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Research Article

Evaluating the Effects of *Leucaena leucocephala* Biomass and Planting Pits on Soil Moisture Content and Maize (*Zea mays L*) Performance

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Abstract

Soil infertility and moisture stress are major constraints hindering crop production in semi-arid areas. Most soils are sandy loams which are infertile with low weatherable minerals. Smallholder farmers are resource poor farmers who are unable to afford large quantities of mineral fertilisers. Low and erratic rainfall plays an important role in causing moisture stress. Adoption of climate smart agriculture must be speeded to increase food security. The overall objective was to evaluate the effects of *Leucaena leucocephala* biomass and planting pits on soil moisture content and maize performance. The experiment was laid as completely randomised block design with soil moisture conservation as main factor and *L. leucocephala* biomass as subplot factor with three levels. Data was analysed using Analysis of Variance (ANOVA) using Genstat version 14. Results show significant effect ($P < 0.05$) on soil moisture content due to application of Leucaena biomass at different rates. Highest soil moisture content was 11.5% at 0-20 cm and 12.5% from 20-40 cm after application of 5 t ha^{-1} biomass. Planting pits had higher soil moisture content for both depths. Interactive effects of Leucaena biomass and rainwater harvesting practices show significant effects ($P < 0.05$) on maize grain yield. Highest maize grain yield was 3326.8 kg ha^{-1} from treatment with 5 t ha^{-1} biomass. Planting pits recorded higher stover yield which was significantly different ($P < 0.05$) from flat cultivation. It can be concluded that the use of *L. leucocephala* biomass and rainwater harvesting of planting pits improved soil moisture content and maize yields. Farmers are recommended to use 5tha^{-1} of biomass in combination with planting pits to increase soil moisture content, grain and stover yields of maize.

Keywords: *Leucaena leucocephala*; Planting Pits; Soil Moisture; Maize

Introduction

Maize (*Zea mays* L) is ranked first in Zimbabwe and third in the world after wheat and rice (Motsi., *et al*. 2019; Tapiwa., *et al*. 2020). Maize is the main staple food in most sub-Saharan African countries including Zimbabwe. Maize production has been on the verge of declining in Zimbabwe due to low erratic rainfall in dry regions (Nyagumbo., *et al*. 2020). Maize succumbs to several constraints such as declining soil nitrogen due to monoculture and leaching. Maize production in semi-arid areas of Zimbabwe have been declining due to several issues including lack of knowledge on soil and moisture conservation techniques [1,2]. Smallholder farmers in these areas were harvesting less than 1 t ha^{-1} which is far much behind the need for human consumption. The only way to avert this is to adopt soil fertility management which can be easily adopted by resource poor smallholder farmers in semi-arid regions. Since nitrogen is the main limiting nutrient, there is need to adopt the use of *Leucaena leucocephala* biomass which quickly restore nitrogen in the soils due to its biological nitrogen fixation (Kugedera., *et al*. 2021).

The use of Leucaena biomass has been witnessed to improve soil fertility and water retention as well as improve maize yields [3-5]. Hence soil fertility management alone cannot improve yields due to moisture stress [6]. There is need to combine soil fertility management and planting pits as rainwater harvesting technique to conserve moisture and improve nutrient availability in the plant root zone (Kugedera., *et al*. 2020; Tapiwa., *et al*. 2020). Combining the two may improve soil moisture content and maize yields. The aim of the study was to evaluate the use of different rates of *Leucaena leucocephala* biomass and planting pits on soil moisture and maize productivity.

Methods and Materials

Experimental site

The experiment was carried out at Chirichoga High School (20°16'17"S and 30°55'121"E, 3100 mals). The experimental site is characterised with sandy loam soils with a pH of 4.3. The site is in agroecological zone IV which receives rainfall in the range 450-650 mm per annum [7]. Maize is the main staple crop grown by farmers in the area and other crops grown include sorghum, groundnuts, roundnuts and cow peas. The site is characterised by Brachystegia species in the Miombo woodlands.

Experimental design and treatments

The experiment was laid out as a randomised complete block design with treatments replicated three times. The experiment consisted of rainwater harvesting as main plot factor which included planting pits and flat cultivation. Leucaena biomass was a sub-factor treatment with three levels (0, 2.5 and 5 t ha^{-1}). Planting pits were having the following dimensions which are 15 cm ×15 cm × 15 cm spaced at 0.9m × 0.6m. A total of eighteen plots with each plot measuring 2m × 3m were used. Three seeds were sown at each planting station and thinned to two after three weeks of emergence. Weeding was done three weeks after emergence using hand hoe. Ammonium nitrate was applied using split application at a rate of 300 kg ha^{-1} at three and seven weeks after emergence. Fall army worm was controlled using Demisec.

Data collection

Data collected was based on soil moisture content, grain and stover yield. Soil moisture content was determined using gravimetric soil moisture content. Fifteen soil samples were collected from the depth of 0-20cm and 20-40cm using an auger 35 days after planting. Soil samples were collected from flat land and planting pits amended at different biomass rates. Soil sample were left in an oven at 105°C for 48 hours. Soil moisture content was calculated as follows:

$$\text{Moisture content} = \frac{\textit{Fresh soil mass} - \textit{oven dry soil mass}}{\textit{oven dry soil mass}}\ X\ 100$$

Grain and stover yield were collected at harvesting. Maize cobs were threshed manually per treatment and yield was adjusted to 13% moisture content after measuring using digital moisture meter. Weights of maize were converted to t/ha using net plot area.

Data analysis

Data was subjected to way analysis of variance using Genstat 14th edition. Means which were significant were separated using least significant difference at 5%.

Results

Effects of planting pits and Leucaena biomass on soil moisture content

Results show significant effect ($P < 0.05$) on soil moisture content due to application of Leucaena biomass at different rates. Moisture content increased due to increase in application rate of Leucaena biomass. Highest soil moisture content was 11.5% at 0-20 cm and 12.5% from 20-40 cm after application of 5 t ha^{-1} biomass (Table 1). Planting pits recorded higher soil moisture content which was significantly different ($P < 0.05$) from flat cultivation at both depths (Table 1).

Treatment	Soil moisture content (%): 0-20 cm	Soil moisture content (%): 20-40 cm
Planting pits	9.8^a	11.2^a
Flat cultivation	8.2^b	10^b

LSD (0.05)	0.231	0.114
P-value	<0.001	<0.001
Leucaena biomass (t ha^{-1})		
0	6.4[a]	8.2[c]
2.5	9.2[b]	11.2[b]
5	11.5[c]	12.5[a]
LSD (0.05)	0.283	0.139
P-value	<0.001	<0.001

Table 1: Effects of planting pits and Leucaena biomass on soil moisture content.

Interactive effects of Leucaena biomass and rainwater harvesting practices show significant effects (P < 0.05) on soil moisture content at 0-20 cm. combined effects of rainwater harvesting practices and Leucaena biomass was not significant at 20-40 cm depth (Figure 1). Higher percent soil moisture content was observed at 5 t ha^{-1} Leucaena biomass + planting pits for both0-20 cm and 20-40 cm depth (Figure 1).

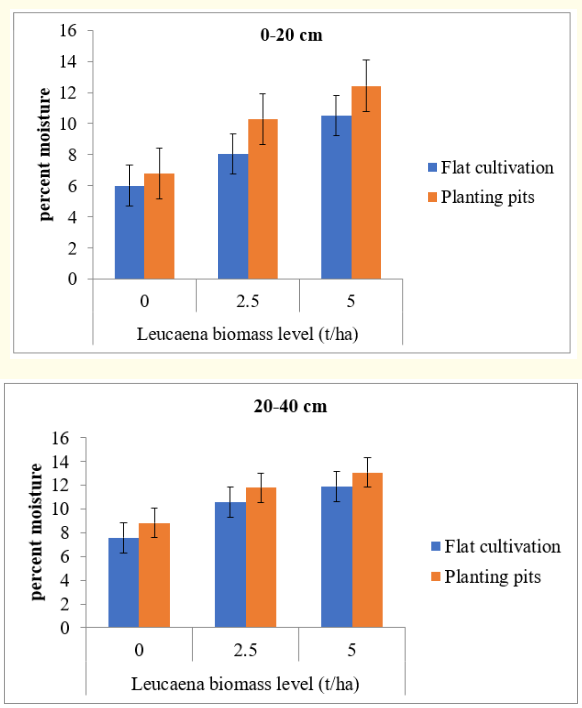

Figure 1: Effects of planting pits and Leucaena biomass on soil moisture content.

Effects of planting pits and Leucaena biomass on maize grain yield

Results show significant effect (P < 0.05) on maize grain yield due to application of Leucaena biomass at different rates. Grain yield increased with increase in application rate of Leucaena biomass. Highest maize grain yield was 2098.3 kg ha^{-1} from treatment with 5 t ha^{-1} biomass (Table 2). Planting pits recorded higher grain yield which was significantly different (P < 0.05) from flat cultivation (Table 2).

Treatment	Maize grain yield (kg ha^{-1})
Planting pits	1420[a]
Flat cultivation	1274.7[b]
LSD (0.05)	14.28
P-value	<0.001
Leucaena biomass (t ha^{-1})	
0	835[c]
2.5	1108.7[b]
5	2098.5[a]
LSD (0.05)	17.49
P-value	<0.001

Table 2: Effects of planting pits and Leucaena biomass on maize grain yield.

Interactive effects of Leucaena biomass and rainwater harvesting practices show significant effects (P < 0.05) on maize grain yield. Higher grain yield was observed at 5 t ha^{-1} Leucaena biomass + planting pits treatments (Figure 2).

Figure 2: Effects of planting pits and Leucaena biomass on maize grain yield.

Effects of planting pits and Leucaena biomass on maize stover yield

Results show significant effect (P < 0.05) on maize stover yield due to application of Leucaena biomass at different rates. Stover yield increased with increase in application rate of Leucaena biomass. Highest maize grain yield was 3326.8[a] kg ha^{-1} from treatment with 5 t ha^{-1} biomass (Table 3). Planting pits recorded higher stover yield which was significantly different (P < 0.05) from flat cultivation (Table 3).

Treatment	**Maize stover yield (kg ha^{-1})**
Planting pits	2844.1[a]
Flat cultivation	2540.1[b]
LSD (0.05)	23.61
P-value	<0.001
Leucaena biomass (t ha^{-1})	
0	1787.8[c]
2.5	2961.7[b]
5	3326.8[a]
LSD (0.05)	28.92
P-value	<0.001

Table 3: Effects of planting pits and Leucaena biomass on maize stover yield.

Interactive effects of Leucaena biomass and rainwater harvesting practices show significant effects (P < 0.05) on maize grain yield. Higher stover yield was observed at 5 t ha^{-1} Leucaena biomass + planting pits treatments (Figure 3).

Figure 3: Effects of planting pits and Leucaena biomass on maize stover yield.

Discussion

Use of *L. leucocephala* biomass led to production of high moisture content, high grain yield as well as high stover yield when applied to planting pits as compared to those obtained when Leucaena is applied on flat land. This was in agreement with Mafongoya and Dzowela (1999) and Mugendi., *et al*. [3] who reported increased maize yields after using Leucaena biomass. This was because the biomass increased soil organic carbon, water retention and nutrient availability which increased plant growth and development. On planting pits, Leucaena conserved and used as mulch, planting pits prevents washing away on Leucaena biomass by agents of erosion. Planting pits maximize utilisation of Leucaena biomass contents as compared to flat land which expose it to the agents of erosion. This concur with results by Mudatenguha., *et al*. [8] and Nyagumbo., *et al*. (2019) who both reported increased soil moisture content with use of rainwater harvesting of planting pits. This has also attributed to improved grain and stover yields. Moisture is conserved for absorption for long period without being utilised as a result of Leucaena biomass acting as mulch. Leucaena leucocephala biomass provide with organic matter which provide with minerals for growth and development of maize crops leading to high grain and stover yield than on flat land where Leucaena got utilised by both maize crops and weeds. This was supporting assertion by Mafongoya and Dzowela (1999) and Kebede., *et al*. [9] who all reported that the use of biomass suppress weed germination and support plant growth leading to increased yields [10,11].

Conclusions

Leucaena leucocephala biomass leads to an increase in crop production mostly on planting pits. Leucaena leucocephala biomass is a good source of organic matter needed for absorption by crops for their good performance yielding high quality of yields. On flat land Leucaena biomass lead to better production but there is a huge difference as compared to consume as own biomass in time of need and water will be conserved regularly. It is recommended that, farmers mostly the communal farmers must use Leucaena leucocephala biomass to produce high yields. If there is no good source of financial support to purchase inorganic fertilizers, Leucaena can be used for improvement of soil structure, water retention, pH regulation as well as fertility increases. On planting pits, water conservation can be managed totally as compared to flat land where land is open and prone to all bad environmental conditions, pests and diseases. Leucaena leucocephala biomass on planting pits is good for plant growth and communal farmers can adapt it easily.

Recommendations

The use of legume biomass played an important role in increasing soil organic matter, conserve moisture, and regulate soil pH and soil structure. This has positively impacted soil fertility and crop production. Legumes are rich in nitrogen which is one of the major limiting nutrients in the soil. If farmers adopt the use of Leucaena biomass and planting pits, this can reduce soil moisture stress and improve food security. This is a climate smart agriculture which does not affect both environmental and biological ecosystems negatively but positively improved biological ecosystems. It can be recommended that smallholder farmers can adopt the use of Leucaena biomass and planting pits to reduce food insecurity and alleviate poverty.

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