the bulk of maize produced is used as human food and the area coverage of maize in West and Central Africa alone increased from 3.2 in 1961 to 8.9 million ha in 2001. This remarkable expansion increased the quantity of maize production from 2.4 in 1961 to 10.6 million Mt in 2001 (FAO., 2002). Developing countries contribute 67% in the world cultivated land of maize but their share in quantity of production is only about 46%, where approximately 60% of the world maize is produced by USA and China collectively (Ghaffari *et al*., 2011). In Ethiopia, maize is the major staple food and one of the main sources of calorie (Million and Getahun, 2001; Tolessa *et al*., 2001) being cultivated on about 1.75 million ha and accounts for 20% of the 8.5 million ha (79.98%) of land allocated for cereals. It ranks second after teff (*Eragrostis tef* (Zucc.)) in area coverage, first in total national production and yield per ha (CSA., 2008). However, the national average yield, 3.2 t ha^{-1} (CSA., 2014) is still very low compared to the global average of 5.2 t ha^{-1} (FAO., 2011). This low productivity is attributed to low soil fertility (Worku and Zelleke, 2007) and poor management practices (Tolessa *et al*., 2001) of which nitrogen and phosphorus nutrient deficiency and improper tillage can be mentioned as the most growth and yield limiting factors in the country. Conventional tillage can decrease soil organic matter, aggregate stability, increase resistance to penetration and bulk density of the soil (Micucci and Taboada, 2006). On the other hand, conservation tillage practices: zero tillage and reduced tillage simultaneously conserved soil and water, reduced farm energy usage, increased crop production (Bescansa *et al*., 2006) and soil moisture content (Angas *et al*., 2006). Moisture content was higher in zero tillage in the top 20 cm layer compared to conventional tillage (Farkas *et al*., 2009). Moisture stress and nutrient deficiency is critical in central rift valley of Ethiopia, where repeated tillage at the shallow depths (13-16 cm) often form plough pan that needs continuous manipulation to increase water infiltration and crop establishment (Temesgen, 2007; Biazin *et al*., 2011; Biazin and Sterk, 2013). In relation to the above problems, the studies on optimization of fertilization under conservation tillage are scarce. Therefore, this experiment was conducted to determine the impact of tillage levels and N and P fertilizers on maize (*Zea mays* L.) production at Dugda district (Meki), Central Rift Valley of Ethiopia.

MATERIALS AND METHODS

Description of the study area: Field experiment was conducted at Dugda district (Meki) in the Central Rift Valley of Ethiopia. The study site is located at about 8°15' N, 38°82' E and at an altitude of 1,650 m above sea level. The experimental site is situated in the South direction at 130 km away from Addis Ababa, the capital city of Ethiopia. The site receives average annual rainfall of 720 mm and with a mean annual temperature of 18°C. It is categorized with semiarid climate and Andosol soil type with sandy loam soil texture. Teff is the first and Maize is the second important crop in this district and other cereals like wheat and pulse crops such as haricot bean and faba beans are also produced at large quantities (CSA., 2014).

Experimental design and treatments: Two tillage levels; (1) Conventional tillage and (2) Minimum tillage assigned to the main plot and four levels of N and P from different N and P fertilizers; (1) No fertilizer as a control treatment, (2) 64 kg N ha^{-1} (3) 20 kg P ha^{-1} and (4) 64 kg N ha^{-1}+20 kg P ha^{-1} assigned to the sub plots based on the recommendation of nitrogen and phosphorus fertilizers in the area (100 kg DAP and urea ha^{-1}) were used in this experiment. The two tillage levels and the four N and P fertilizer treatments were laid out in a split plot design with three replications.

Experimental procedure: A high yielding maize variety, Melkasa-2 (ZM-521) released in 2004 by Melkasa Agricultural Research Centre was used as an experimental material. For the main plot factor, tillage levels in (1) Minimum tillage, the soil was opened to place maize seeds at a depth of 10 cm and in (2) Conventional tillage, the depth and intensity of tillage was based on local practices (20 cm depth and 4-6 times tillage) using traditional plough locally called Maresha. In this experiment, each main plot had a size of 10×10 m (100 m^2) and each sub plots had a dimension of 4.5×4.5 m (20.25 m^2). A spacing of 75 cm between rows and 30 cm between plants was used and accordingly six rows with a length of 4.5 m were made on each plot and the net plot size was 3×3.9 m (11.7 m^2). An open space of 1 m was left between blocks and within the blocks as pathways. Sowing was done on June 8, 2014 by placing two seeds per hole to maximize emergence of seedlings and then to obtain plants with good stand. The required density was attained by thinning 4 weeks after plant emergence to get one plant per stand. In the sub plot factor, N and P levels: 64 kg N ha^{-1}+20 kg P ha^{-1} from DAP+UREA each at 100 kg ha^{-1}, 64 kg N ha^{-1} from UREA alone at 139 kg ha^{-1} and 20 kg P ha^{-1} from Triple Super Phosphate (TSP) alone at 100 kg ha^{-1} were applied to the sub plots except the control plots. Phosphorus fertilizers (TSP and DAP) were applied by band at the time of sowing and half of nitrogen fertilizer, urea was applied at the time of sowing and the remaining half was applied after maize plants reached knee height. All the other field activities were carried out following the recommended cultural practices.

Data collection and analyses: Data was collected on growth and yield parameters namely plant height, leaf area, harvest index, biomass yield and grain yield using five randomly selected plants from each plot. Leaf area was determined by multiplying leaf length and maximum breadth adjusted by a correction factor of 0.75 (i.e. 0.75×leaf length×maximum breadth) as suggested by Francis *et al*. (1969). Plant height was measured as the height of the plant from the soil surface to the base of the tassel. Grain yield (kg ha^{-1}) and biomass yield (kg ha^{-1}) was measured on plants harvested from the net plot area at maturity. Data was analyzed using the GLM procedure of SAS Version 9.2 statistical software (SAS., 2002) and treatment means were compared using Least Significant Difference (LSD) value at 5% significance level (Gomez and Gomez, 1984). Correlation analysis among yield and growth parameters was done using Pearson correlation analysis procedure of SAS Version 9.2 statistical software (SAS., 2002).

RESULTS AND DISCUSSION

Effect of tillage levels and N and P fertilizers on growth and yield parameters: The results showed that the most important growth and yield parameters: plant height, leaf area, biomass yield and grain yield were significantly ($p<0.05$) affected by N and P fertilizers but not significantly ($p<0.05$) affected by the interaction effect of tillage and fertilizers as well as tillage alone (Table 1).

Plant height: The result of the current investigation showed highly significant ($p<0.01$) effect of N and P fertilizers on yield but no significant ($p>0.05$) interactions effects of fertilizers and tillage levels as well as tillage levels alone on plant height (Table 1). Furthermore, the tallest plant height (178.24 cm) was observed in plot with the application of 64 kg N ha^{-1}+20 kg P ha^{-1} (100 kg DAP ha^{-1}+100 kg urea ha^{-1}), while the shortest plant height (143.31 cm) was observed in the control plot (no fertilizer). The treatments with N and P fertilizers significantly increased plant height when compared to the control treatment but there was no significant difference between the applications of 64 kg N ha^{-1}+20 kg P ha^{-1} (100 kg DAP ha^{-1}+100 kg urea ha^{-1}) and

Table 1: Mean square values for growth and yield parameters of maize (*Zea mays* L.) as affected by tillage levels and N and P fertilizers

Source of variation	DF	Plant height	Leaf area	Biomass yield	Harvest index	Grain yield
Tillage levels	1	4080.47^{ns}	22632.87^{ns}	60365608.08^{ns}	0.002^{ns}	5990349.26^{ns}
N and P fertilizers	3	1784.11**	28319.58**	26345977.15*	0.004^{ns}	3511962.20*
Tillage levels X N and P fertilizers	3	19.76^{ns}	2805.06^{ns}	4198078.26^{ns}	0.003^{ns}	258015.81^{ns}
Error	12	318.76	3870.40	4689544.10	0.002	44622.58
CV		10.97	17.94	23.66	18.34	26.89
LSD		47.48	62.40	21049.00	0.41	1990.30

LSD: Least significant difference, CV: Coefficient of variation, DF: Degrees of freedom, ^{ns}Non significant, *Significant, **Highly significant at 5 and 1% probability level, respectively

Table 2: Effects of N and P fertilizers on plant height of maize (*Zea mays* L.)

Fertilizer levels	Plant height (cm)
Control (no fertilizer)	143.31^{b}
64 kg N ha^{-1} (139 kg urea ha^{-1})	176.05^{a}
20 kg P ha^{-1} (100 kg TSP ha^{-1})	152.87^{b}
64 kg N ha^{-1}+20 kg P ha^{-1} (100 kg DAP ha^{-1}+100 kg urea ha^{-1})	178.24^{a}
LSD (p<0.05)	22.459

LSD: Least significant difference, Means with similar letters in each column are not significantly different

64 kg N ha^{-1} (139 kg urea ha^{-1}) alone where the two treatments had equal nitrogen content but differed in the phosphorus content. Similarly, there was no significant difference between the application of 20 kg P ha^{-1} (100 kg TSP ha^{-1}) and the control treatment (Table 2).

In both cases, comparing 64 kg N ha^{-1}+20 kg P ha^{-1} (100 kg DAP ha^{-1}+100 kg urea ha^{-1}) and 64 kg N ha^{-1} (139 kg urea ha^{-1}) and 20 kg P ha^{-1} (100 kg TSP ha^{-1}) with the control treatment, where the difference in content was phosphorus, it seems that phosphorus was not a limiting nutrient in this study. The current finding is in agreement with Khalil *et al*. (1988), who reported that nitrogen (N) and phosphorus (P) alone or in combination increased plant height. Ahmad *et al*. (2005) also concluded that the application of 120 kg N ha^{-1} increased maize plant height. Similarly, Hammad *et al*. (2011) also reported that there was more vegetative as well as reproductive growth with increase in the amount of N. In line with our current findings, Aikins *et al*. (2012) also found no significant effect of tillage on plant height and in another similar study, Al-Ghrerie (1988) also reported that zero tillage and conventional tillage showed no significant effect on plant height of maize.

Leaf area: The current results showed that the leaf area was significantly (p<0.05) affected by N and P fertilizers but not significantly (p>0.05) affected by the interaction effect of fertilizers with tillage levels as well as the tillage levels alone (Table 1). The highest leaf area (431.85 cm^2) was recorded from the plots that received the application of 64 kg N ha^{-1}+20 kg P ha^{-1} (100 kg DAP ha^{-1}+100 kg urea ha^{-1}) while the lowest (282.25) leaf area was recorded from the control plots (no fertilizer). In this respect there was no significant difference between 64 kg N ha^{-1} (139 kg urea ha^{-1}) and 20 kg P ha^{-1} (100 kg TSP ha^{-1}). Furthermore, no significant difference was observed between 20 kg P ha^{-1} (100 kg TSP ha^{-1}) and the control treatment (Table 3).

This increase in leaf area could be due to the synergistic effect of nitrogen and phosphorus on plant growth. The same effect of nitrogen and phosphorous was reported by Rai *et al*. (1982), who found that both elements increased plant growth up to 100 days from sowing. In a similar manner the current finding is also in agreement with Khan *et al*. (1999), who reported that leaf area increased with increase in nitrogen and phosphorus levels.

Biomass yield: Biomass yield of maize was significantly (p<0.05) affected by N and P fertilizers but not significantly (p>0.05) affected by the interactions of fertilizers and tillage levels as well as

Table 3: Effects of N and P fertilizers on the leaf area of maize (*Zea mays* L.)

Fertilizer levels	Leaf area (cm^2)
Control (no fertilizer)	282.25^{c}
64 kg N ha^{-1} (139 kg urea ha^{-1})	371.81^{ab}
20 kg P ha^{-1} (100 kg TSP ha^{-1})	300.59^{bc}
64 kg N ha^{-1}+20 kg P ha^{-1} (100 kg DAP ha^{-1}+100 kg urea ha^{-1})	431.85^{a}
LSD (p<0.05)	78.26

LSD: Least significant difference, Means with similar letters in each column are not significantly different

Table 4: Effects of N and P fertilizers on biomass yield of maize (*Zea mays* L.)

Fertilizer levels	Biomass (kg ha^{-1})
Control (no fertilizer)	6103^{c}
64 kg N ha^{-1} (139 kg urea ha^{-1})	10455^{ab}
20 kg P ha^{-1} (100 kg TSP ha^{-1})	8115b^{c}
64 kg N ha^{-1}+20 kg P ha^{-1} (100 kg DAP ha^{-1}+100 kg urea ha^{-1})	11925^{a}
LSD (p<0.05)	3746.9

LSD: Least significant difference, Means with similar letters in each column are not significantly different

tillage levels alone (Table 1). The highest biomass yield was obtained from both the application of 64 kg N ha^{-1}+20 kg P ha^{-1} (100 kg DAP ha^{-1}+100 kg UREA ha^{-1}) and 64 kg N ha^{-1} (139 kg urea ha^{-1}) alone which were statistically the same. Application of 20 kg P ha^{-1} (100 kg TSP ha^{-1}) provided the same yield as in the control treatment with no fertilizer application (Table 4). The increased biomass yield of maize from the application of 64 kg N ha^{-1}+20 kg P ha^{-1} (100 kg DAP ha^{-1}+100 kg urea ha^{-1}) and also 64 kg N ha^{-1} (139 kg UREA ha^{-1}) might be due to the higher nitrogen content in these two treatments than the remaining two treatments with no nitrogen content.

In agreement with the current finding, Amanullah *et al*. (2009a) also reported increase in biomass yield of maize at the higher rate of nitrogen than at the lower rate.With regards to the effect of tillage levels, contrary to the current finding, significantly highest biomass yield of maize was obtained in case of the conventional tillage when compared to the minimum (reduced) tillage as indicated by Gul *et al*. (2009). According to them, minimum tillage showed less biomass yield of maize due to high weed density and competition with the main crop, maize.

Harvest Index (HI): The results obtained from the current study showed that harvest index was not significantly affected by both tillage and N and P fertilizers (Table 1). Even though the effect of fertilizers on the harvest index was not significant statistically, the higher harvest index was obtained from the application of 64 kg N ha^{-1}+20 kg P ha^{-1} (100 kg DAP ha^{-1}+100 kg urea ha^{-1}) while the lowest harvest index was recorded from the control treatment where there was no fertilizer application (Table 5).

The results of this study indicated that harvest index of crops is usually affected by different fertilizer application levels and could be increased with increase in the rate of fertilizers rather than with the type of fertilizers because harvest index is influenced with the percentage of photosynthetic matters translocated from the vegetative organs (source) to the seeds (sink), which is also in turn affected by the quantity of nutrients applied to the soil and percentage of nutrients absorbed by the maize crop (Emami *et al*., 2011). Similarly, Lawrence *et al*. (2008) also reported that harvest index in corn is increased by increasing rates of nitrogen application. In agreement with the current finding, Muhammad *et al*. (2002) also reported an increase in harvest index of maize but conversely Ali *et al*. (2002) reported that harvest index was not affected by change in nitrogen dose in maize.

Table 5: Effects of N and P fertilizers on harvest index of maize (*Zea mays* L.)

Fertilizer levels	Harvest index (%)
Control (no fertilizer)	0.2450[a]
64 kg N ha^{-1} (139 kg urea ha^{-1})	0.2575[a]
20 kg P ha^{-1} (100 kg TSP ha^{-1})	0.2525[a]
64 kg N ha^{-1}+20 kg P ha^{-1} (100 kg DAP ha^{-1}+100 kg urea ha^{-1})	0.3150[a]
LSD (p<0.05)	0.0849

LSD: Least significant difference, Means with similar letters in each column are not significantly different

Table 6: Effects of N and P fertilizers on grain yield of maize (*Zea mays* L.)

Fertilizer levels	Yield (kg ha^{-1})
Control (no fertilizer)	1482.3[c]
64 kg N ha^{-1} (139 kg urea ha^{-1})	2689.5[ab]
20 kg P ha^{-1} (100 kg TSP ha^{-1})	2083.0[bc]
64 kg N ha^{-1}+20 kg P ha^{-1} (100 kg DAP ha^{-1}+100 kg urea ha^{-1})	3678.8[a]
LSD (p<0.05)	1155.8

LSD: Least significant difference, Means with similar letters in each column are not significantly different

Grain yield: Grain yield of maize was significantly ($p<0.05$) increased by N and P fertilizers but not significantly ($p>0.05$) affected by the interaction effects of fertilizers and tillage levels as well as tillage levels alone (Table 1). Accordingly, the highest grain yield (3678.8 kg ha^{-1}) of maize was obtained from the plots that received the application of 64 kg N ha^{-1}+20 kg P ha^{-1} (100 kg DAP ha^{-1}+100 kg urea ha^{-1}) followed by the application of 64 kg N ha^{-1} (139 kg urea ha^{-1}) alone. Although, there were no significant difference in grain yield of maize between the treatments with 64 kg N ha^{-1}+20 kg P ha^{-1} (100 kg DAP ha^{-1}+100 kg urea ha^{-1}) and 64 kg N ha^{-1} (139 kg urea ha^{-1}) alone, the current grain yield of maize obtained with the application 64 kg N ha^{-1}+20 kg P ha^{-1} (100 kg DAP ha^{-1}+100 kg urea ha^{-1}) seemed better than the grain yield obtained from the application of 64 kg N ha^{-1} (139 kg urea ha^{-1}) alone due to the synergistic effect of N and P functions on the metabolic activities of the maize plant (Table 6).

The highest grain yield obtained from the treatment with phosphorus content (64 kg N ha^{-1}+ 20 kg P ha^{-1} (100 kg DAP ha^{-1}+100 kg urea ha^{-1})) in the presence of nitrogen may be due to the higher translocation and activity of phosphorus into fruiting and seed formation, which resulted in highest grain yield of the maize plant (Amanullah *et al*., 2009b). In similar manner, Sahoo and Panda (2001) also confirmed that increased phosphorus levels resulted in increased grain weight of maize. Furthermore, the effect of tillage levels on the biomass yield of maize above, contrary to the current investigation, significantly increased the grain yield of maize in a conventional tillage compared to the minimum (reduced) tillage which showed less grain yield of maize plant due to high weed density in competition with the main maize crop according to Marwat *et al*. (2007).

Correlation among growth and yield parameters of maize: Correlation analysis among growth and yield parameters of maize was done and this revealed highly significant positive associations among some of the growth and yield parameters studied (Table 7).

Accordingly, plant height was highly significantly and positively correlated ($R = 0.653$) with leaf area. This means when plant height of the maize plant was increasing, its leaf area was also increasing according to this study. In similar manner, the biomass yield was highly significantly and positively correlated ($R = 0.893$) with grain yield and this indicated that when the biomass yield of maize is increasing, its grain yield was also increasing. Grain yield was significantly and positively correlated ($R = 0.606$) with harvest index of maize and according to the current result the treatment that increased the grain yield could result in increased harvest index. Thus the

Table 7: Correlation analysis among some growth and yield parameters of maize (*Zea mays* L.)

Parameters	Plant height	Leaf area	Biomass yield	Grain yield	Harvest index
Plant height	1	0.653**	0.112	0.087	0.001
Leaf area		1	0.229	0.228	0.028
Biomass yield			1	0.893**	0.204
Grain yield				1	0.606*
Harvest index					1

*'**Significant at 5% and highly significant at 1% significance level (2-tailed)

result of the current correlation analysis of fertilizer level with higher biomass yield and harvest index could result in higher grain yield of maize. In other similar studies, different authors also reported positive correlations among certain growth and yield parameters of maize (Loffer *et al*., 1985; Van Sanford and MacKown, 1986; Sinebo *et al*., 2004; Muurinen, 2007).

CONCLUSION

According to the results of the current investigation, N and P fertilizers had highly significant effects on the growth parameters: plant height and leaf area as well as yield parameters: biomass yield and grain yield of maize but tillage levels as well as the interaction of tillage levels and N and P fertilizers had no significant effect. The highest plant height (178.24 cm), leaf area (431 cm^2), biomass yield (11925 kg ha^{-1}) and grain yield (3678.8 kg ha^{-1}) were recorded from the treatment with 64 kg N ha^{-1}+20 kg P ha^{-1} (100 kg DAP ha^{-1}+100 kg urea ha^{-1}) but the effects of 64 kg N ha^{-1}+20 kg P ha^{-1} (100 kg DAP ha^{-1}+100 kg urea ha^{-1}) and 64 kg N ha^{-1} (139 kg urea ha^{-1}) alone on biomass and gain yield of maize was not significantly different. This indicated that nitrogen is a more limiting nutrient than phosphorous in the study area.

The results of the correlation analysis also indicated that biomass yield was highly significantly and positively correlated with grain yield and this indicated that when the biomass yield of maize is increasing, its grain yield was also increasing. In similar manner, grain yield was also significantly and positively correlated with harvest index and this indicated, fertilizer level with higher biomass yield and harvest index could result in higher grain yield of maize. According to the current results, it can be concluded that N and P fertilizer levels significantly but tillage levels none significantly affected the growth and yield of maize. No difference was observed between conventional and minimum tillage. But minimum tillage needs minimum labor of the farmer compared to the conventional tillage and also with minimum soil disturbance that further minimizes soil erosion and nutrient depletion.

Therefore, the use of 64 kg N ha^{-1}+20 kg P ha^{-1} (100 kg DAP ha^{-1}+100 kg urea ha^{-1}) and minimum tillage could be recommend for optimum growth and yield of maize and also save the valuable soil, money and time of the resource poor small holder farmers' of the study area.

REFERENCES

Ahmad, M., J. Mmanullah, M. Majida and N. Mammona, 2005. Effect of nitrogen and seed size on maize crop. J. Agric. Soc. Sci., 4: 380-381.

Aikins, S.H.M., J.J. Afuakwa and O. Owusu-Akuoko, 2012. Effect of four different tillage practices on maize performance under rainfed conditions. Agric. Bio J. North Am., 3: 25-30.

Al-Ghrerie, D.A., 1988. Influence of tillage system on maize. Ph.D. Thesis, College of Agricultural, Al-Ghrerie Submitted to the Baghdad University, Baghdad, Iraq.

Ali, J., J. Bakht, M. Shafi, S. Khan and W.A. Shah, 2002. Effect of N and P on yield components of maize. Pak. J. Agron., 1: 12-14.

Amanullah, K.B. Marwat, P. Shah, N. Maula and S. Arifullah, 2009a. Nitrogen levels and its time of application influence leaf area, height and biomass of maize planted at low and high density. Pak. J. Bot., 41: 761-768.

Amanullah, R., A. Khattak and S.K. Khalil, 2009b. Effects of plant density and N on phonology and yield of maize. J. Plant Nutr., 32: 246-260.

Angas, P., J. Lampurlanes and C. Cantero-Martinez, 2006. Tillage and N fertilization: Effects on N dynamics and barley yield under semiarid Mediterranean conditions. Soil Tillage Res., 87: 59-71.

Bescansa, P., M.J. Imaz, I. Virto, A. Enrique and W.B. Hoogmoed, 2006. Soil water retention as affected by tillage and residue management in semiarid Spain. Soil Tillage Res., 87: 19-27.

Biazin, B., L. Stroosnijder, M. Temesgen, A. AbdulKedir and G. Sterk, 2011. The effect of long-term *Maresha* ploughing on soil physical properties in the Central Rift Valley of Ethiopia. Soil Tillage Res., 111: 115-122.

Biazin, B. and G. Sterk, 2013. Drought vulnerability drives land-use and land cover changes in the Rift Valley dry lands of Ethiopia. Agric. Ecosyst. Environ., 164: 100-113.

CSA., 2008. Statistica 1 bulliten for crop production forecast sample survey. Centreal Statistical Agency, Addis Ababa, Ethiopia.

CSA., 2014. Agricultural sample survey report on area and production for major crops (Private peasant holdings Meher Season) for 2007/08. The Federal Democratic Republic of Ethiopia Statistical Bulletin No. 417, Addis Ababa, Ethiopia.

Emami, T., R. Naseri, H. Falahi and E. Kazemi, 2011. Response of yield, yield component and oil content of safflower (*Cv.* Sina) to planting date and plant spacing on row in rain fed conditions of western Iran. J. Agric. Environ. Sci., 10: 947-953.

FAO., 2002. Food crops and shortages No. 2. Food and Agriculture Organization of the United Nations, April 2002, pp: 1-10.

FAO., 2011. Scaling-up Conservation Agriculture in Africa: Strategy and Approaches. Food and Agricultural Organization, Rome, Italy.

Farkas, C., M. Birkas and G. Varallyay, 2009. Soil tillage systems to reduce the harmful effect of extreme weather and hydrological situations. Biologia, 64: 624-628.

Francis, C.A., J.N. Rutger and A.F.E. Palmer, 1969. A rapid method for plant leaf area estimation in maize (*Zea mays* L.). Crop Sci., 9: 537-539.

Ghaffari, A., A. Ali, M. Tahir, M. Waseem, M. Ayub, A. Iqbal and A.U. Mohsin, 2011. Influence of integrated nutrients on growth, yield and quality of maize (*Zea mays* L.). Am. J. Plant Sci., 2: 63-69.

Gibbon, D.P. and A. Pain, 1985. Crops of the Drier Regions of the Tropics. Longman Publishing Limited, Singapore, ISBN-13: 9780582775060, pp: 92-98.

Gomez, K.A. and A.A. Gomez, 1984. Statistical Procedures for Agricultural Research. 2nd Edn., John Wiley and Sons, New York, USA., ISBN-13: 9780471870920, Pages: 680.

Gul, B., K.B. Marwat, G. Hassan, A. Khan, S. Hashim and I.A. Khan, 2009. Impact of tillage, plant population and mulches on biological yield of maize. Pak. J. Bot., 41: 2243-2249.

Hammad, H.M., A. Ahmad, F. Azhar, T. Khaliq, A. Wajid, W. Nasim and W. Farhad, 2011. Optimizing water and nitrogen requirement in maize (*Zea Mays* L.) under semi arid conditions of Pakistan. Pak. J. Bot., 43: 2919-2923.

Khalil, S.K., M.S. Afridi and M. Iqbal, 1988. Plant height, weeds weight, thousand grain weight and hay yield of maize and mungbean in mono and associated culture us affected by NPK application. Sarhad J. Agric., 4: 377-385.

Khan, M.A., N.U. Khan, K. Ahmad, M.S. Baloch and M. Sadiq, 1999. Yield of maize hybrid-3335 as affected by NP levels. Pak. J. Biol. Sci., 2: 857-859.

Lawrence, J.R., Q.M. Ketterings and J.H. Cherney, 2008. Effect of nitrogen application on yield and quality of Silage corn after forage legume-grass. Agron. J., 100: 73-79.

Loffer, C.M., T. L. Rauch and R.H. Busch, 1985. Grain and plant protein relationships in hard red spring wheat. Crop Sci., 25: 521-524.

Marwat, K.B., M. Arif and M.A. Khan, 2007. Effect of tillage and zinc application methods on weeds and yield of maize. Pak. J. Bot., 39: 1583-1591.

Micucci, F.G. and M.A. Taboada, 2006. Soil physical properties and soybean (*Glycine max*, Merrill) root abundance in conventionally-and zero-tilled soils in the humid Pampas of Argentina. Soil Tillage Res., 86: 152-162.

Million, T. and D. Getahun, 2001. Review of on-farm research and adoption studies on maize in Southern Ethiopia. Research Project Progress Report of the Second National Maize Workshop of Ethiopia, Hawassa Agricultural Research Center, Hawassa, Ethiopia.

Muhammad, S., J. Bakht, M.T. Jan, W.A. Shah and N.P. Khan, 2002. NP levels effect on yield and yield components of maize varieties. Sarhad J. Agric., 18: 252-257.

Muurinen, S., 2007. Nitrogen dynamics and nitrogen use efficiency of spring cereals under Finnish growing conditions. Yliopistopaino, 29: 1 -38.

Rai, R.K., M.N. Sinha and M. Singh, 1982. Studies on direct and residual effect of phosphorus on growth and yield of maize and wheat in sequence. Indian J. Agron., 27: 354-364.

SAS., 2002. SAS Online Documentation, Version 9.2. SAS Institute Inc., Cary, NC., USA.

Sahoo, S.C. and M. Panda, 2001. Effect of phosphorus and detasseling on yield of baby corn. Indian J. Agric. Sci., 71: 21-22.

Sinebo, W., R. Gretzmacher and A. Edelbauer, 2004. Genotypic variation for nitrogen use efficiency in Ethiopean barley. Field Crops Res., 85: 43-60.

Temesgen, M., 2007. Conservation tillage systems and water productivity implications for smallholder farmers in semi-arid Ethiopia. Ph.D. Thesis, Cergy-Pontoise University, France.

Tolessa, D., B. Tesfa, N. Wakene, W. Tena and L. Minale *et al*., 2001. A review of fertilizer management research on maize in Ethiopia. Proceedings of the 2nd National Maize Workshop of Ethiopia, November 12-16, 2001, Addis Ababa, Ethiopia, pp: 46-60.

Van Sanford, D.A. and C.T. MacKown, 1986. Variation in nitrogen use efficiency among soft red winter wheat genotypes. Theor. Applic. Genet., 72: 158-163.

Worku, M. and H. Zelleke, 2007. Advances in improving harvest index and grain yield of maize in Ethiopia. East Afr. J. Sci., 1: 112-119.