EFFECT OF SOIL WATER CONSERVATION TECHNIQUES ON THE GROWTH AND YIELD OF MAIZE (*Zea mays* L) IN LAFIA, NASARAWA STATE, NIGERIA

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Abstract: Water conservation practices are used in crop production for enhancing soil water storage especially when there are fluctuations in rainfall under rain-fed cropping. This study was carried out to evaluate the effect of soil moisture conservation techniques on the growth and yield of maize under rain-fed condition. Four treatments were laid out in a Randomized Complete Block Design (RCBD) and replicated three times. The treatments were; conventional ridge, tied ridge, soil bund and film mulch. Data on growth parameters and yield were collected and tested using analysis of variance (ANOVA) using Gen-stat Edition 3. The differences among the treatments were determined using least significant difference (LSD). The results showed that tied ridge recorded the highest plant heights (56.80 and 150.00 cm) at 6 and 8 WAS, number of leaves (6.73 and 12.47) at 4 and 8 WAS, and highest value (9000.00 kg) of yield as compared to the other treatments with soil bund performing least averagely. It can be concluded that tied ridge performed better with highest values of the growth parameters.

Keywords: Maize, water conservation practices, rain-fed cropping, ridge, bund

Introduction

Maize (*Zea Mays* L) is a major cereal crop grown in the world and an important staple food in Africa (FAO, 2014). Maize is grown worldwide in a wider range of environments because of its greater adaptability. Among cereal crops, maize has the highest average yield per ha and remains third after wheat and rice in total area and production in the world (FAOSTAT, 2014). Maize crop started as a subsistence crop in Nigeria and has gradually risen to a commercial crop on which many agro-based industries depend on as raw materials (Iken and Amusa, 2004). Maize is most productive in the middle and Northern belts of Nigeria, where sunshine is adequate and rainfall is moderate (Obi, 1991). It is widely eaten as food (roasted, baked, fried, pounded or fermented) (Agbato, 2003) and also serves as forage feeds for livestock and raw materials for many food industries.

Globally, rain fed agriculture is practiced on 83% of cultivated land and supplies about 60% of the world's food (FAO, 2001). This shows that rain-fed agriculture will remain the dominant source of food production for the foreseeable future in sub-Saharan Africa (Karrar *et al*., 2012). In Nigeria, rainfall is one of the major sources for agricultural production. However, rainfall is highly variable both in amount and distribution from year to year. As a result, crops frequently suffer from moisture stress at some stages during their growth period with ultimate results of reduced yield. Every year there is a loss of 25% crop yield globally caused by severe drought (Bankole *et al*., 2017) and 36 million people in sub-Sahara Africa are experiencing severe food shortage because of the drought and shortage of moisture in soil profile (Nazareth, 2016; Water Aid, 2017). The uncertainty of precipitation forces farmers to adopt in-situ moisture conservation practices (Haibu *et al*. 2006). The practice of judicial water conservation undoubtedly plays a significant role in increasing agricultural production in arid, semi-arid and sub-humid areas where agriculture is hampered by periodic low soil moisture, drought and slow soil fertility (Heluf and Yohannes, 2002). Effective agronomic practices are necessary not only for the utilization of light rains but also to reduce surface run off and storing it in the crop root zone for use during moisture stress (Belachew and Abera, 2010).

Maize is grown predominantly under rain fed conditions, as such, subject to both biotic and abiotic stresses which are largely influenced by distribution and quantity of rainfall. Improving soil water content is a fundamental approach for addressing water constraint and enhancing water storage in the field. Thus, increasing agricultural productivity requires optimal utilization of rainfall by implementing measures such as water storage, thereby improving the crop water use efficiency of crops. In-situ moisture conservation technologies may provide an opportunity for increasing soil water availability and boosting crop productivity in arid and semi-arid (Hatibu and Mahoo, 1999). Therefore, planting crops using in-situ moisture conservation reduces problems of soil moisture stress by reducing runoff by about 30-50% of rainfall through increased infiltration and storage of water in the soil profile, the onset and occurrence of severe water stress is delayed thereby buffering the crop against damage caused by water deficits during dry periods (Nyamadzawo *et al*., 2013). In these regards using tied ridges, cultivating in furrows, mulching, construction of earth basin and sunken beds are some of the methods that contribute to mitigate soil moisture deficit and enhance maize productivity (Prinz and Malik, 2004). There is currently no sufficient research works on evaluating the effectiveness of in-situ moisture conservation techniques on improving maize yield in Lafia. The objectives of the present work is to investigate the effects of in-situ moisture conserving techniques on maize growth and yield and recommend relevant treatments in improving production in the study area.

Materials and Methods

Study area

The study was conducted at the Faculty of Agriculture Demonstration Farm of Nasarawa State University, Keffi, located at Shabu - Lafia, Nasarawa State, Nigeria. It lies on latitude 08° 33'N, longitude 08° 32'E at an altitude of 181.53 m above sea level. The area is located in southern – guinea savannah characterized by a sub-humid tropical climate with distinct wet and dry seasons. The mean annual temperature is 28.75°C while mean minimum and maximum temperatures are 24.5 and 33°C, respectively. The relative humidity fluctuates between 43.2 and 86.3%. The average rainfall ranges from 1138.0 to 1595.7 mm per annum with a maximum rainfall occurring between July and September. The soil type is mostly sandy loam, well drained, porous and brownish red below the surface, made of kaolinite clay (Jayeoba, 2013).

Land preparation and field layout

The experimental plots were marked out after land clearing and tilled manually using hoe. The plots sizes were 4 x 3 m and separated by 1 m buffer between blocks and replicates. The experiment constituted a total of 12 plots with a net plot area of 144 m^2 and gross plot of 209 m^2. Each plot consisted of five ridges maintained at 0.75 m apart.

Experimental treatments/design

Four soil water conservation techniques; conventional ridge (CR), Tied ridge (TR), Soil bund (SB) and film mulching (FM) were applied to maize plots in a Randomized Complete Block Design (RCBD) and replicated thrice. The treatments were represented as T_1, T_2, T_3 and T_4, respectively, where T_1 is conventional, T_2 – tied ridge, T_3 – soil bund and T_4 – film mulch.

Agronomic practices

Two seeds of Samaz 37 maize (extra-early maturing variety) was sown per hill on 25th May of 2018 at a spacing of 25 × 75 cm between plants and rows respectively at 2 – 5 cm depth. The seedlings were thinned to one plant per hill two weeks after germination and missing plants were replaced. Split fertilizer application were done using the band placement method at the rate of 200 kg/ha NPK (20:10:10) at two weeks after planting and top dressed before tasselling. Weeding was done manually using hoe at third and sixth week after sowing. The green cobs were harvested at physiological maturity and kept to dry.

Data collection

Growth parameters were collected at 4, 6 and 8 weeks after sowing (WAS) on five randomly selected plants from each plot and recorded and the yield parameters were collected after harvest. The plant height was measured from the soil surface to the terminal bud using a meter rule while the numbers of leaves was counted manually. The cob length was measured from the base of the cob to its tip, the cob girth was measured using a vernier caliper and the seed weight of cobs of selected plant were weighted while the yield was obtained from the seed weight of net plot and expressed in kg per hectare and the means recorded.

Statistical analysis

The data obtained from measured plant parameters were subjected to analysis of variance (ANOVA) for Complete Randomized Block Design (RCBD) and analyzed using Gen-Stat Edition 3. The differences among the treatments were determined using least significant difference (LSD) at $P < 0.05$ probability level.

Results and Discussions

Effect of soil water conservation techniques in plant height

Table 1 shows the effect of soil water conservation techniques on plant height. Analysis of variance showed that there was no significant difference among the treatments at 4 and 8 WAS but statistically significant at 6 WAS. However, at 4 WAS convectional ridge had the highest (31.83 cm) plant height compared to the other treatments while soil bund had the lowest (25.90 cm) plant height. At 6 WAP tied ridge showed the highest (56.80 cm) plant height and statistically at par with conventional ridge but was different from soil bund and film mulch treatments. At 8 WAP the result showed that tied ridge had highest (150.00 cm) plant height while film mulch had the least (95.00 cm) plant height. The result conforms to the finding of Dulo and Zelalem (2020) that recorded the highest plant height (214.51 cm) of maize from tied ridge but statistically not different from other treatments. Similarly, Chimdessa *et al*. (2019) that had the highest plant height (171.59 cm) of maize from tied ridge at Goro District trial field in their study. Likewise, Tekle and Wedajo (2015) had the highest plant height of 180 cm from tied ridge from their study on different moisture conservation practices on growth, yield and yield components of sorghum and stated that the tied ridge gave the maximum plant height per plant than the other moisture conservation practices due to its relatively high efficiency in soil moisture retention capacity than the other moisture conservation practices. This is consistent with the findings of Wiyo *et al.* (1997) which stated that tied ridge retains rain water within the plant root zone. Similarly, Gebreyesus *et al.* (2006) showed that tied ridge increased maize growth by more than 40% and soil water by more than 25% compared to other moisture conservation practices in Nigeria.

Table 1: Effect of soil water conservation techniques on plant height (cm)

Treatment	4WAS	6WAS	8WAS
Convectional ridge	31.83	46.00^{ab}	146.00
Tied ridge	30.00	56.80^{a}	150.00
Soil bund	25.90	38.10^{b}	125.00
Film mulching	26.00	38.30^{b}	95.00
Mean	28.40	44.80	129.00
Significant	0.159^{ns}	0.038^{**}	0.365^{ns}
SEM	1.884	3.78	22.5
$LSD_{0.05}$	6.521	13.08	77.9
CV (%)	11.5	14.6	30.2

WAS – Week after sowing; ** - Significant at 5%; NS – Not significant; SEM- Standard error mean

Table 2: Effect of soil water conservation techniques on number of leaves

Treatment	4WAP	6WAP	8WAP
Convectional ridge	6.53	9.00^{a}	12.00
Tied ridge	6.73	8.00^{c}	12.47
Soil bund	6.53	8.37^{b}	12.23
Film mulching	6.10	9.20^{a}	12.07
Mean	6.48	8.64	12.19
Significant	0.477^{ns}	<0.001***	0.200^{ns}
SEM	0.275	0.193	0.1430
$LSD_{0.05}$	0.953	0.3782	0.4950
CV (%)	7.4	2.2	2.0

WAP – Week after sowing; *** - Significant at 1%; NS – Not significant; SEM – Standard error mean

Effect of soil water conservation techniques on number of leaves

Table 2 shows that at 4 and 8 WAP mean treatment were not significantly different but highly significant at 6 WAP. Tied ridge had the highest number of leaves at 4 and 8 WAP with values of 6.73 and 12.47, respectively but had the least (8.00) at 6 WAP. Film mulch had the lowest (6.10) at 4 WAP while conventional ridge had the lowest number of leaves (12.00) at 8WAP. The result agrees with the finding of Chimdessa *et al*. (2019) that recorded the highest number of leaves (25.11) of maize from tied ridge at Goro District field trial in their study. Also, Adam and Arkin (2000) showed in their study that the tied ridge resulted in a higher level of vegetative growth and attributed it to greater water availability within the plant root zone. The concept of tied ridge lays emphasis on soil conservation while conserving soil moisture (Bekele and Drake, 2003). Tied ridging is known to be of importance in reducing runoff (Fournier, 2000) by helping hold rain water on the soil, and thus giving it time to infiltrate (Macartney *et al.*, 2012).

Effect of soil water conservation techniques on yield parameters

Table 3 shows that tied ridge had the highest cob length, cob girth, seed weight per cob and yield with value of 12.70 cm, 3.935 cm, 121.8 g and 9000 kg/ha^{-1}, respectively while film mulching had the least cob length and cob girth with values of 11.30 and 3.385 cm, respectively. However soil bund had the least seed weight per cob and yield values of 62.7 g and 4444 kg, respectively. There was significant difference among the treatment means for cob girth and yield and no significant difference for cob length and seed weight per cob. According to Chimdessa *et al*. (2019) findings at Goro District field trial, which supports this results, tied ridge showed significantly higher yield improvement over ridging and furrow without ties (open furrow) and the flat bed with the highest maize grain yield of 5.3 t ha^{-1} which is 28.3% higher over the flat bed. Similarly, Tekle and Wedajo (2015) showed that grain yield of sorghum obtained from tied ridge (3.625 t ha-1) was higher by 55.72% compared to flatbed (1.605 t ha-1). They also showed that tied ridge had the highest 1000 seed weight (33.95 g) compared to the flat bed which had the least (24.50 g) and attributed the recorded maximum yield to the efficiency of tied ridge to conserve and retain moisture when compared to the other moisture conservation practices.

Table 3: Effect of soil water conservation techniques on yield parameters

Treatment	Cob length (cm)	Cob girth (cm)	Seed weight per cob (g)	Yield (kg/ha)
Convectional ridge	11.87	3.860^{a}	93.6	7778.0^{a}
Tied ridge	12.70	3.935^{a}	121.8	9000.0^{a}
Soil bund	11.43	3.536^{b}	62.7	4444.0^{b}
Film mulching	11.30	3.385^{b}	80.5	7472.0^{a}
Mean	11.83	3.679	89.6	7174.0
Significant	0.074	0.003**	0.077	0.021**
SEM	0.321	0.0663	12.76	727.0
$LSD_{0.05}$	NS	0.2295	NS	2515.6
CV (%)	3.6	2.5	15.3	9.2

WAP – Week after sowing; ** - Significant at 5%; NS – Not significant; SEM - Standard error mean

Similarly, Dulo and Zelalem (2020) in their study stated thattied ridge practices increased maize grain yield and thousand seed weight (g) by up to 45.52% (2.7913 $tonha^{-1}$) and 41.43% over farmer's practice (control), respectively. They attributed the higher grain yield of maize obtained from the structure of tied ridge to greater infiltration and storage of water in soil; which gives plants sufficient time to take up the stored water as compared to the farmer's practice. The findings of Mudalagiriyappa *et al*. (2012) also agrees the result obtained and attributed the increased yield of rabi sorghum to reduced surface runoff, reduced risk of erosion and soil nutrients and also due to increased availability of soil moisture in tied ridge.

Conclusion

Maize is predominantly cultivated under rain-fed farming thereby exposing it to low productivity due to periodic low soil moisture due to erratic and poorly distributed rainfall and runoff loss of water during the cropping season. This study was conducted to determine the potential of in-situ water harvesting techniques on maize growth and yield components and soil moisture. The comparative study between the four soil water conservation techniques; conventional ridge (CR), Tied ridge (TR), Soil bund (SB) and film mulching showed that the soil moisture, growth and yield for the tied ridge were consistently higher when compared to the other techniques. This study clearly demonstrated that in-situ rainwater harvesting techniques could play an important role in improving crop growth and yield.

Conflict of Interest

Authors declare that there is no conflict of interest reported in this work.

References

Adam JE & Arkin GF 2000. A light interception method for measuring row crop growth cover. *Soil Sci. Soc. Am. J.,* 41: 789-792.

Agbato SO 2003. Principles and Practices of Crop Production. Odumatt Press Publisher, Oyo, pp. 57-62.

Bankole F, Menkir A, Olaoye G, Crossa J, Hearne S, Unachukwu N & Gedil M 2017. Genetic gains in yield and yield related traits under drought stress and favorable environments in a Maize population improved using marker assisted recurrent selection. *Frontiers in Plant Sci.,* 8(808).

Bekele W & Drake L 2003. Soil and water conservation decision behavior of subsistence farmers in the Eastern Highlands of Ethiopia: A case study of the Hunde-Lafto area. *Ecol. Econ*., 46: 437-451.

Belachew T & Abera Y 2010. Response of maize (*Zea mays* L.) to tied ridges and planting methods at Goro, Southeastern Ethiopia. *Am. Euroasian J. Agron*., 3: 21-24.

Chimdessa GC, Bedaso N & Eshetu M. 2019. Evaluating the effect of soil moisture conservation and management practices on yield and yield components of maize crop in the Midlands of Bale Zone, Southeastern Ethiopia. *Irri. Drainage Sys. Eng*., 8: 234.

Dulo H & Zelalem S 2020. Effects of in-situ moisture conservation techniques on maize (*Zea mays*) yield and yield components (moisture deficit area of Dugda Woreda, Ethiopia). *Int. J. Agric. & Agribusiness,* 7(1): 17 – 23.

FAO 2001. Crop and Drops: Making the Best Use of Land and Water. FAO, Rome.

FAO 2014. Food and Agricultural Of the United Nations. (Helping to build a world without hunger) Technical Cooperation Department Turning Expertise into Action.

FAOSTAT 2014. Statistical Year Book 2014, Europe and Central Asia Food and Agriculture.

Fournier F 2000. Research on soil water conservation in African. *African Soil*, 12: 52 – 96.

Haibu N, Mutabazi K, Senkondo EM & Msangi ASK 2006. Economics of rain water harvesting for crop enterprises in semiarid areas of east Africa. *Agric. Water Mangmt*., 80: 74-86.

Hatibu N & Mahoo H1999. In Conservation tillage with animal traction. *A Resource Book of the Animal Traction Network for Eastern and Southern Africa* (*ATNESA*) (ed. Kaumbutho PG & Simalenga TE). Harare, pp. 161–171.

Heluf G & Yohannes U 2002. Soil and water conservation (tied ridges and planting methods) on cultivated lands: The case of Eastern Ethiopian. *Soil and Water Managt. Res. Program,* p. 154.

Iken JE & Amusa NA 2004. Maize research and production in Nigeria. Institute of Agricultural Research and Training (IAR&T), Obafemi Awolowo University, PMB 5029, Moor Plantation, Ibadan. Nigeria, pp. 302-307.

Jayeoba OJ 2013. Suitability of soil qualities for arable agriculture using geoinformatics in Nasarawa state, Nigeria. Ph.D Thesis, Geography Department, Nasarawa State University, Keffi.

Karrar AB, Mohamed HI, Elramlwai HR, Saeed AB & Idris AE 2012. Effect of planting geometry on soil moisture content, yield and yield component of sorghum (*Sorghum bicolor* L. Moench). *Glob. J. Plant Ecophysiol.*, 2(1): 23-30.

Mudalagiriyappa BK, Ramachandrappa HV & Nanjappa 2012. Moisture conservation practices and nutrient management on growth and yield of rabisorghum (*Sorghum bicolor*) in the vertisols of peninsular India. *Agric. Sci.,* 3(4): 588-593

Nazareth V 2016. Evaluating conservation agriculture and its adoption potential in developing countries (Master Dissertation). University of Florida, USA.

Nyamadzawo G, Wuta M, Nyamangara J & Gumbo D 2013. Opportunities for optimizing in field water harvesting to cope with changing climate in semiarid smallholder farming areas of Zimbabwe. *Springer Plus,* 2: 1 – 9.

Obi IU 1991. Maize: its agronomic, diseases, pest and food values. Optimal computer solution Ltd. Publ., p. 206.

Prinz D & Malik AH 2004. More yield with less water: How efficient can be water conservation in agriculture? *Europea Water*, 5/6: 47-65.

Tekle Y & Wedajo G 2015. Evaluation of different moisture conservation practices on growth, yield and yield components of sorghum at Alduba, southern Ethiopia. *Res. J. Agric. and Environ. Mgt*., 4(3): 169-173.

Water Aid 2017. Wild Water: The State of the World's Water, 1–24.

Wiyo KA, Kasomekera ZMJ & Feyen J 1997. On Rain water harvest and its effect on soil water and crop yield, final technical report to International Development Research Centre (IDRC), Bunda College of Agriculture. *Crop Sci.,* 196: 109-121.