Effect of tillage method on weed control and Zea mays (maize) yield under Zimbabwean dry conditions

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ABSTRACT

Maize production in semi-arid areas is faced with numerous daunting challenges that include weeds, low rainfall and excessive infield water loss through runoff. This compounded to declining grain yield. An experiment was done at Domboshava Training Centre, Zimbabwe to determine effects of two tillage methods and mulching (basin planting + grass mulch and conventional + grass mulch) on Zea mays (maize) height, yield and weeds density. The experiment was a 2 x 1 factorial laid in a randomised complete block design with three replicates. Mulch cover was done on each of the tillage method at a rate of 5 t/ha. The blocking factor was fertility gradient. Data on plant height, weed density and grain yield was collected. The data was analysed for One Way Analysis of Variance at p < 0.05 to determine the effect of tillage on plant height, weed density and yield. Least Square Difference at 5% level was used to separate means. There was a statistical significant effect (p<0.05) of tillage method and mulch on plant height, weed density and grain yield. Conventional tillage + mulch and basin planting + mulch were statistically insignificant (p < 0.05) on weed density and grain yield. The results showed that conventional tillage + grass mulch had lowest weed density, vigorous plant height and highest yield whereas planting basin had the highest weed density, shortest plants. It is therefore recommended that farmers in dry areas would need to mulch their fields for an improved maize yield.

Key words: Tillage, mulching, basin planting, weed, semi arid.

INTRODUCTION

Agriculture is the backbone of the Zimbabwean economy and the rural communities of Zimbabwe which make up approximately 70% of the Zimbabwean population are mainly dependent on agriculture for household food security (FAO, 2010). The major crops grown in Zimbabwe are Nicotiana tabacum (tobacco), Gossypium hirsutum (cotton), Triticum aestivum (wheat), Arachis hypogeaI (groundnuts), Glycine max (soya beans), Helianthus annulus (sunflower), Pennisetum glaucumI (millet) and Phaseolus vulgaris (sugar beans). Zea mays (maize) ranks first in terms of number of producers, area grown and total cereal production. Maize occupies about 60% of cropped area (Rukuni et al., 2004). Maize is grown throughout the country under diverse climatic and soil conditions. Being a strategic and staple crop, maize quantity must be maintained at adequate levels, thereby enhancing food self-sufficiency at both household and national level (Rowland, 1994). Steep decline in production over the years have seen farmers earnings dwindling and rise in food insecurity (FAO, 2010).

Crop production in Zimbabwe has declined and Maize yield has significantly declined in the country especially in communal areas causing food insecurity (Rukuni et al., 2004). Erratic rainfall received corresponding with high water loss and dry spells largely contribute to low variable yields in communal areas. Increased water loss from weed canopies, evaporation from bare soil surfaces and water loss through run off exacerbates water constrains in dry
land farming (Rowland, 1994). Weeds have been present and problematic in all crop production systems and the odd occasion present causes massive crop failure and subsequently maize yield reduction in communal areas. Such adverse changes in weed composition largely increase labour requirements and costs for weed control (Acquah, 2002). Conventional tillage has resulted in severe loss degradation in particular soil erosion and fertility decline. The main effect of soil erosion is the reduction of soil depth and its capacity to store soil water and nutrients for maize growth. Farmers had little knowledge about the benefits of alternative physical methods of weed control and land preparation using cheap resources such as grass and hand hoes. In addition communal farmers had limited information about water harvesting and water conservation techniques through the use of planting basins and ground cover. In most communal areas draught animals are weak at a time when land preparation has to commence due to pasture shortages. Majority of smallholder farmers struggle to plant their crop in time because they lack draught power and critical stages of maize growth coincide with dry spells due to late plantings (Arnon, 2005).

Basin planting and grass mulching is a suite of conservation agriculture practices that aim to improve productivity and sustainability of the environment by reducing erosion (Govindan, 2003). The use of planting basins may enable farmers without draught power and money for hiring equipment to prepare fields early using hoes. By the use of basin planting and ground cover (grass mulching); it is possible to supplement the available soil moisture by water harvesting and water conservation from one season to another (Allison, 2003). A combination of planting basins and mulch improves water availability into the soil by promoting water infiltration into the soil and reduced water loss from the soil. Effective weed control prevents them from reaching a mature stage of growth that could be harmful to crop. This study was to find the effectiveness of planting basins, conventional tillage and grass mulch on weed control and maize yield. The study was also to help farmers to determine agronomic practise methods that can be used by communal farmers with the available resources to increase yield and effectively control weeds. In addition, the study also seeks to determine the effectiveness of planting basins and grass mulch to increase yield and possibility weed control.

In line with government and researcher’s efforts to develop sustainable tillage, water harvesting techniques and weed control method that will ensure household food security, findings from this research may be useful to the farming community on the combined effect of mulch and minimum tillage on maize yield. More so the research was aimed at planning extension and implementing projects for adoption by small holder farmers for increasing crop yield. Through tillage manipulation and residue management, weed pressure to farmers may be relieved at the same time yields increasing.

MATERIALS AND METHODS

Site description

The project was carried out at Domboshava Training Centre (DTC) which is under the Ministry of Agriculture, Mechanization and Irrigation development. Domboshava Training Centre is in Mashonaland East province of Zimbabwe; about 27 km north of Harare situated at 19° 55’ 00” S and 30° 57’ 00” E latitude at an altitude of 1500 m.

Domboshava lies in agro-ecological region IIb which receives an annual average rainfall of 700-1000 mm per annum and a temperature range between 23 and 32°C. The area receives good rains but is subjected to frequent mid-season dry spells. DTC is located in an area of granite hills and the predominant soils are sandy loams and some occasional sands and clay loams. The soils are fertile and support a wide range of crops and animals; soya beans and maize are the major crops grown. Production of horticultural crops such tomatoes and vegetables contribute to agriculture activity in the area.

Experimental design

The experiment had two factors that is tillage methods at two levels (conventional ploughing and planting basins) and mulching at one application rate (5 t/ha). The experiment was a 2 × 1 factorial laid in a randomized complete block design replicated twice. The blocking factor was fertility gradient.

Dried thatching grass applied at a rate of 5 t/ha was used as ground cover and the application rate was calculated using the formulae: (Mass of grass/plot area)*area (ha).

Plots measuring 10 × 5 m were pegged out with 1 m foot paths between plots and blocks.

Land preparation

Primary tillage using a tractor drawn disc plough and secondary tillage to obtain fine tilth using a Rom disc plough was done. Planting basins were dug at 0.6 × 0.15 m spacing using a hand hoe and each basin measured 0.15 m (length) × 0.15 m (width) × 0.15 m (depth). Planting rows of inter row spacing 0.6 m at a varying depth between 0.18 m to 0.20 m were made using ox drawn plough without mould board. Strings were used in planting basins preparation to maintain straightness.

Planting

A short season Seed Co hybrid maize variety SC 413 was planted in all the plots. Plant spacing was 0.6 × 0.15 m with three kernels /station for planting basins. In-row spacing
for conventional tillage was 0.15 m with two kernels per station. Two weeks after planting one plant per station was thinned to two plants per basin in planting basin treatments.

**Application of ground cover**

Thatching grass was applied at the second week after planting (fourth leaf stage) at a thickness of 3 cm, to randomly selected plots in each block. Using the photo comparison method, the ground cover was between 80 and 85%. The photo comparison chart was obtained from the Food and Agriculture Organization of the United Nation Conservation Agriculture unit. At the same time, weed management in plots without mulch was done using hand hoes. Ground cover and hand hoeing were done for weed control.

**Data collection**

Data collected during the study were for maize plant height, weed density and average grain yield. Maize height was first collected two weeks after emergency; data was then collected at fortnight interval for five weeks. Data collection for plant height was done from week two to week ten after emergency. Height of ten random sampled plants was measured using tape measure from ground level up to tip using tape measure. A quadrant of 1m² was thrown at seven randomly selected points in each plots, the weeds within the quadrant were counted and recorded as weed frequency/m². Data for weed density was first collected two weeks after weed control (mulching and hand hoe weeding), then collected between two weeks intervals, until week eight after weed control. Yield data was obtained by weighing the total grain harvested in each plot. The average grain yield (g) obtained was then converted to tonnes/ hectare.

**Data analysis**

Collected data was analysed using statistical package GENSTAT Discovery edition. One way Analysis of Variance (ANOVA) at 5% level of significance was used to determine the effect of treatments to maize height, weed density and yield. Least Square Difference at 5% level was used to separate treatment means.

The following is the mathematical model used:

\[ Y_i = \mu + Bi + Ti + e \]

Where : Yi= variable measured, \( \mu \)= mean (grand mean), Bi= effect of block, Ti=effect of treatments, e=random error term.

**RESULTS AND DISCUSSION**

**Plant height**

There was significant (p<0.05) difference in maize height among the tillage methods. At two weeks after emergency, maize height under planting basins + mulch and conventional tillage was not statistically (p>0.05) different. Conventional tillage + mulch and Planting basins + mulch had the taller plants than conventional tillage and planting basins (Figure 1). Conventional tillage + mulch had the tallest plants while conventional tillage and planting basins had the shortest (Table 1). It could be due to improved moisture infiltration, retention and easy root growth under the conventional tillage + mulch. This agrees well with Rowland (1994), who noted that the extent of growth of crops in dry land farming depends partly on fertility and physical structure of the soil. Plant roots under the conventional tillage + mulch could have larger fine tilled area to expand and moisture than those under planting basins this tally to Acquah (2002) who noted that growth of roots depends on soil texture, structure and depth. Conventional tillage + mulch could have improved the soil structure hence many fissures which allow roots to penetrate vertically and horizontally in the sub soil to explore water and nutrients more fully in each horizon (Arnon, 2005; Balasubramaniyan and Palaniappan, 2004).

The increased root growth under the conventional tillage + mulch could have contributed to increased water and nutrient uptake which largely contribute to the growth and development of the apical plant parts (Pandey, 2006) hence tall plants. Compacted layers under planting basins resisted root growth and development and may also resist the entrance of water. The presence of highly compacted layers (panns) under the planting basins could also have resulted to limited depth of the soil and thus deprive the crop to access soil moisture and nutrients (Acquah, 2002). Holland (2004), also noted that plant performance under minimum tillage in terms of plant height, dry matter and fresh weight was very low than plants under conventional tillage. The similarity in height between the conventional tillage and planting basin could be due to differences in moisture availability, planting basins could have retained moisture for a longer time than the conventional tillage without mulch.

**Weed density**

There was significant (p<0.05) difference in weed density among the tillage methods. Weed density between conventional tillage and planting basins at eight weeks after weed control was insignificantly (p > 0.05) different.

The results have indicated that addition of mulch to planting basins and conventional tillage reduces weed density (Table 2). Effective weed control by grass mulch
was noted after the land was conventionally tilled. This is in agreement with Rowland (1994), who noted that effective weed control using grass mulch under conventional tillage from studies in Kenya. Similar results were also noted in Uganda where mulch under conservation agriculture trials conducted by the government in Kampala District using crop residue showed effective weed control (FAO, 2010). Thick layer of mulch inhibits weed growth and density in two important ways, interception and disturbance. Covering of the soil with a thick layer of mulch, deprive weed seeds from sunlight necessary for germination, photosynthesis and grow (Rao, 2002). The limited supply of sunlight to weeds interferes with the plant processes such as photosynthesis which lead to weed death. Secondly, mulch could have prevented weed seeds from gaining a foothold with the soil in the first place and this might have prevented weeds from germination (Rowland, 1994; Lembi and Ross, 2009). Bare soil, is the perfect place for weed seeds to land and germinate and this could have resulted to high weed densities under planting basins and conventional tillage, and by covering bare surfaces with mulch, most weed seeds did not come into contact with the soil hence low densities under mulched trials (Lavadie, 2002).

There was a statistical significant difference (p<0.05) in grain yield under the different tillage systems. Yield produced under conventional tillage + mulch and planting...
Table 2. Comparison of average weed density rate under different tillage and grass mulch.

<table>
<thead>
<tr>
<th>Average weed density (weeks after weed control)</th>
<th>Week 2</th>
<th>Week 4</th>
<th>Week 6</th>
<th>Week 8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conventional tillage + mulch</td>
<td>10.29&lt;sup&gt;a&lt;/sup&gt;</td>
<td>15.62&lt;sup&gt;a&lt;/sup&gt;</td>
<td>23&lt;sup&gt;a&lt;/sup&gt;</td>
<td>38.90&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Planting basins + mulch</td>
<td>11.78&lt;sup&gt;a&lt;/sup&gt;</td>
<td>17.16&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>21.4&lt;sup&gt;a&lt;/sup&gt;</td>
<td>37.86&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Conventional tillage</td>
<td>14.08&lt;sup&gt;a&lt;/sup&gt;</td>
<td>19.3&lt;sup&gt;b&lt;/sup&gt;</td>
<td>27.21</td>
<td>43.86&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Planting basins</td>
<td>17.97</td>
<td>23.41</td>
<td>33.02</td>
<td>46.65&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>SED</td>
<td>0.8</td>
<td>1.098</td>
<td>1.015</td>
<td>1.444</td>
</tr>
<tr>
<td>LSD (5%)</td>
<td>1.629</td>
<td>2.162</td>
<td>2</td>
<td>2.845</td>
</tr>
<tr>
<td>P Value</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

*Values with same superscript are not significant different.

basins + mulch had insignificant (p > 0.05) difference. Conventional tillage + mulch and planting basin + mulch produced the highest grain yield of 8.12 t/ha and planting basins produced the lowest average grain yield of 3.79 t/ha.

The high mean of yield under conventional tillage + mulch could be as a result of good water infiltration, efficient water recharge, good root development, effective weed control, good soil aeration and reduced water loss. Improved infiltration of rainwater into the soil increases water availability and existence of ground cover reduces water loss (Arnon 2005). This had been supported by Acquah (2002), who elaborated that supply of moisture at critical stages of growth results in higher yields. Soil biota activity under mulched soil promotes residue decomposition thereby improving nutrient cycling. Decomposition of organic matter provides nutrients to crops which contribute to high yields (Balasubramanayan and Palaniappan, 2004). Scott (2002) also reported that amounts of nutrients in crop residue could be as much as seven to eight times higher than quantities supplied by fertilizers and that could have applied to mulched cropping systems in this study.

Conclusion and recommendations

The study has shown that tillage practice has a significant effect on maize height, weed density and maize yield. Conventional tillage + mulch and planting basins + mulch were most effective in controlling weeds and had high yield. Planting basins without much had higher yield than conventional tillage without mulch.

Weed control and maize yield under conventional tillage + mulch was not significantly different with planting basins + grass mulch.

It can be recommended that farmers in dry areas should mulch their fields regardless of the tillage practice used. In cases where there is no mulch, farmers are recommended to opt for planting basins instead of conventional tillage.

The research also needs to be replicated in other areas and in more than one season for improved results.

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