

Full Length Research Paper

Evaluation of maize (*Zea mays* L.) performance under minimum and conventional tillage practice in two distinct agroecological zones of Uganda

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Maize is one of the major staple foods in Uganda, providing over 40% of Uganda's daily calorie consumption. Tillage practice is one of the crucial factors that influence crop productivity through maintenance of soil health. The aim of this study therefore is to validate the effect of tillage practice on the vegetative growth and yield of maize in Uganda. The trial was established on-station at Ngetta Zonal Agricultural Research and Development Institute, Lira district and on-farm in Njeru Town Council, Buikwe district. It was laid out in a factorial design with two tillage practices (conventional tillage, CT and minimum tillage, MT) as the main factors and two maize varieties (Longe 10H and Longe 5) as the levels. The results showed significant differences in plant height between the two tillage methods ($p < 0.001$). Conventional tillage practice had a higher mean maize grain yield per hectare compared to minimum tillage although the difference was insignificant ($p < 0.332$). Thus, the adoption of minimum tillage practice by farmers in Uganda would require investment in organic herbicides in order to control the weeds sustainably and boost maize productivity.

Key words: Conventional tillage, minimum tillage, vegetative growth, yield, maize.

INTRODUCTION

Among the most important cereals worldwide is maize (*Zea mays* L.) with the highest average yield per hectare (FAOSTAT, 2012) in developing countries, about 62% of the crop is consumed by humans as food, 34% as animal feed while the rest is as seed and industrial purposes (FAOSTAT, 2012). Due to its numerous uses, the crop is

increasingly gaining an important position in the cropping system especially in Uganda where there is a rapid increase in the population (Karunatilake et al., 2000). In Uganda, the North, Eastern and Central regions are the major producers of maize (Khurshid and Nawaz, 2006). However, a number of factors limit its production

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including poor farming practices (conventional and minimum tillage operations).

Tillage has been recognized as a factor that causes degradation of natural resources through soil erosion, contamination, decline in above and below ground biological diversity, deforestation, desertification, salinization, and greenhouse gas emissions (Le Guillou et al., 2019). Despite profound evidence of soil translocation processes, it was only in the 1990's that systematic research on this topic began (Van Oost et al., 2006). Conservation tillage, also known as minimum tillage is the use of agricultural practices that have minimal soil disturbances (Hossain et al., 2015). It is also defined as a farming system that employs a broad set of practices with a goal leaving some crop residue on the soil's surface to increase water infiltration and reduced erosion (Reicosky, 2015). Small resource poor farmers who have adopted conservation tillage methods cite the reduction in labor inputs and drudgery as major drivers for adoption (Andersson and D'Souza, 2014). Conservation tillage is also known to enhance soil fertility through reducing soil erosion and ultimately improving crop yields (Pittelkow et al., 2015).

Several types of conservation tillage such as minimum tillage, incomplete tillage, reduced tillage, and no tillage are practiced across the world. According to data gathered by the Conservation Technology Information Center (Anonymous, 2004), about 40.7% of total crop land on 45.44 million hectares was under conservation tillage system. Of that, no tillage was used on about 23.6% of land in the United States. Generally, reduced or no tillage provides minimum disturbance of the soil and leaves the surface covered with crop residues. The crop residues are not absolutely mixed and most or all of them remain on the top of the soil surface rather than being ploughed into the soil. They maintain a constant cover of organic material on the surface, which retains water and minimizes runoff, reduces erosion and sedimentation and improves water quality.

On the contrary, there is a common practice referred to as conventional tillage which deploys stirring up the deep layer of soil, incorporating plant debris and exposing the soil pests to sunshine for control, then lump breaking and levelling (Barbosa, 2015). It is also composed of harrowing which involves removing crop residues, subsoiling which breaks the compacted soil layer before levelling to form a fine seedbed.

In improving soil condition, tillage is a key factor and plays a significant role in improving maize growth and grain yield. A compacted soil layer, because of its high strength and low porosity, confines the crop roots in the top layer and reduces the volume of soil that can be explored by the plants for nutrients and water (Lipiec et al., 2003).

There is inadequate information on the effect of tillage methods on maize growth and yield in Uganda. This study was therefore to bridge the information gap in

regards to the influence of tillage practices on the performance of maize in the country using Lira and Buikwe districts as case studies. The information generated will contribute to enhanced sustainable production of maize and thus guarantee both food and income security.

MATERIALS AND METHODS

Experimental sites

Two field trials were established in Uganda in the districts of Buikwe (Njeru) and Lira (Ngetta Zonal Agricultural Research and Development Institute). These sites represent two maize growing agro-ecological zones of Uganda, namely Lake Victoria Crescent and Northwestern Savannah Grassland respectively.

Lake Victoria Crescent is characterized by sandy clay alluvial soils with moist semi-deciduous forest, savannas, and swamps. The area receives rainfall ranging from 1750 to 2000 mm with bimodal rains comprising of April to May for the first ones and October to December for the second rains. Temperature ranges from 11 to 33°C. Climate is warm and wet with relatively high humidity and an average altitude of 1134 m above sea level. Northwestern Savannah Grassland is comprised of ferruginous sandy loam soils with intermediate savanna grassland and scattered trees. The rainfall received ranges averagely from 1340 – 1371 mm with bimodal rains followed by a dry spell for about 5 months. Temperature and altitude range from 15 to 25°C and 951 to 1341 m above sea level respectively (Gwandu et al., 2019). These two agro ecological zones were selected for the study based on their distinct ecological features or conditions and the history of maize growing.

Source and description of maize variety

Two maize varieties (Longe 5 and Longe 10H) were used for the study. These varieties were selected because they are the most widely grown in the two agro-ecologies. Longe 5 is a drought tolerant variety, sweet at green maturity, resistant to grey leaf spot and maize streak virus. It also has a good cob size and is suitable for low and mid altitude areas like Buikwe and Lira district. On the other hand, Longe 10H is high yielding, ideal for mid-altitude, bred with good drought and storage pest resistance. The seed was acquired from NASECO Seed Company in Uganda.

Experimental design and management

The experiment was arranged in a factorial design with 2 tillage practices (conventional tillage, CT and minimum tillage, MT) as the main factors and 2 maize varieties (Longe 10H and Longe 5) as the levels. It was replicated three times. Plot sizes were 5 m x 5 m with inter-plot spacing of 1 m. For no tillage, planting basins were dug after slashing at 0.6 m x 0.9 m spacing using a hand hoe and each basin was measuring 0.15 m (length) x 0.15 m (width) x 0.15 m (depth). Conventional tillage was done using a hand hoe. The first trial was planted in the second season (A) of September 2017 while the second one (B) was planted in the first season of March, 2018. It was done at 0.75 m x 0.25 m spacing with 4 maize seeds per hole for planting basins. Thinning was done to 2 plants each per hole for minimum tillage and conventional tillage.

Field data collection

Data was collected every fort night from two weeks after planting for

8 weeks on the following parameters; plant height, stem girth, number of leaves. Data on maize yield was later recorded at harvest.

Data collection procedure

10 plants were randomly selected from each of the plots. Each plant was observed and measurements done every after two weeks. Plant height, stem girth was measured using a string and the values read from a ruler. The maize cobs were harvested after 15 weeks and weighed on a weighing scale. The cobs from each of the plots were also threshed and weighed separately. The maize grains were washed clean and their moisture content (%) was obtained using a moisture meter (Infratec™ 1241 Grain Analyser - FOSS analytical). 100-seed weight (g) was also weighed per plot and the overall maize yield (tons/ha) was calculated (Kayode and Ademiluyi, 2004).

Data analysis

The data set for maize vegetative growth (plant height, stem girth and number of leaves) and maize yield were summarized and mean values obtained. ANOVA was done using GenStat version 12 statistical package to establish the effect of different tillage practices on maize.

RESULTS AND DISCUSSION

Effect of tillage practice on vegetative growth of maize

Most of the vegetative growth parameters did not significantly vary with location and season; therefore, the data was pooled together.

Plant height

Regardless of the tillage practice, the plant height increased with the age of the maize crop (Table 1). This could be attributed to the active cell division that occurs in the plant cells and thus cause a rapid change in size and length of the cells as the plants grow. This analogy is supported by research work of Nielsen (2000) who studied the growth and development of corn in Indiana, USA. He attributed the increase in plant height with age to the apical meristem which is an area of rapid cell division located at the tip of the corn stalk. Generally, plant height differed significantly with the tillage practice, variety and crop age ($p < 0.001$). For both varieties, minimum tillage registered higher mean height compared to conventional tillage (Table 1). This could be attributed to the ample soil cover for the minimum tillage plots which conserves soil moisture as well as the decomposition of the slashed residues that improve on the fertility of the soil and thus enhancing crop growth. These results are similar to those by Soropoon and Jayasuriya (2013) who reported taller corn plants in the minimum tillage plots in Bangrakum district, Phitsanulok Province, Thailand. On the contrary, Kayode and Ademiluyi

(2004) observed the least mean height in the minimum tillage plots in comparison with that in the tilled plots in Southwestern Nigeria. In fact, study by Drakopoulos et al. (2016) confirmed this trend when it registered significantly higher plant height of organic potatoes in the conventional plots as compared to the reduced tilled ones in Droevendaal, Wageningen, Netherlands. Also, Jokela and Nair (2016) reported no significant difference in plant height of organic bell pepper plants under minimum and conventional tillage plots in the Iowa region of United States of America.

Stem girth

Conventional tillage registered a much higher mean stem girth compared to the minimum tillage across the two varieties (Table 1). Mean stem girth did not vary significantly with tillage practice ($p < 0.301$). However, generally, plants under minimum tillage had higher stem girth compared to those under conventional practice especially in Longe 5 (Table 1). This could be attributed to the presence of crop residues in the minimum tillage plots which decompose and form nutrients that result into better crop establishment. Similarly, a study by Jokela and Nair (2016) in the United States of America revealed that the stem diameter of the organic bell pepper plants under the minimum and conventional tillage plots was not significantly different. On the contrary, a study by Aikins and Afuakwa (2010) observed that the conventional tillage practices of disc ploughing alone, combination of ploughing and harrowing registered the biggest mean stem girth compared to the no tillage practice in cowpea rainfed fields of Kumasi region in Ghana.

Number of leaves per plant

Mean number of leaves per plant did not vary significantly with tillage practice ($p < 0.075$) and variety ($p < 0.910$). Higher mean number of leaves were recorded in minimum tillage plots compared to the conventional tillage plots in Longe 5 but the reverse was true for Longe 10H (Table 1). The number of leaves produced by a plant is directly proportional to the amount of photosynthate generated (Ridge, 1991). This literally means that this parameter was inconsistent and may not be used to explain the observed trend.

Effect of tillage practice on the yield components of maize

Mean grain yield (t/ha) and weight per 100 g of seed did not vary significantly with tillage practice. On the contrary, there was a significant difference observed between these two parameters with variety. A generally higher yield and weight per 100 g of seed was registered in conventional tillage plots compared to those of minimum

Table 1. Mean plant height/cm, stem girth/cm and number of leaves of two maize varieties under two contrasting tillage practices.

Parameter	Longe 10H		Longe 5H	
	CT	MT	CT	MT
Height (cm)	74.59 ^a	82.90 ^b	82.51 ^a	83.27 ^a
Stem girth (cm)	4.30 ^a	4.28 ^a	4.41 ^a	5.29 ^a
Number of leaves	9.65 ^a	9.81 ^a	9.63 ^a	9.46 ^a

Means denoted by a different letter indicate significant differences between treatments ($p < 0.05$).

Source: Research data analysis.

Table 2. Mean 100 maize seed weight (g) and mean maize yield (tons/ha) of two maize varieties under two contrasting tillage practices.

Season	Location	Mean weight per 100 g of maize seed				Mean maize yield (tons/ha)			
		Variety							
		Longe 10H		Longe 5		Longe 10H		Longe 5	
		Treatment							
		CT	MT	CT	MT	CT	MT	CT	MT
2017B	Buikwe	33.67 ^a	30.67 ^a	44.00 ^b	43.33 ^b	10.40 ^c	9.00 ^c	6.80 ^d	6.00 ^d
	Lira	34.77 ^a	32.33 ^a	43.70 ^b	42.01 ^b	8.60 ^c	7.30 ^c	4.90 ^d	4.60 ^d
2018A	Buikwe	37.67 ^a	34.67 ^a	45.67 ^b	45.33 ^b	9.10 ^c	8.60 ^c	7.10 ^d	7.50 ^d
	Lira	34.90 ^a	34.33 ^a	42.77 ^b	43.93 ^b	10.00 ^c	8.70 ^c	4.70 ^d	5.80 ^d

Means denoted by a different letter indicate significant differences between treatments ($p < 0.05$). Source: Research data analysis.

tillage (Table 2). This observed trend could be associated with increased soil loosening in the conventional tillage which enhances root penetration and nutrient uptake resulting into higher yields. This observation agrees with Salem et al. (2015) who reported an increment of 15.4% in the maize yield under the conventional tilled plots compared to the minimum tilled ones in the central region of Spain. Their study attributed this increase in yield to the tillage operations that improved soil physical properties like aeration and water retention. Rashidi and Keshavrpour (2007) reported similar results after evaluating the effects of seven tillage practices on the yield components of maize under clay loam soil and they observed significantly higher grain yield in the tilled plots compared to the non-tilled ones. On the contrary, Armengot et al. (2015) observed no significant difference in the yields of organic sunflower and wheat between the reduced and conventional tillage plots in the arable lands of Switzerland.

Effect of tillage practice on the maize grain moisture content

There was no significant difference observed between the tillage practice and maize grain moisture content ($p < 0.387$). However, the latter varied significantly with the location, variety and season ($p < 0.001$). Generally, maize

plants that were under conventional tillage recorded a higher grain moisture content compared to those that were under minimal tillage operations (Figure 1).

Abiotic factors like air flow, air temperature and air humidity which are largely influenced by the location and season significantly influence the grain moisture content (Hellevang, 2013). Grain moisture content can also be influenced by the inherent quality traits that are largely variety related factors.

Conclusion

This study revealed that conventional tillage practice resulted in higher maize grain yield compared to minimum tillage although the yield difference was insignificant. It however recommends research to be carried out on the influence of tillage practice on herbage yield in order to come up with a comprehensive package for the dairy farmers in Uganda. The study also guides that a deliberate research on the cost benefit analysis between the two tillage practices be carried out before any can be recommended to farmers.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

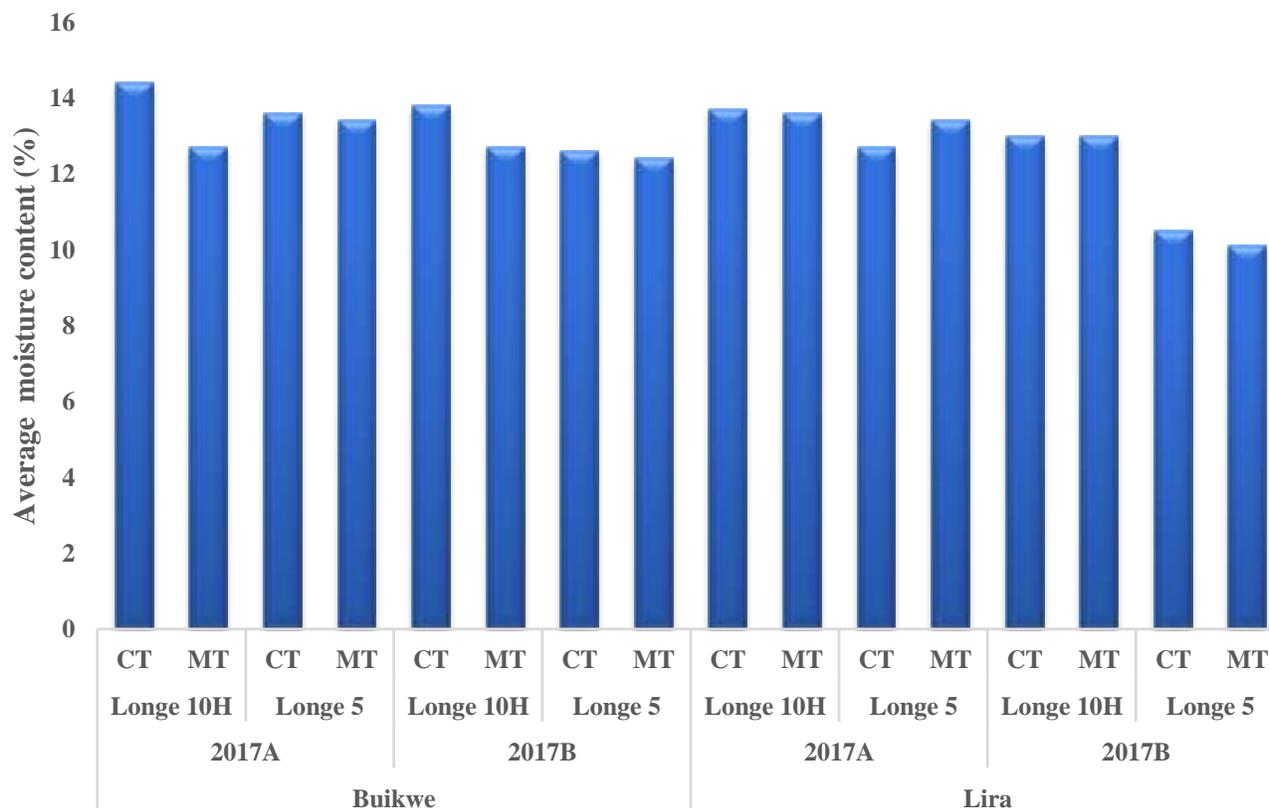


Figure 1. Mean percentage moisture content of maize grain under two contrasting tillage practices. Source: Research Data (2017).

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