Impact of Tillage practice and Mineral Fertilizer on Maize (*Zea mays* L) Production in Dugda Wereda, Meki, Central Rift Valley, Ethiopia

M.Sc. THESIS

BY

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Jimma, University
July, 2015

Impact of Tillage practice and Mineral Fertilizer on Maize (*Zea mays* L) Production in Dugda Wereda, Meki, Central Rift Valley, Ethiopia

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I have incorporated the suggestions and modifications given during the internal thesis defence and got the approval of my advisors. Hence, I hereby kindly request the Department to allow me to present the findings of my work and submit the thesis.

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Chairperson, DGC Signature Date

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STATEMENT OF AUTHOR

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BIOGRAPHICAL SKETCH

Hawi Mohammed Yasin was born in Ilubabor zone Didessa Woreda Yembero town on July 8, 1983 G.C. He attended elementary education at Yembero and secondary education at Dambi High school up to 2003.After he successfully passed the Ethiopian School Leaving Certificate Examination (E.S.L.C.E.), he joined Assella TVET in 2004 and graduated with Diploma in Plant Sciences in June 2006. He was employed by Ilubabor zone and worked at Didessa Woreda Agriculture office for four years. He joined Jimma University on October 2010, and graduated in Bachelor of Science in plant science in June 2012.

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ABBREVIATIONS and ACRONYMS

C= Carbon

CA = conservation Agriculture

CSA = central statistical authority

DAP = Day after planting

DM = Dry matter

FAO = Food and Agricultural Organization

ha = Hectare

Kg = kilogram

mm =millimeter

m = meter

N = Nitrogen

p = Phosphorous

SOC = soil organic carbon

SSA = sub-Saharan Africa

TSP = triple superphosphate

USA = United States of America

WUE = water use efficiency

MSLA =means single leaf area

Al = Aluminum

Fe = Iron

t/ha = tone per hectare

MC= moisture content

CT = conventional tillage

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Impact of Tillage Practice and Mineral Fertilizer on Maize (*Zea mays* L) Production in Dugda Wereda, Meki, Central Rift Valley, Ethiopia

Hawi Mohammed, Tesfaye Shiferaw and Solomon Tulu

ABSTRACT

*An experiment was conducted at Dugda Woreda in the central rift valley of Ethiopia under field condition to determine impacts of tillage type and mineral fertilizer on maize (Zea mays L.) production. The experiment was laid out in split plot design with three replications. The experiment consisted of two tillage systems: tilled plot and not tilled plot assigned to the main plots and four types of fertilizers: DAP+UREA, UREA, TSP and no fertilizer as a control assigned to the subplot. Analysis of variance indicated that tillage had no significant ($p>0.05$) effect on plant height, leaf area, leaf number, biomass and grain yield. But fertilizer had significant ($p<0.05$) effect on plant height, leaf area, biomass and grain yield. The tallest plant height (178.24 cm) was recorded for application of DAP+UREA which was not statistically different from UREA alone while the shortest (143.31 cm) was recorded for the control treatment. The highest mean leaf area of 431.85cm^2 and 282.25cm^2 was recorded under the application of DAP+UREA and the control treatment respectively. Biological yield and grain yield obtained from application of DAP+UREA and UREA alone were statistically similar, but they differ from application of TSP and the control treatment. Tillage and fertilizer did not affect harvest index. Plant height and leaf area (R= 0.653**), biomass and yield (R= 0. 893**), tasseling and silking date (R= 0.725**) were positively and highly significantly ($P<0.01$) correlated. Similarly leaf number and leaf area (R=0.417*) as well as grain yield and harvest index (R=0.606*) were positively and significantly ($p<0.05$) correlated. Based on the current result it can be concluded that there was no significant impact of tillage on maize production in the study area. Fertilizer affected both biomass and yield of maize. Therefore based on the result of the current study, the use of zero tillage with application of DAP + UREA, could be recommend.*

Key word: Maize, Phosphorous, Nitrogen, Tillage, Triple Superphosphate

1. INTRODUCTION

Maize (*Zea mays L.*) is an important cereal crop, which ranks the third after wheat and rice in the world (David and Adams, 1985; FAO, 2011). It is grown widely in many countries of the world. The major producers are the United States, Brazil, France, India and Italy. In Africa, the bulk of maize produced is used as human food although it is increasingly been utilized for livestock feed. The area planted of maize in West and Central Africa alone increased from 3.2 million in 1961 to 8.9 million in 2001.This phenomenal expansion of the land area devoted to maize resulted in increasing the production from2.4 million metric tons in 1961 to 10.6 million metric tons in 2001 (FAO, 2002).Maize represents the main source of calories and minerals for many rural populations in a number of developing countries. Maize is, however, very poor in concentrations of protein and micronutrients, especially zinc. Although it has a huge grain yield capacity on a given area, its yield can be significantly affected by adverse soil and climatic conditions, such as drought stress and mineral nutrient deficiencies due to lack of zinc (Hythum and Nasser, 2012).

Developing countries contribute a major share in the world cultivated land of maize which is nearly 67% but their share in production is only about 46%, where approximately 60% of the world maize is produced by USA and China collectively. There are many factors responsible or lower grain yield in these countries such as improper selection of genotype or hybrid, less optimal plant population in the field and absence of standard crop husbandry for hybrids of varying maturity groups. Among these, fertilizer management plays an important role for obtaining satisfactory yield (Azhar *et al*, 2011).Maize was introduced to Ethiopia during the late 16^{th} or early 17^{th} century (Huffnagel, 1961). Since its introduction, it has gained importance and became first in total production and yield among the cereals (Benti and Joel, 1993). In Ethiopia, maize is the major and staple food and one of the main sources of calorie in the major maize producing regions (Million and Getahun, 2001; Tolessa *et al*., 2001) being cultivated on about 1.75 million hectares (ha), which accounts for 20% of the 8.5 million ha (79.98%) of land allocated for all cereals. It ranks second after teff (*Eragrostis Tef*) in area coverage, first in total national production and yield per ha (CSA, 2008).

Considering its importance in terms of wide adaptation, total production and productivity, maize has been selected as one of the high priority crop to feed the increasing population of Ethiopia. Past research efforts in Ethiopia resulted in the development and release of open-pollinated and hybrid varieties for different agro-ecologies of the country (Mosisa and Habtamu, 2009).However, the national average yield 3.2 t/ha (CSA, 2014) is still very low as compared to the global average of 5.21t/ha (FAO, 2011). This low productivity is attributed to maize production constraints such as low soil fertility (Mosisa *et al*., 2001), poor management practices (Tolessa *et al*., 2001) and drought stress (Dewitt *et al*., 2008). Pests and diseases also cause significant losses to maize production in different regions of the country (Dewitt *et al*., 2008).

The smallholder agriculture sector in Ethiopia dominates both economic and social activity for millions of farm households those have limited resources and face severe food insecurity and show high vulnerability to climate change. With an ever-increasing population, increase in crop production is needed to tackle food security problems and improve rural livelihoods. With no technological improvement, global area under irrigation would double by 2050 from its current value of 2000 and the quantities of nitrogen and phosphorus applied globally would rise from two to four times in the same period (Tilman *et al.*, 2000).

Conventional Tillage can decrease soil organic matter content and aggregate stability in upper layer horizon. It also create plough pan below the ploughed layer consequently, resistance to penetration and bulk density in these depths increases (Micucci and Taboada, 2006).
The importance of Conservation Agriculture (CA) in enhancing productivity includes: time saving, reduction of costs, increase in organic matter, soil and water conservation, improvement of soil structure, reduction in soil erosion, improved water and air quality, increased biodiversity and enhanced carbon sequestration. Conservation tillage system including no-till and reduced tillage practices simultaneously conserved soil and water resources, reduced farm energy usage and increase and stabilize crop production (Bescansa *et al*, 2006). Soil moisture content (MC) was improved and increased by conservation tillage system (Angas *et al*., 2006).

Moisture content was higher in no-tillage system in the top 20 cm layer as compared to CT system Farkas *et al*. (2009).Cultivation in reduced or minimum tillage decreases energy consumption and overall farming costs as less area has to be tilled (Monzon *et al*., 2006). Conventional tillage (CT) is utilized for seed bed preparation and or improving seed-soil contact. However, in long-term CT (comprising primary and secondary tillage operation) may have negative effects on the soil fertility, and it can vary at different depths of the ploughed layer (Josa *et al*., 2010). A number of CA implements have been developed. These modifications to the maresha plough cause minimal soil disturbance. The aim has been to make the CA implements affordable, light and easy to use by smallholder farmers (Rockström *et al*., 2009; Temesgen, 2007; Temesgen *et al*., 2009).

Moisture stress and nutrient deficiency is critical in central rift valley of Oromiya. Of all nutrients, nitrogen and phosphorus are the most crop growths and yield limiting factors in the country. The study conducted in the central rift valley of Oromiya also emphasized that the principal constraints to increase crop production in semiarid regions were the minimal combination of technologies for water availability, soil fertility, and new genetic material (Kidane *et al*., 2001). Repeated tillage has been reported to be the main cause of land degradation in Ethiopia (Araya *et al*., 2012; oxen rental cost for tillage is high and unaffordable to most farmers in Ethiopia, despite the low access to oxen particularly during peak time of planting (Aune *et al*., 2001). In the central rift valley (CRV) of Ethiopia, the repeated tillage at the shallow depths (13–16 cm) is often found to form plough pans below the plough layer which needs continuous manipulation in order to increase infiltration and crop establishment(Temesgen *et al.*, 2008; Biazin *et al*., 2011; Biazin and Sterk, 2013). On other hand, intensive tillage increases evaporation of moisture from the soil surface, increasing vulnerability of crop to drought particularly during dry and low rainfall season (Biazin and Sterk, 2013) The major findings from the limited research with regard to Conservation Agriculture in Ethiopia are improved grain and biomass yields in Teff, maize and wheat (Araya et al., 2012) Thus. studies that focus on optimization of fertilization under conservation tillage are scarce. Therefore, this experiment was initiated with the following objectives

- To determine the impact of tillage type and mineral fertilizers on maize (*Zea mays L.*) production at Dugda Woreda, Meki, central rift valley, Ethiopia.

2. LITERATURE REVIEW

2.1 Impact of Tillage on Maize Production

FAO, (2011) defines Conservation Agriculture (CA) as a toolkit of agricultural practices that combines the simultaneous principles of reduced soil disturbance, permanent soil surface cover and crop rotations or associations, where farmers choose what is best for them. The importance of CA in enhancing productivity includes: time saving, reduction of costs, increase in organic matter, soil and water conservation, improvement of soil structure, reduction in soil erosion, improved water quality, improved air quality, increased biodiversity and enhanced carbon sequestration (FAO, 2013). With all the reported benefits, adoption of CA has been stagnant, especially in Sub-Saharan Africa (Rockstrom *et al.*, 2009; Temesgen *et al.*, 2009; Enfors *et al.*,2011 and Andersson and D'Souza, 2013).

It has been found that one of the critical constraints to adopt CA in smallholder farmers' condition is competing uses for crop residues (Giller *et al.*, 2009). Combining CA with Agroforestry trees may reduce the constraint of surface cover from litter and other tree parts while the trees themselves can contribute to the existence of green cover, which can serve as rotation with annual crops. Another point that this study aims to explore is how different degrees of tillage (till or no-till) affects tree-crop competition, as tillage can reduce tree root distribution(Haynes, 1980; Bertomeu *et al.*, 2011).

Tillage can also serve as root pruning technique, enhancing integration of organic carbon (C) to the soil. In addition to reduced resource depletion (Schenk, 2006) the presence of tree root would increase other impacts on the under canopy crops (e.g. Allelopathy). On the other hand, conservation tillage improves crop yields and water productivity (Rockstrom *et al.*, 2009). This benefit of conservation tillage can be maximized by utilizing it in combination with other agronomic practices. For example, the fitness of annual crops and its performance under trees might vary depending on the level of commercial fertilizer applied as well as the variety of the crop itself. Agricultural practices affect soil carbon (C) reserve by influencing at least two processes: (I) increasing rate of biomass decomposition and mineralization releasing CO2 into the atmosphere, and (II) exposing SOC in the soil surface to the climatic elements thereby increasing mineralization of C. The rates of these processes are governed by several exogenous and endogenous factors including inherent soil properties, micro and meso-climate, and management practices. Extensive agricultural systems, with none or a little external input may accentuate C efflux from soil (Lal *et al.,* 1995b).Carbon efflux from agricultural land is also accentuated by onset of soil degradation processes. Those processes, which are accentuated by agricultural practices and exacerbate carbon (C) flux, include erosion, leaching and soil fertility depletion, and decline of soil structure.

There are three principal components of soil and water management related to C sequestration in the soil. Soil surface management involves: (I) seedbed preparation through varying frequency, intensity and type of tillage operations, and (II) crop residue management and return of organic byproducts to the soil surface. Seedbed preparation, based on mechanical soil manipulation, is a principal factor responsible for exacerbating soil processes that accentuate C mineralization and decomposition. Several experiments have shown that ploughing decreases SOC content both in temperate (Carter, 1993) and in tropical ecosystems (Lal, 1989). In contrast to ploughing, conservation tillage practices reduce frequency and intensity of tillage, retain crop residues as mulch on the soil surface, reduce risks of runoff and soil erosion, and increase SOC content of the surface soil. Conservation tillage is known to enhance SOC in the surface soil horizons through several mechanisms (e.g., alterations of soil temperature and moisture regimes, and erosion control) (Lal, 1989; Kern and Johnson, 1993).

Conservation tillage, a generic term denoting a range of tillage practices that reduce soil and water losses in comparison with conventional or plow-based tillage method and use crop residue mulch to provide a protection against raindrop impact, increases SOC through enhancement of soil aggregating processes and reversal of soil degrading processes (Lal, 1989; Carter,1993). Several experiments conducted in temperate and tropical regions have demonstrated the beneficial effects of conservation tillage on SOC (Juo and Lal, 1978; Lal, 1979; Dalal, 1989; 1992; Lal *et al*., 1989; Carter, 1993). On an Ultisol in Eastern Nigeria, Ohiri and Ezumah (1990) observed about 8% higher SOC in conservation tillage compared with conventional tillage systems. Conservation tillage usually has a positive impact on activity and species diversity of soil fauna. Earthworm activity is notably improved by conservation tillage (Lal *et al.,* 1980; Lal, 1975).

Conservation tillage also improves aggregation and stability of aggregates (Lal, 1989). Increase in water availability in the root zone improves biomass production and improves SOC content (Letey, 1985). Kern and Johnson (1993) evaluated the impact of conservation tillage on C sequestration in soils of the contiguous United States. They estimated that maintaining conventional tillage level of 1990 until 2020 would result in 46 to 78Tg SOC loss. In contrast conversion of conventional tillage to no-till would result in 80 to 129 Tg SOC gain in soil for the low scenario and 286 to 468 Tg SOC for the high scenario as cited by R. Lal & J.M. Kimble 1997.

2.2 Nutrient requirement of maize

2.2.1. Soil fertility and maize production

The majority of the soils in sub Saharan Africa (SSA) are deficient in both nitrogen (N) and phosphorus (P) (Mafongoya *et al.* 2000). N is considered to be the more limiting nutrient for plant growth, at least in most soils of Ethiopia (Tadesse 2001). In addition, low soil C levels limit ecosystem functioning of microbes in soils of SSA (Sanchez and Jama 2002), which in turn impacts on nutrient availability to plants. Hence, low soil fertility is recognized as the fundamental biophysical cause of declining per capita food production and food security in smallholder farms in SSA (Sanchez *et al.* 1997). It is evident that capita food production will continue to decrease unless soil fertility depletion is effectively addressed (Buresh *et al*. 1997; Sanchez *et al*. 1997; Sanchez and Jama 2002).

Among the commonly used indicators of soil physical health are soil depth and rooting, infiltration, bulk density, water holding capacity, aggregate stability, and penetration resistance.

Fertilizer trees improve soil physical properties due to the addition of large quantities of litter fall, root biomass, root activity, biological activities, and roots leaving macropores in the soil following their decomposition (Rao *et al*., 1997).

In studies conducted in eastern Zambia, Sesbania fallows significantly increased the percentage of water-stable aggregates (>2 mm) compared with continuous maize cultivation without fertilizer (Sileshi and Mafongoya, 2006a).In the same experiment after two years of cropping, significantly lower bulk density and higher porosity (P < 0.05) was recorded in pigeon pea and Sesbania fallows than a monoculture maize. Similarly, bulk density was higher under monoculture maize compared with maize grown in association with Gliricidia and *L. leucocephala* (Sileshi and Mafongoya, 2006a).

The fact that fertilizer trees consistently improve soil physical properties is seen from measured increases in infiltration rates, soil penetration resistance and reduced runoff and soil losses (Nyamadzawo *et al.,* 2007; Phiri*et al*., 2003). Treatments involving fertilizer trees (Leucaena, Gliricidia and Sesbania) have consistently shown significantly higher infiltration rates than monoculture maize. Hence, increased water infiltration implies reduced water runoff and thus low soil erosion, generally compared to continuously cropped maize plots (Chirwa *et al*., 2003).

Soil quality is of great concern to farmers, particularly resource poor smallholder farmers who are commonly found in SSA and rely to a large extent on the biological soil fertility rejuvenation (such as fallowing) and productivity of soil for their livelihoods. Smallholder farmers around the world have developed a plethora of detailed local soil characterization and classifications experiences, based on years of observations and which are informed by a variety of soil quality indicators (Barrios and Trejo, 2003; Pawluk *et al*., 1992; Talawar and Rhoades, 1998; WinklerPrins and Barrera-Bassols, 2004).

In many farming systems of Ethiopia, soil nutrient depletion is the main limitation to crop production (Rockström *et al.*, 2009; Tefera and Sterk, 2010). Observable poor soil fertility (Tefera and Sterk, 2010; Sileshi *et al.*, 2011), limited capacity of farmers to use commercial fertilizers (Yirga and Hassan, 2010; Sileshi *et al.*, 2011), loss of nutrients through soil erosion and leaching (Rockström *et al.*, 2009; Tefera and Sterk, 2010) are indicators that the problem will continue to constrain crop production in the country for the foreseeable future.

As population of the country is increasing at a rate of close to 3% per annum (CSA, 2007), there is a clear need for sustained increase in food crops production. According to FAO (2012), the total quantity of food produced has risen three fold between 2002 and 2011 for maize and wheat. However, over nearly the same period the use of commercial fertilizers (DAP and Urea) has risen by four fold. In addition, land under maize production increased by 50% and that under wheat production expanded by three fold. The same trend can be observed for other cereals during this period as predicted byCSA (2007). Given the scarcity of land and increasing price of commercial fertilizer, there is a clear indication that an alternative to increase in area of production and sustain yield is needed.

2.2.2. Nitrogen

Maize is a heavy feeder with high N requirement. Its demand for P is also high and it is sensitive to a low phosphate supply particularly at early stages of growth. Because of this, it is sometimes used as a test crop to assess P deficiencies (Ahn, 1993). The nutrient demands of maize are very high especially for Nitrogen. Inorganic fertilizers are commonly used to provide maize crops with the required nutrients (Andy Deaville, 2011).

The recent development of soil tests for assessing soil levels has provided new tools for improving the efficiency of N fertilizer applications to corn. Soil testing for N allows corn N recommendations to be adjusted for the numerous year and site specific conditions that can influence availability (Andy Deaville, 2011).Two soil N tests are currently available. One is a technique for assessing N requirements based on measuring the residual soil profile nitrate present before planting. The other is a pre side dress soil nitrate test that provides an index of N availability and predicts side dress N requirements.Nitrogen is an important plant nutrient and lost in the form of leaching, denitrification or volatilization if not managed properly. Nitrogen application in splits proved to be a best practice in the sense that it reduced various losses and resulted to higher dry matter accumulation and plant height in maize as compared to sole application (Harikrishna *et al*., 2005).

Nitrogen fertilizer is a key nutrient in the production of non-legume crops. It is a component in many biological compounds that plays a major role in photosynthetic activity and crop yielding capacity (Cathcart, R.J. and C.J. Swanton, 2003)and its deficiency constitutes one of the major yield limiting factors for cereal crops production (Shah, Z *et al* 2003).

Nitrogen (N) application rate is often the single most important factor affecting the efficiency of N use by corn and the extent of nitrate loss to groundwater. It is imperative that nitrogen (N) application rate recommendations accurately predict the amount of N needed to obtain acceptable corn yields and minimize environmental impacts. The recent development of soil tests for assessing soil N levels has provided new tools for improving the efficiency of N fertilizer applications to corn. Soil testing for N allows corn N recommendations to be adjusted for the numerous year and site-specific conditions that can influence N availability (Shah, Z *et al* 2003).

Application of nitrogen (N) not only increases the growth and fruit yield of crops, but also improves soil characteristics by affecting soil micro flora and fauna. The lack of N in soil may lead to poor plant growth due to a decline in soil productive potential and fertility status. Therefore, N is the most essential element of plant nutrition and hence, plants take it up in significant amounts. Sufficient N supply improves cell division, foliage production, and photosynthetic activity of the plant, thus producing higher numbers of flowers and fruits and seeds (Sharma and Yadav, 1996). Optimal use of N improves dry matter, especially the economic parts of the plant (i.e. flowers and fruits). However, N availability to plants depends on the source, soil type, and environmental conditions, which may affect crop performance. Therefore, a crop's N supply should be synchronized to its demand. N losses are observed in every type of soil and management of such losses should always be a top priority when considering the study of N supply to crops (Salazar *et al.*, 2011).

Rotation of maize with legume fallows can result in more effective subsoil nitrate and water utilization than maize monoculture (Chirwa *et al*., 2007; Nyamadzawo *et al*., 2007; Phiri*et al*., 2003). Where both soil organic matter and phosphorus are very poor, legumes may not accumulate a significant amount of biomass and will fix little N. To maintain positivenutrient balances for N and P in these environments, organic resources need to be combined with low rates of mineral fertilizer amendments (Sileshi *et al*., 2009).The fact that grain yield varied significantly with timing and regimentation of nitrogen strongly underscores the necessity of fine tuning N application to match nutrient supply to crop demand and grain yield varied significantly with timing and split application of nitrogen strongly underscores the benefit of fine tuning nitrogen application in order to match nutrient supply to crop demand (Macharia *et al*, 2007). Research findings in Bako Research Centre indicated that a maximum yield of maize was obtained with the application of 125 kg ha^{-1} N and 100 kg ha^{-1} P_2O_5 at the tested locations (IAR, 1982). Therefore, split application of nitrogen is crucial for efficient utilization and optimum yields of maize. Most agricultural soils already put under production in Ethiopia are responsive to split application of nitrogen (Tolessa *et al*. 1994).

2.2.3. Phosphorous

Phosphorus (P) plays a key role in energy transfer and thus essential for photosynthesis and other chemo-physiological processes in plants and it is inevitable and crucial for cell differentiation and development of tissue (Anonymous, 2000).Phosphorus has many essential functions in plant life; its role in energy storage and transfer is singly the most important function. Large quantity of Phosphorus is found in seed and it is considered essential for seed formation. Phosphorus is essential for inflorescence, grain formation; ripening and reproductive parts of maize plant (Ibrahim and Kandil 2007). It is needed for growth, nucleus formation, photosynthesis, utilization of sugar and starch, cell division and fat and albumen formation. Phosphorus is readily translocated within the plants and it moves from older tissues to younger tissues (Ali *et al*. 2002) Hence, phosphorus in adequate amount is necessary for earlier maturity, rapid growth, improved quality of vegetative growth and improved quality of consumable plant parts. Deficiency of phosphorus is responsible for small ears in maize due to crooked and missing rows as kernel twist and low quality of consumable parts of the plant (Masood *et al*. 2011). Phosphorus (P) alone or high quantity did not increase the yield of maize when nitrogen is in short supply. This is because the nitrogen in a short supply is limiting the yield of maize, since the nutrient in minimum quantity is always a limiting factor. However, the combined application of phosphorus with nitrogen increased the yield significantly (Moschler and Martens 1975).

In small scale farming systems in Africa, crop harvesting removes almost all of the P accumulated by cereal crops (Sanchez *et al*., 1997). Application of plant biomass from fertilizer trees as green manure can contribute to P availability, either directly by releasing tissue P during decomposition and mineralization or indirectly by acting on chemical processes that regulate P adsorption-desorption reactions (Mweta *et al*., 2007).Soil organic matter contributes indirectly to raising P in soil solution by complexing certain ions such as Al and Fe that would otherwise constrain P availability (Li *et al*., 2003; Mweta *et al*., 2007). Decomposing organic matter also releases anions that can compete with P for fixation sites, thus reducing P adsorption. The more extensive root systems that trees and shrubs have compared to crops increase the exploration of larger soil volumes, which results in enhanced uptake of P and other nutrients (Schroth, 1999).

Careful management of phosphorus (P) in corn production is essential for preventing nutrient enrichment of surface waters. Contributions of P to surface waters have been shown to increase with increasing rates of applied P. Fertilizer applications at rates higher than crop utilization are unwise from both an environmental and economic viewpoint (Shah, Z *et al* 2003).Using soil tests to determine crop P needs, setting realistic crop yield goals, and taking appropriate nutrient credits are techniques that will reduce environmental risk and increase economic benefits. To avoid over-fertilization with P and other nutrients, fertilizer additions should be made according to soil test results. Regular and systematic soil testing is required for determining P application rates. Differences in phosphorus utilization efficiency may occur among plant species or genotypes of the same species due to differences in amounts of shoot dry matter produced per unit of P acquired. This may be related to the ability of plants to conserve re translocation and use inorganic P in its tissue (Caradus and Snaydon, 1987).

3. MATERIALS AND METHODES

3.1 Description of the Study area

Field experiment was conducted in the Jawe bofo kebele, Dugda Woreda, East Showa Zone, Oromiya regional state, in the central rift valley of Ethiopia. The study site is located at 130 km away south of Addis Ababa, the capital city of Ethiopia. The geographical location of the experimental site is 8^0, 15' N, 38^o, 82' E and altitude of 1650m above sea level. The experimental site is receiving an annual rainfall of 720mm and with annual average temperature of 18^o C It is categorized with semi-arid climate and Andosol with sandy loam soil texture.

Tef is the first and Maize is the second important crop in this Woreda and other cereals like wheat and pulse crops such as haricot bean and fababean are also produced at large scale.

3.2 Planting (experimental) material

A high yielding maize variety, Melkasa-2(ZM-521) released in 2004 by Melkasa Agricultural Research Centre was used as a planting material in this experiment. It is adapted to an area with the altitude of 1200-1700 m.a.s.l. and rainfall of 600-800 mm. The seed rate of this variety is 25-30 kg/ha and the optimum planting date is early May to early June depending on the start of rainfall. The recommended rate of fertilization for this maize variety is 46 kg P_2O_5 or as per recommendation for the area, 64 kg N or as per recommendation for the area and expected yield is 55-65 quintal per hectare on research field and 45-50 quintal per hectare on farmer's field.

3.3 Experimental design and treatments

The experiment was laid out in split plot design with three replications. For this experiment, the treatments are two types of tillage as tilled plot and non-tilled plot assigned to the main plot and four types of fertilizers such as TSP, UREA, DAP+UREA and no fertilizer as a control treatment assigned to the sub plot.

The fertilizer treatments are based on the fertilizer recommendation of the area and hence the fertilizer treatments are: T1 = 100 TSP kg/ha, T2 = 100 kg DAP/ha + 100 kg UREA/ha, T3 = 139.1 kg UREA/ha and T4 = No fertilizer (control). These four fertilizer treatments were applied to the sub plots arranged in the two main plots assigned to the two tillage levels as none tilled (1) and tilled (2).

3.4 Fertilizer application and field activities

Depth of tillage, frequency, and intensity: Depth and intensity for conventional (tilled) plots was based on local practices (equivalent of 4-6 times using traditional Maresha). For conservation tillage, we used ripping to place maize seeds at depth of 7-10cm

The total area of experiment is 600m^2 and size of main plot was 10mX10mfor tillage and size of sub plot was 5mx5m for fertilizer. All field activities were carried out following standard production practices. Planting was done on June 8 2014 by placing the seeds in hand made furrows at inter and intra-row spacing of 75 cm and 30 cm, respectively Phosphate fertilizers in the form of triple super phosphate (TSP) and DAP at the rate of 100 kg/ha were applied to the sub plots according to the treatments indicated above by banding at the time of planting. Nitrogen fertilizer in the form of UREA was applied at 139.1 kg/ha applied alone as one treatment (T3) and also applied at 100 kg/ha together with DAP as another treatment (T2). Accordingly ½ UREA was applied at sowing and the remaining was applied at knee height.

3.5 Data collection and measurement

3.5.1 Phenological and growth parameters

Five plants were selected randomly from each plot and tagged. The data was collected and recorded were plant height, leaf area, number of leaf per plant, 50% tasseling and silking, above ground biomass, harvest index and grain yield.

Leaf area: Leaf area was determined by multiplying leaf length and maximum breadth adjusted by a correction factor of 0.75 (i.e. 0.75 x leaf length x maximum breadth) as suggested by (Francis *et al*., 1969).Data was taken every week from selected plant until flag leaves emerge.

Plant height (cm): It was measured as the height from the soil surface to the base of the tassel of five randomly selected plants from the net plot area at each week up to physiological maturity.

3.5.2 Data on Yield and Yield components

Grain yield (kg/ha): Grain yield per plot was measured using electronic balance and then converted to hectare basis.

Above Ground Biomass yield (kg/ha): Plants from the net plot area were harvested at maturity and weighed after sun drying.

3.6 Statistical Analysis

Analysis of variance (ANOVA) was performed to see the impacts of tillage type and mineral fertilizer on maize growth and production, using SAS 9.2 version statistical software and least significant difference (LSD) test at 5% probability was used for mean separation when the analysis of variance indicated the presence of significant differences(Gomez,1984).

4. RESULTS AND DISCUSSION

Effects of two tillage levels (none tilled plot and tilled plot) and four fertilizer types (DAP+UREA, UREA, TSP and no fertilizer as a control) on the growth and production of maize were evaluated in terms of plant height, leaf area, leaf number, date to fifty percent tasseling and silking, biomass yield, grain yield and harvest index and the results obtained are presented (Table 1) and accordingly discussed in light of the available literature as follows.

Table 1. Mean separation for Phenological and Growth Parameters

Source of variation	DF	PH	LN	LA	DL
Tillage	1	4080.47 ns	0.24 ns	22632.87 ns	0.08 ns
Fertilizer	3	1784.11 **	1.16 ns	28319.58 **	0.51 ns
Tillage X Fertilizer	3	19.76 ns	4.07 ns	2805.06 ns	2.21 ns
Error	12	318.76	1.64	3870.40	0.34
CV		10.97	9.81	17.94	18.61
LSD		47.48	3.25	62.40	2.72

DF: Degree of freedom, PH: Plant Height, LN: Leaf Number, DL: Dead Leaf, *: Significant difference, **: Highly Significant Difference, ns: None Significant Difference at 5% probability level.

4.1 Plant height

All the interactions effects of fertilizer and tillage were none significant ($P > 0.05$) on plant height (Table 1). It implies that the fertilizer and tillage methods are independent and behave separately on plant height. In addition, the current result also showed that none significant difference in maize plant height between none tilled and tilled (Table2).Aikins *et al*. (2012) also found the same results that there is no significant effect of tillage on the plant height.In similar manner, Al-Ghrerie (1988) also reported that the two tillage systems (zero tillage and conventional tillage) had showed none significant effect on plant height of maize.

Table 2. Effects of tillage system on the growth of maize (*Zea mays* L)

Tillage	Plant height (cm)	Leaf area (cm2)	Leaf number (number)
None tilled plot	149.58[a]	315.91[a]	12.98[a]
Tilled plot	175.66[a]	377.33[a]	13.18[a]
LSD(<0.05)	47.483	62.4	3.2579

Means with similar letters in each column are not significantly different

According to the result of the current investigation, there is significant ($P < 0.05$) impact of fertilizer types on plant height. The tallest plant height (178.8cm) was observed in plot with the application of 100 kg DAP+UREA/ha. But the shortest plant height (123.98cm) was observed in the plot with the control treatment. The comparison of various fertilizer treatments revealed that plant height increased significantly compared to the control treatment but there is no difference between application of DAP+UREA and UREA as well as between TSP and control (Table3). These current findings are in agreement with Khalil *et al*.(1998), who reported that N & P alone or in combination increased plant height. Ahmad Khan (2005) also concluded that the application of 120 kgN/ha increase maize height. Hammad *et al*. (2011), also reported that there is more vegetative as well as reproductive growth with increasing amount of nitrogen (N).

4.2 Leaf Area

The current result showed that type of fertilizer significantly ($p < 0.05$) affected leaf area of maize but the effect of tillage was none significant ($p > 0.05$) on leaf area (Table 1). The highest leaf area (431.85 cm^2) was recorded with the application of DAP+UREA together but the lowest (282.25) was recorded at the control (no fertilizer). In this regard there was no significant difference between UREA and TSP as well as between TSP and control (Table 3)

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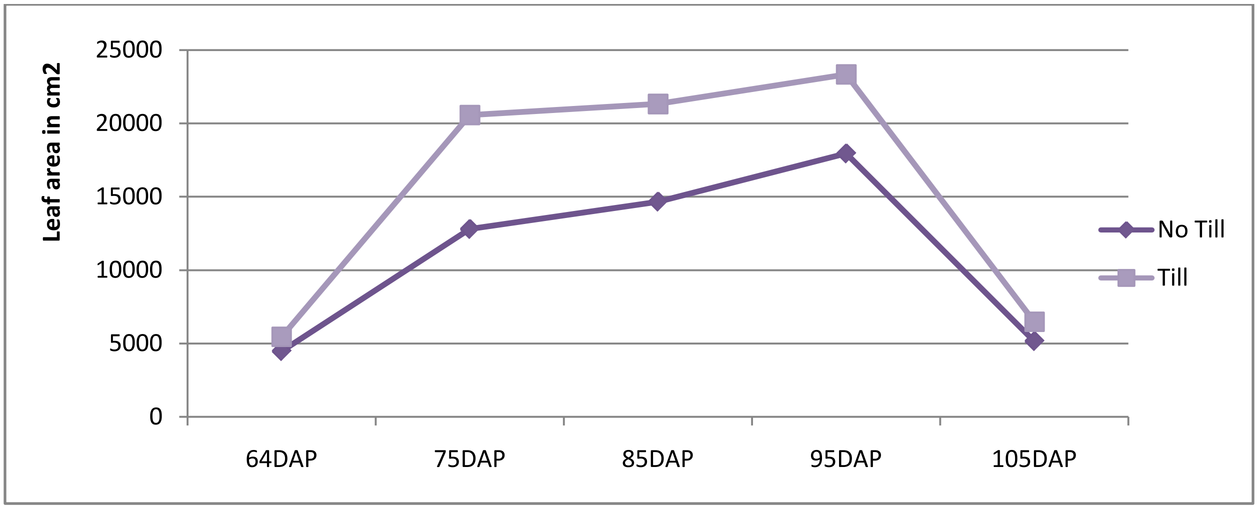
Table 3. Effects of fertilizer type on the growth of maize (*Zea mays* L.)

Fertilizer types	Plant height (cm)	Leaf Area (cm^2)	Leaf Number (number)
DAP+UREA	178.24[a]	431.85[a]	13.70[a]
UREA	176.05[a]	371.81[ab]	13.10[a]
TSP	152.87[b]	300.59[bc]	12.80[a]
Control	143.31[b]	282.25[c]	12.73[a]
LSD (P<0.05)	22.459	78.26	1.6148

Means with similar letters in each column are not significantly different

This increase in leaf area could be the synergic effect of nitrogen and phosphorus on plant growth. The same effect of nitrogen and phosphorous was reported by (Rai, R.K *et al*, 1986) who found that both elements increased plant growth up to the 100 days (Fig. 1) from sowing. In similar manner the current finding is also in agreement with Khan, M.A (1999) who reported that leaf area increased with increase in nitrogen and phosphorus levels. Larger leaf area of Maize is important for increasing the photosynthetic capacity as well as yield of the plant since the photosynthetic capacity of crops is a function of leaf area. This could be due to the fact that leaf area is important for crop light interception and therefore has a large influence on crop yield (Dwyer and Stewart, 1986).



DAP: Day after Planting, Till: Tilled Plot, No Till: None Tilled plot

Figure 1.Trend observed in the leaf area of maize (*Zea mays*) at different growth stages of maize

Leaf area influence interception and utilization of solar radiation of maize crop canopies and consequently maize dry matter accumulation and grain yield. Leaf area and number are important factors in the estimation of canopy photosynthesis in crop growth simulation models that compute dry matter accumulation from temporal integration of canopies photosynthesis (Boote *et al.*, 1996).

4.3 Leaf number

Tillage and types of fertilizer are none significantly ($P > 0.05$) affected leaf number of maize (Table 2 and 3). This could be due to the reason that leaf number is affected by the genetic make of the plant than the cultural practices including tillage and fertilizers.

Table 4. Mean separation for Yield and Yield Components

Source of variation	DF	50% T	50% S	B	Y	HI
Tillage	1	36.00 ns	2.25 ns	60365608.08 ns	5990349.26 ns	0.002 ns
Fertilizer	3	16.83 ns	10.41 ns	26345977.15 *	3511962.20 *	0.004 ns
Tillage X Fertilizer	3	0.83 ns	2.41 ns	4198078.26 ns	258015.81 ns	0.003 ns
Error	15	53.00	6.41	4689544.10	44622.58	0.002
CV		14.67	9.42	23.66	26.89	18.34
LSD		19.05	12.70	21049.00	1990.30	0.41

DF: Degree of freedom, 50% T: 50% Tasseling, 50% S: 50% Silking, B: Biomass, Y: Yield, HI: Harvest Index, *: Significant difference, **: Highly Significant Difference, ns: None Significant Difference at 5% probability level.

4.4 Day to fifty percent tassiling and silking

There was no significant ($P > 0.05$)effects of tillage and fertilizer on both date to 50% tasseling and silking of maize (Table 4 and 5). The result of the current investigation with respect to the effect of tillage on silking is in agreement with Sharma *et al.* (1988),who reported that different tillage systems did not affect silking and maturity of maize. But on the contrary Cox *et al.*, (1990) also found that delayed silking under zero tillage system compared to conventional tillage systems. In addition opposite the current result, Khan and Parvej (2010) reported that a greater number of days to silking of maize in none tilled plots compared to the tilled plots.

Table5. Impacts of tillage system on 50% tasseling and silking of maize (*Zea mays* L)

Tillage system	Date to 50% Tasseling	Date to 50% Silking
None tilled plot	21.750[a]	27.2500[a]
Tilled plot	18.750[a]	26.5000[a]
LSD (P < 0.05)	19.059	12.70620

Means with similar letters in each column are not significantly different

Table 6. Impacts of fertilizer type on date to 50% tasseling and silking of maize (*Zea mays* L.)

Fertilizer types	50% Tasseling	50% Silking
DAP+UREA	20.50[a]	26.25[a]
UREA	17.75[a]	25.00[a]
TSP	20.00[a]	27.50[a]
Control	22.75[a]	28.75[a]
LSD (P < 0.05)	5.1424	4.3829

Means with similar letters in each column are not significantly different

4.5 Above ground biomass yield

Biomass yield of maize was significantly ($P< 0.05$) affected by fertilizer types but none significantly ($p > 0.05$) affected by tillage (Table 4,7and 8). Accordingly no difference observed between none tilled (zero tillage) and tilled plots on maize biomass yield. The highest biomass yield was observed in the application of DAP+ UREA together and also UREA alone which were statistically the same. Application of UREA and TSP provided the same yield as well as TSP and the control (Table 5). The increased biomass in higher level of N in DAP+UREA compared to the lower level of N in UREA alone might be due to the increase in MSLA, LAPP and plant heights at higher than at lower N rate. In agreement with the current finding Amanullah *et, al* (2009), also reported that increase in biomass yield at higher N than lower N rate.But contrary to the current finding, significantly highest biological yield (Gul *et al*., 2009) and was obtained in case of conventional tillage (tilled) compared to zero tillage (none tilled) or reduced tillage which showed less biological yield due to high weed density.

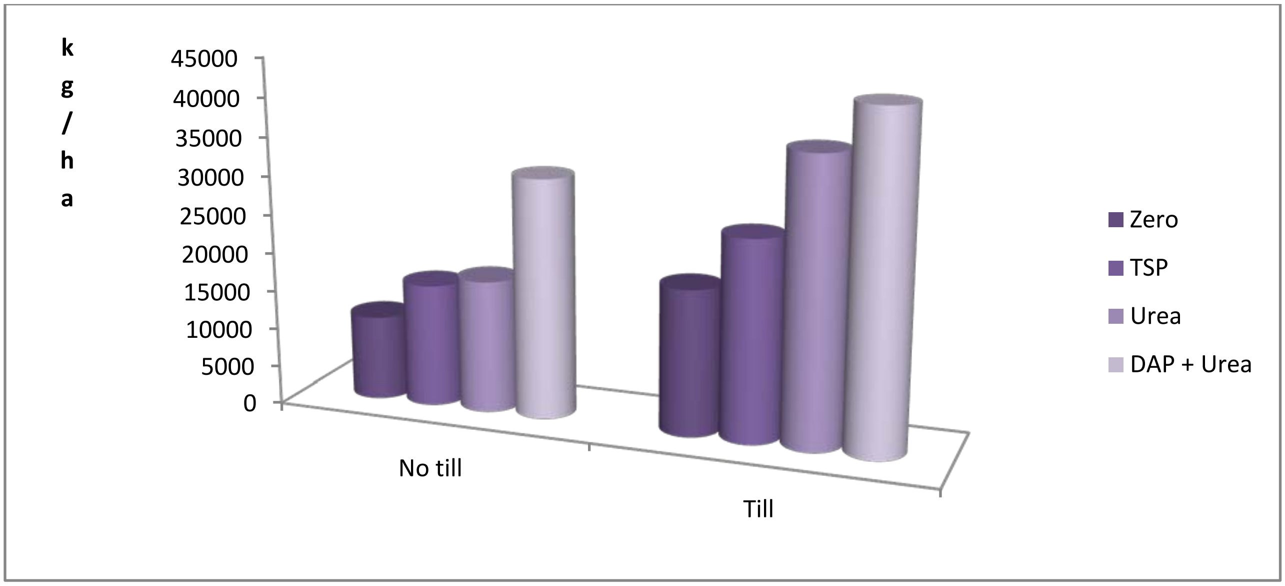


Figure2.Impacts of fertilizer type on above ground biomass production of maize (*Zea mays* L)

4.6. Grain yield

Grain yield was not significantly (*P > 0.05*) affected by both the effect of tillage and fertilizer types and their interaction effect (Table 4,7 and 8). None tilled plots provided similar yield as tilled plots. Contrary to the current investigation, significantly grain yield was obtained in case of conventional tillage compared to no tillage or reduced tillage which showed less grain yield due to high weed density according to the work of Marwat *et al*. (2007).

Table 7. Effects of fertilizer type on Biomass, Grain Yield and HI of maize (*Zea mays* L.)

Fertilizer type	Biomass (kg/ha)	Yield (kg/ha)	HI (%)
DAP+UREA	11925[a]	3678.8[a]	0.31500[a]
UREA	10455[ab]	2689.5[ab]	0.25750[a]
TSP	8115b[c]	2083[bc]	0.25250[a]
Control	6103[c]	1482.3[c]	0.2450[a]
LSD(P<0.05)	3746.9	1155.8	0.0849

Means with similar letters in each column are not significantly different

Although, there was none significant difference between DAP+UREA and UREA alone statistically but the grain yield obtained with the application DAP+UREA seems better than that obtained with the application of UREA alone (Table 7). Heaviest grain yield with higher P level obtained from DAP may be due to the higher P translocation and activity into fruiting and seed formation, which resulted in highest grain weight (Amanullah *et al.*, 2009b). In similar, Sahoo and Panda (2001) also suggested that increase in P levels increased grain weight in maize.

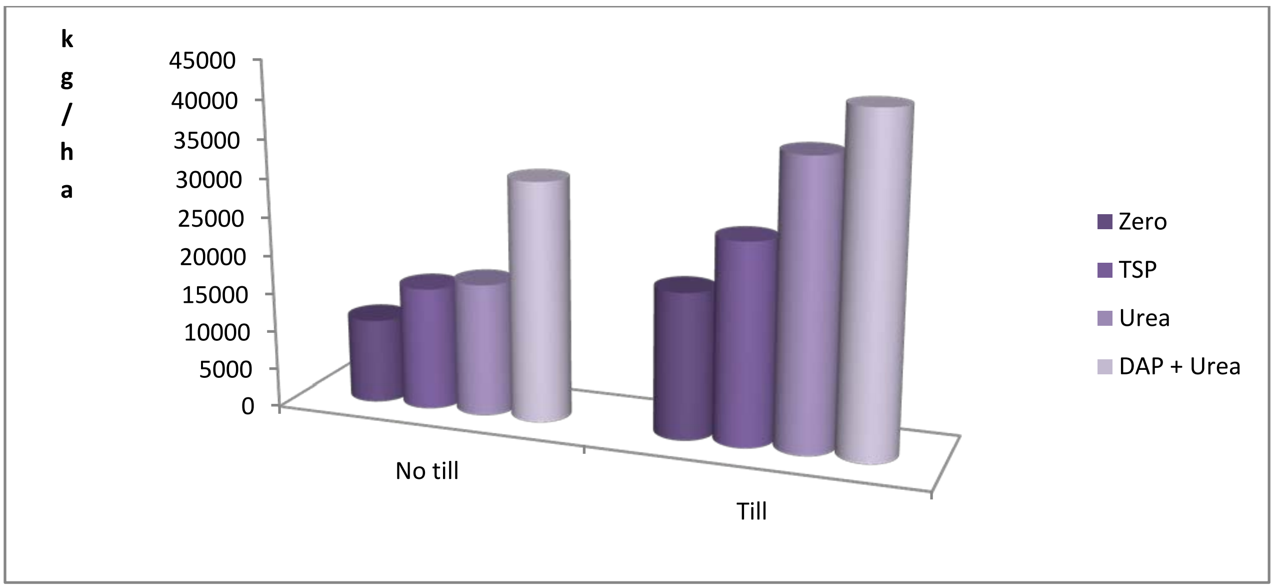


Figure 3. Impacts of fertilizer type on grain yield of maize (*Zea mays* L.)

4.7 Harvest Index (HI)

Harvest index is the ratio of grain yield and total upper ground biomass, which indicates the efficiency of plant to assimilate partition to the parts of economic, yield (i.e. maize grain). Harvest index is also indicating transforming percent of photosynthetic matters from vegetative organs (source) to seeds (sink), according to Emami, *et al*. (2011).

According to the result obtained, harvest index was none significantly affected by both tillage and fertilizer types (Table 4, 7 and 8). Although the effect of fertilizer is none significant on the harvest index of maize, the higher harvest index of 31% was obtained with the application of DAP+UREA but the lowest harvest index of 24% was recorded in the control (no fertilizer).

Table 8. Effects of Tillage on Biomass, Grain Yield and HI of maize (*Zea mays* L)

Tillage system	Biomass (kg/ha)	Yield (kg/ha)	HI (%)
None tilled plot	7207[a]	1871.6[a]	0.255[a]
Tilled plot	11092[a]	3095.3[a]	0.280[a]
LSD(P<0.05)	21049	1990.3	0.413

Means with similar letters in each column are not significantly different

The current result indicates that harvest index of crops is usually affected and could be increased with rate of fertilizers rather than with the type of fertilizers. Lawrence (2008) reported that harvest index in corn is increasing with increasing rates of nitrogen. In agreement to the current finding, Muhammad *et al.* (2002) also reported an increase in HI in maize while contrary to the current finding Ali *et al.* (2002) reported that HI is not affected by change in nitrogen dose in maize, since in our case the rate of nitrogen is higher in DAP+UREA compared to the control treatment with no fertilizer.

4.8 Correlation analysis

Plant height was highly and positively correlated (R = 0.653**) with leaf area. This means when plant height is increasing leaf area of the maize plant is also increasing according to the result of the current investigation. In similar manner biomass was highly and positively correlated (R = 0.893**) with yield and also date to tasseling was highly and positively correlated (R = 0.725**) with date to silking (Table 9). The current correlation result showed that increase in biomass is positively affecting the increase in grain yield of maize. Similarly as date to tasseling is increasing the date to silking is also increasing.

Table 9. Correlation coefficients of parameters for maize (*Zea mays*)

	PH	LN	LA	BIO	YILD	HI	Ts	Silk
PH	1	0.165	0.653**	0.112	0.087	0.001	-0.176	-0.02
LN		1	0.417*	-0.212	-0.171	0.035	0.279	-0.204
LA			1	0.229	0.228	0.028	-0.275	-0.314
BIO				1	0.893**	0.204	0.146	0.397
YILD					1	0.606*	0.163	0.282
HI						1	0.188	0.001
Ts							1	0.725**
Silk								1

** = Correlation is significant at the 0.01 level (2-tailed).

* = Correlation is significant at the 0.05 level (2-tailed).

5. CONCLUSION AND RECOMMENDATION

According to the result of the current investigation, there was no significant interaction effect of tillage and fertilizer types. In addition, there was none significant difference between none tilled (zero tillage) and tilled (conventional tillage) plots on the growth and productivity of maize. Accordingly plant height, leaf area and leaf numbers were not affected by tillage. But the second factor fertilizer types affected growth and productivity of the maize plant. Accordingly plant height and leaf area were affected by type of fertilizers but leaf number was not affected by fertilizer type. Plant height was significantly affected by the application of DAP+UREA and UREA but more leaf area was obtained from application of DAP+UREA than the application of UREA alone.

In similar manner there was also no significant effect of tillage on biomass, yield and harvest index of maize in the study area. Both biomass, yield and harvest index of maize were the same in both none tilled (zero tillage) and tilled (conventional tillage) plots. Contrary to the effect of tillage, fertilizer types affected biomass and yield of maize although DAP+UREA and UREA alone provided similar biomass and yield statistically. Nitrogen is more limiting nutrient than phosphorous in the study area because application of DAP+UREA providing phosphorus and nitrogen and application of UREA providing nitrogen alone resulted in similar yield levels.

Based on the current result, it can be said that tillage does not affected growth and production of maize in the study area and therefore, using zero tillage (none tilled) with application of DAP + UREA is advised to save money, time and other resources of the farmer.

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7. APPENDEXES

Appendixes of Table-1 P-value for plant height, leaf area and leaf number

Source	DF	PH(cm)	LA(cm)2	LN	DL
Tillage	1	0.141	0.051	0.816	0.870
fertilizer	3	0.012	0.004	0.565	0.265
Tillage*fertilizer	3	0.978	0.556	0.111	0.007
C.V		10.98	17.94	9.81	18.612

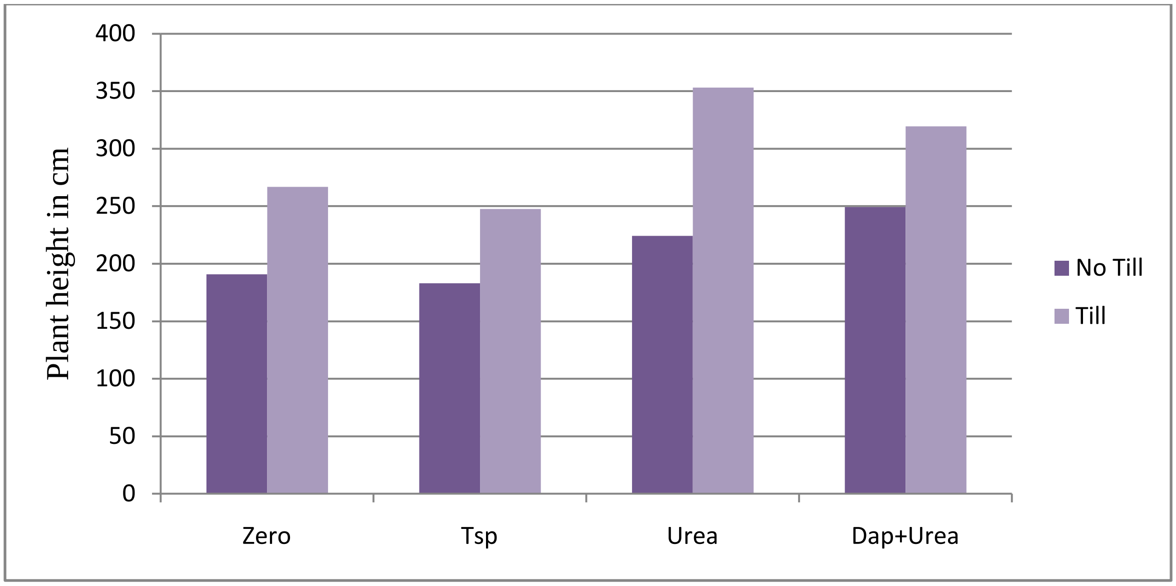
PH=plant height, leaf area, leaf number, dead leaf

Appendixes of Table 2 P-value for biomass, yield and harvest index

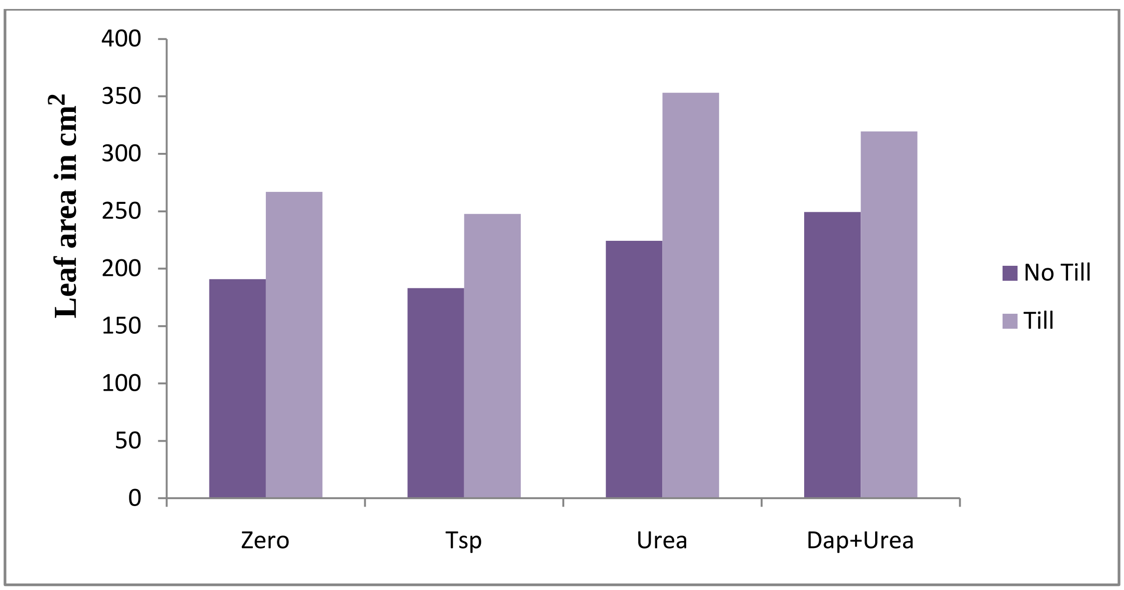
Source	DF	Biomass	yield	Harvest index
Tillage	1	0.256	0.081	0.582
fertilizer	3	0.035	0.016	0.263
Tillage*fertilizer	3	0.496	0.650	0.351
C.V		23.66	26.89	18.34

Appendixes of Table 3 P-value for date to 50%tassiling and 50%silking

Source	DF	50%tassiling	50%silking
Tillage	1	0.295	0.204
fertilizer	3	0.229	0.280
Tillage*fertilizer	3	0.960	0.773
C.V		14.677	9.425



Appendixes of figures 1Average plant height in conventional and conservational tillage for maize (*Zea mays L*) production



Appendixes of figures 1 Average leaf area in conventional and conservational tillage for maize (*Zea mays L*) production