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Effect of Different Tillage Methods on the Growth and Yield of Pearl Millet under Rainfed Conditions

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Abstract
Field experiment was conducted under rainfed conditions from July to September, during 2012 and 2013 cropping seasons at Agricultural Research Farm, Ramat Polytechnic Maiduguri, Nigeria, to evaluate the effects of three varied tillage methods on the growth and yield of pearl millet. The experiment was laid out in a randomized complete block design with three different treatments namely disc harrowing, disc harrowing followed by ridging and zero tillage, with four replicates arranged in a split-plot configuration. The results obtained eight weeks after of planting for the two growing seasons showed significance difference at 5% in plant height, stem girth, number of leaves per plant, tiller count, panicle length, grain weight per panicle and grain yield for disc harrowing followed by ridging as compared to the disc harrowing and zero tillage. Zero tillage treatment presented the worst growth and yield components parameters. There was no significant difference in pearl millet plant growth and yield components between the disc harrowing and zero tillage treatments. Thus, considering the soil and weather conditions, which the experiment was conducted, the optimum tillage practice for producing pearl millet variety is disc harrowing followed by ridging.

Keywords*: Grain yield, Growth, Pearl millet, Tillage and treatment*

1. Introduction

Pearl millet [*Pennisetum glaucum* (L.) R. Br.] is second in importance only to sorghum as a staple food crop in the northern Nigeria, over 40% of land sown annually to cereals is devoted to millet. Thus, millet is sown annually on about five million hectares of land between latitude 7^0N and 14^0N with a yield of about 4 million metric tonnes of grain (Ikwelle, 1998). Pearl millet has relatively high resistance to drought, high production capacity in hot and dry areas and high efficiency of water use of the three-carbon, which is considered the most suitable for the plant growing areas with limited water (Ibrahim *et al*., 1995). As reported by Aminu-Kano *et al*. (1998), Nigeria is among the leading millet producing country. Within the last two decades, the country has become increasingly in the production of the crop, accounting for 14% of average annual global production in the period 1992 – 1994 in comparison with only 9% in the period 1979 -1981 period. This has moved it from being the third to the second largest millet producing country in the world. This increase in production is because of the expansion in cultivation area rather than yield increase. The dominant millet species grown in Nigeria is pearl millet, which are classified into three types: the early maturing ‘Gero’ is the most widespread and cultivated in the Southern and Northern Guinea savanna areas as well as in the Sudan savanna and Sahel zones. ‘Maiwa’ and ‘Dauro’ types are late maturing and are mostly grown in the southern and northern Guinea savanna area, which are been processed in various form for human consumption. However, the Stover is fed to animals and the stalks are used for fencing. The major production constraints are low and erratic rainfall, high soil and air temperatures, poor soil fertility and biotic stresses.

Soil as a growing medium for plants and human food supply has always been one of the most important and valuable resources in agriculture. Therefore, proper management of the operation and its stability will be important (Rashidi et al., 2008). According to Rashidi and Khabbaz (2009), the major benefits of tillage is the aeration resulting from pulverization, this aeration not only provides a free circulation of oxygen and water but also result in increased of biological activities in the soil, including that of organism that fix atmospheric nitrogen. Tillage contributes to the health of plants by inhibiting plant diseases and discourages the development of various types of insects that can harm plants. Tillage is an operation that distracts the soil through various operations to place seeds and grow crops (Khan et al., 2001). However, almost all tillage operations are carried out to prepare a fine seedbed for growing crops. Appropriate tillage operations are required for better crop yields and as a result, increases production. Proper operations improve soil physical properties while inappropriate, excessive, and unnecessary tillage operations may not provide the desirable results hence yield can significantly decreased (Iqbal et al., 2005). Most of these studies suggest that tillage tends to improve certain soil physical properties, which provide favorable soil conditions for plants growth. Tillage also exerts adverse effects on soil when it is perform under inadequate moisture conditions, or when improper tillage implements are used.

2. Materials and Method

2.1. Experimental site

This study was conducted under rainfed conditions from July to October, in the year 2012 and 2013 cropping seasons, at Agricultural Research Farm, Ramat polytechnic Maiduguri, Nigeria. Maiduguri lays between latitude $11^0 51^1$ – 11^0 55^1N and longititude 13^0 02^1-13^0 16^1E at an altitude of 354 m above sea level. The climate is classified as dry sub-humid and the soil type is sandy loam. The mean daily temperature ranges between 22^0C in January to 33^0C from the middle of April to mid May. The rainfall is erratic and poorly distributed, which usually starts from early June to September followed by cold harmatan season of three to four months and hot dry season from March-June.

2.2. Experimental Design and Treatments

The experiment was arranged in a randomised complete block design (RCBD) with three tillage treatments in four replicate blocks. The treatments include disc harrowing (T_1), disc harrowing followed by ridging (T_2), and zero tillage (T_0), Each plot measured 4 x 5 m. The tillage treatments were chosen because of their widespread usage as major tillage operations in the area. The tillage treatments were achieved by the use of disc harrow and a ridger coupled to a tractor. In zero tillage, herbicide was sprayed at the rate of 250ml/ha to kill weeds. Beds were prepared on the plots manually by raising the soil level with hoe. Soil samples were collected at a depth range of 0-30cm for determination of some soil physical and chemical properties using standard laboratory procedure.

2.3. Agronomic practice

Pearl millet seed (SOSAT C-88) was obtained from Lake Chad research institute (LRCI), Maiduguri, which was sown at a depth of 5cm with 1 x 1m spacing and the seed rate of 7-10 seeds per hole as recommended by LCRI, (2010). Thinning was carried out a week after germination, where five plants stand per hole was adopted. Weeds control was carried out at 2 and 5 weeks after planting (WAP). Weeds in the disc harrowing and disc harrowing plus ridging plots were controlled using a hand hoe while those in the zero tillage plots were controlled using weed off herbicide at a rate of one litre per hectare mixed in 200 litres of clean water. Fertilizer NPK (15-15-15) was applied two weeks after planning at the rate 4bags/ha as recommended by LCRI (2007). Planting of resistant variety, LC-ICMV-1(SOSAT C-88) reduces the effect of pest and disease damage. Harvesting was done when the seed could not be crushed between two fingers and the panicles were cut out using sharp knife and dried out properly for threshing, which is in agreement with LCRI, (2010).

2.4. Data Collection

Ten plants were tagged per plot for the determination of growth parameters and dry matter yield. The growth parameters include; Plant height, stem girth, number of leaves per plant and tiller count were measured at weekly intervals for eight weeks beginning at one week after planting. Dry matter yield were determined at harvest. Plant height was measured as the vertical distance between the ground and the appex living part of the plant with a ruler/metre rule. Stem girth was measured using a white thread and a ruler. Number of leaves per plant was determined by counting all the leaves on each plant and number of tiller per hole was accounted. The mean for the ten plants was used as the number of leaves per plant.

Soil property	2012	2013
Sand (%)	31.03	32.40
Silt (%)	67.05	65.30
Clay (%)	1.92	2.30
Organic Carbon (%)	0.42	0.42
Organic Matter (%)	1.34	1.31
pH	6.30	6.20
Total N (%)	0.20	0.29
Ca (cmol kg 1)	21.20	20.12
Mg (cmol kg 1)	7.10	7.17
K (cmol kg 1)	1.20	1.27
Available P (cmol kg 1)	0.35	0.40
Na (cmol kg 1)	3.80	3.54

Table 1: Selected Soil Physical and Chemical Properties at the Experimental Site

Month	Tmax (°C) 2012	Tmin (°C) 2012	Tmax (°C) 2013	Tmin (°C) 2013	Rainfall (mm)	
					2012	2013
July	32.5	22.7	33.3	22.4	22.3	21.3
August	30.4	20.5	31.4	20.1	68.9	65.1
September	33.0	23.7	35.1	23.4	34.0	35.6
Total					**125.2**	**121.0**

Table 2: Temperature and rainfall at the experimental Site
Tmax (°C) - Maximum air temperature °C
Tmin (°C) - Minimum air temperature °C

2.5. Data Analysis

Statistical analysis of data was conducted using the Balanced Analysis of Variance (ANOVA) procedure in MINITAB Statistical Software Release 15 (MINITAB Inc., 2007). The Least Significant Difference (LSD) test was determined at $p < 0.05$ to pinpoint significant difference between treatment means.

3. Results and Discussion

3.1 Effect of tillage practice on plant height

Plant height is an important growth parameter that directly linked with the yield (Saeed et al.,2001). The effect of tillage practice on pearl millet height is presented in Figure 1 and 2 for the 2012 and 2013 crop-growing seasons respectively. Analysis of variance showed no significant difference in plant height between the different tillage treatments up to the fifth week after planting. At eight weeks after planting there was a significance difference in plant height between harrowing plus ridging treatment and the two other treatments for the two growing seasons. The tallest plants were observed in the harrowing plus ridging treatment, followed by harrowing treatment, while the shortest plants were observed with zero tillage treatment during 2012 growing season, which is similar to 2013 growing season. These results are similar to that of Kayode and Ademiluyi (2004) who observed the shortest maize plant in the No Tillage plots in comparison with that in the tilled plots on a sandy clay loam alfisol in Southwestern Nigeria. Increasing soil loosening effect created by disc harrowing plus ridging seedbed condition which influenced the growth of the crop resulting in the tallest plant in both years. Aikins and Afuakwa (2010) also reported taller cowpea plants in the tilled plots compared that of the No Tillage plots. In contrast, Ojeniyi and Adekayode (1999) reported taller maize plants in the No Tillage plots in comparison with that of the tilled plots except for that in the ploughing followed by harrowing plus ridging plots on sandy clay loam soil (Ferric Luvisol) at Akure, located in the rainforest zone of Nigeria. They reported no significant difference in plant height between the indicated treatments.

3.2 Effect of tillage practice on stem girth

Stem girth is an expression of vegetative growth (Squire, 1990). Figure 3 & 4 illustrate the mean values of stem girth over the period of the experiment for both the 2012 and 2013 cropping seasons, respectively. Stem girth was significantly affected by tillage practices over the course of the experimental period except for the first four weeks after planting in 2012 and 2013. In 2012 and 2013, at eight weeks after planting, significant tillage practice effect on stem girth was in the order harrowing plus ridging treatments followed by harrowing and zero tillage. Overall, the biggest pearl millet plant stem girth was observed in the harrowing plus ridging plots. The second biggest stem girth was located in the disc harrowing plots. The smallest stem girth was found in the zero Tillage plots for 2012 and 2013 growing seasons. Similar results were obtained by Aikins and Afuakwa (2010) for cowpea.

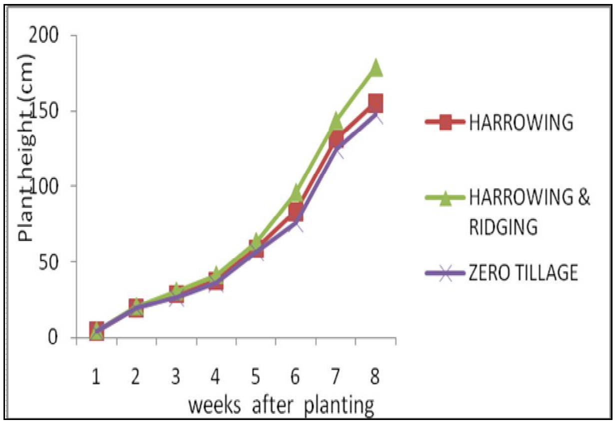
3.3 Effect of tillage practice on number of leaves per plant

Leaves are the site of photosynthetic activities of crops through which biomass are produced, partitioned among various parts of crops and stored for crop productivity (Asare *et al*., 2011). Figure 5 & 6 illustrates the effect of the different tillage practices on pearl millet number of leaves per plant during the 2012 and 2013 cropping seasons. There was significant effect of tillage practices on number of leaves per plant except for the first and second weeks after planting. At 8 weeks after planting, the harrowing plus ridging treatments produced the highest number of leaves per plant, followed by harrowing treatment. Zero Tillage treatments presented the lowest number of leaves per plant significantly lower than that of all the other treatments for both 2012 and 2013 cropping seasons. There was significant difference in number of leaves per plant between the harrowing plus ridging treatments and the other two treatments during the 2012 cropping season. In 2013 cropping seasons there was no significant difference in number of leaves per plant between the three tillage practices as shown in figure 6. Similar result were obtained by Aikins and Afuakwa (2010) which indicate no significant difference in number of leaves per plant between the three tilled treatments.

3.4 Effect of tillage practice on Tiller count

tillering is an important growth parameter in pearl millet yield. Figure 7 & 8 illustrates the effect of the different tillage practices on pearl millet tiller count during the 2012 and 2013 cropping seasons. Tillering was significantly affected by tillage practices over the course of the experimental period except for the third weeks after planting in 2012 and 2013. At 8 weeks after planting, the harrowing plus ridging treatments produced the highest tiller, followed by harrowing treatment. Zero Tillage treatments presented the lowest number tiller significantly lower than that of all the other treatments for both 2012 and 2013 cropping seasons. In 2012 harrowing plus ridging treatment shows a significant difference in tiller count as compared to the harrowing and zero tillage treatments, while 2013 there was no significant difference between the three treatments. This result is similar to

Haussmann (2006) the high-tillering population had significant genetic variation for phenological and morphological traits including grain yield when tested under rainfed Sahelian conditions.



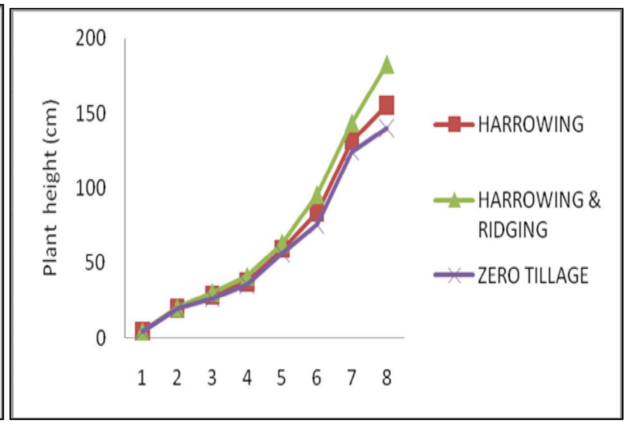
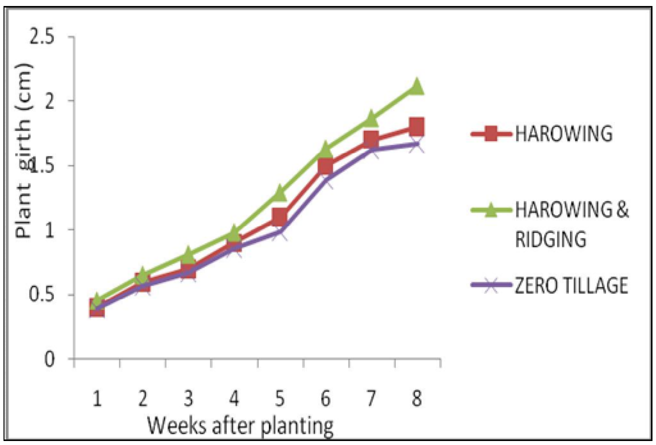


Figure 1: Effect of tillage practice on plant height in 2012
Figure 2: Effect of tillage practice on plant height in 2013



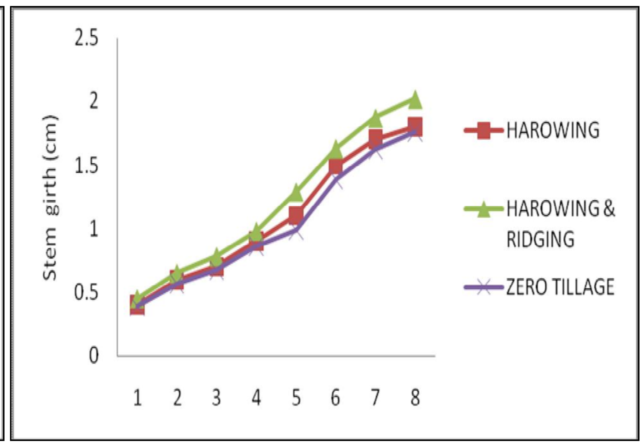
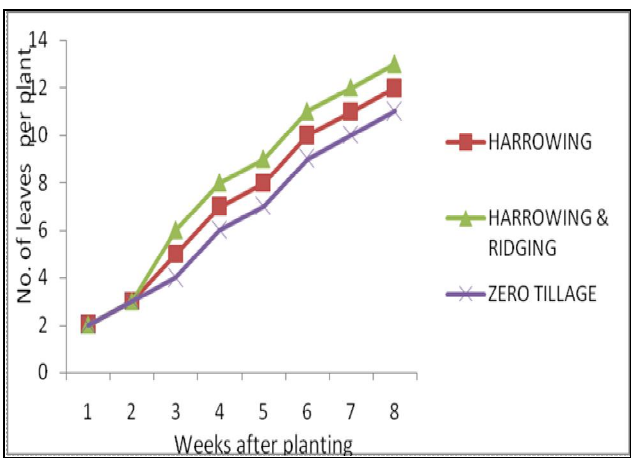


Figure 3: Effect of tillage practice on stem girth in 2012
Figure 4: Effect of tillage practice on stem girth in 2013



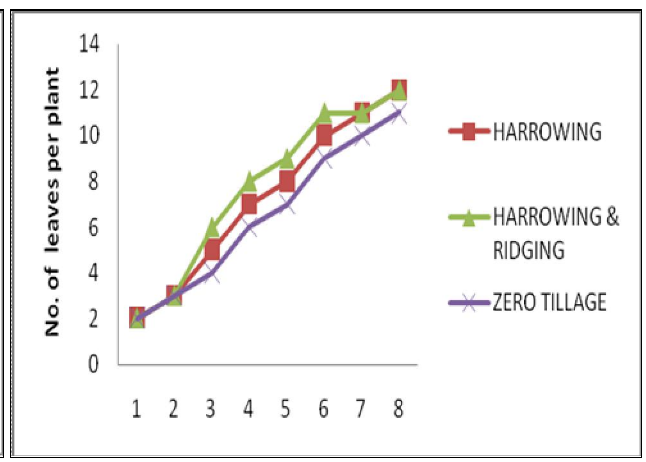
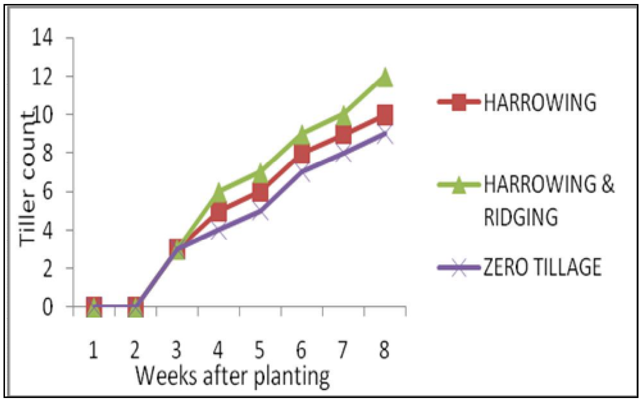


Figure 5: Effect of tillage practice on number of leaves per plant in 2012
Figure 6: Effect of tillage practice on number of leaves per plant in 2013



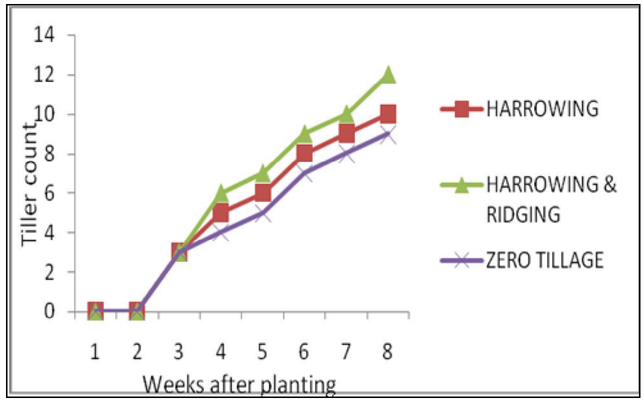


Figure 7: Effect of tillage practice on Tiller count in 2012
Figure 8: Effect of tillage practice on Tiller count in 2013

3.5. Effect of tillage practice on the yield of pearl millet

The influence of the three different tillage practices on the pearl millet yield components is shown in Table 3. Panicle length, grain weight per panicle and grain yield (t/ha) were all significantly influenced by the tillage treatments for both growing seasons. Among the different tillage practices, disc harrowing followed by ridging gave the longest panicle length, highest grain weight per panicle and highest grain yield for 2012 and 2013. The zero tillage treatment gave the shortest panicle length, lowest grain weight per panicle and lowest grain yield. The significant difference shown by disc harrowing followed ridging in all the parameters was associated with increased in soil loosening. Similar results have

been reported by Rashidi and Keshavrzpour (2007), who evaluated the effects of seven tillage methods on grain yield and yield components of maize (Zea mays L.) under clay-loam soil and observed significantly greater maize grain yield and yield components under tilled treatments compared with that of the no tillage treatment. In contrast, Agbede et al. (2008), also observed greater sorghum grain yield in the no tillage treatment in comparison with the ploughing followed by harrowing treatment.

	Panicle length (cm)		grain mass per panicle (g)		grain yield (t/ha)	
Treatment	**2012**	**2013**	**2012**	**2013**	**2012**	**2013**
T1	24.3	24.5	7.07	7.13	0.94	0.91
T2	33.7	33.2	9.23	9.20	1.45	1.43
T0	20.8	20.1	6.93	6.85	0.76	0.78
LSD ($p \leq 0.05$)	8.4	10.2	9.4	9.3	0.3	0.5

Table 3: The yield component of pearl millet

4. Conclusion

The study revealed that pearl millet variety was significantly influenced by tillage practice treatments. Disc harrowing followed by ridging produced the tallest plant height, largest stem girth, highest number of leaves per plant, highest tiller count, longest panicle length, highest grain weight per panicle and highest grain yield shows a significant difference at 5% significance level. The zero tillage treatment presented the worst growth and yield components parameters. Therefore, disc harrowing followed by ridging is the best alternative for the production of pearl millet considering the soil and weather conditions of the experiment.

5. Acknowledgment

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