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Impact of Tillage Operation on the Fruit Yield of six Exotic Tomato Varieties on an Alfisol in the Southern Guinea Savanna of Nigeria

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Abstract

Three separate field experiments were conducted at the Teaching and Research Farm, University of Ilorin, Nigeria on an alfisol with low inherent fertility status to study the effect of two conventional tillage methods on yield of tomato (Lycopersicon esculentum) during 2006 normal and 2007 irrigation growing seasons. The conventional tillage treatments (Ridge: tractor ploughed, harrowed and ridged and Flat: tractor ploughed and harrowed) were used to assess the response of the varieties to four N-Fertilizer regimes (0, 30, 60 and 90 Kg N/ha), two different growing seasons (rainfed versus irrigation) and two moisture regimes (normal watering versus post-anthesis moisture deficit) respectively. Tomato yields were significantly influenced by tillage methods with planting on the flat producing a significantly higher fruit yield than planting on the ridge except under moisture deficient condition. Roma (check variety) significantly yielded higher than other varieties under both N-Fertilizer regimes and growing seasons while Periondonta was superior for fruit yield under moisture regime.

Keywords: *Tillage system, fruit yield, N-Fertilizer rate, Moisture regime.*

1. Introduction

Tomato (*Lycopersicon esculentum* Mill) is an important vegetable crop world wide. In Nigeria, commercial tomato production relies mostly on exotic introductions, the production of which is essentially restricted to the Northern Guinea Savanna and the Sudan ecologies due to favourable climatic conditions, particularly high insolation and low relative humidity. However, because of its nutritive and commercial values, production of exotic tomatoes has also spread to the Southern and Derived Guinea Savanna ecologies where hitherto, the traditional varieties are produced. Consequently, it has almost replaced the traditional varieties of the southwest Nigeria.

Presently, there are tomato cultivars and hybrids which can be cultivated in climate different from the site of origin and which could also serve as sources of genes for improvement of adapted varieties. However, commercial cultivation of tomatoes in Nigeria exhibits seasonality with much of the production concentrated in the relatively cool and dry period under irrigation or in the 'fadamas'. Furthermore, yields of the introductions in the tropics are generally low compared with yields obtainable in the temperate region (McGraw *et al.*, 1987; Anon. 1992; Surya, 1993).

Although the use of improved varieties along with fertilizer application have increased tomato production in the tropics, the full potential of the crop has not been achieved when compared to the temperate countries where fruit yields are almost doubled that of the tropics.

The low yield obtained in the tropics has been attributed to several factors including high temperatures, high humidity, excessive rainfall (Opena *et al*., 1989), diseases and insect pests (Tee *et al*., 1979; Ma, 1985), lack of appropriate varieties (Villareal, 1979) and unsuitable cultural practices (Znidarcic *et al*., 2003).

Soil tillage is one of the cultural practices that affect soil physical properties and yield of crops (Keshavarpan & Rashidi, 2008). Khurshid et al.(2006) reported that among the crop production factors, tillage contributes up to 20%. Tillage method affects the sustainable use of soil resources through its influence on soil properties, proper tillage can improve soil related constraints, while improper tillage may cause a range of undesirable processes such as destruction of soil structure, accelerated erosion, depletion of organic matter content and fertility (Rashidi et al., 2010), destruction of cycles of water, organic carbon and plant nutrients (Lai, 1993) and encourage excessive weed emergence (Takim and Fadayomi, 2010).

The predominant land preparation practices in the sub-humid tropics is the conventional tillage involving disc ploughing, harrowing and ridging or disc ploughing followed by two processes of disc harrowing. These practices modified the soil structure by changing the physical properties such as soil bulk density, soil penetration resistance and soil moisture content. Annual disturbance and pulverizing caused by continuous tillage produce finer and loose soil structure as compared to conservation and no-tillage methods which leave soil intact (Reddy et al., 2007). This difference results in change of number, shape, continuity and size distribution of the pores network, which controls the ability of soil to store and transmit air, water and agricultural chemicals. This also improves porosity and water holding capacity of the soil. This consequently leads to a favorable environment for crop growth and nutrient use (Khan *et al*., 2001). The response of crop yield to conventional, no tillage and intensive farming system is well documented for temperate climates. However, there have been conflicting reports on the influence of soil tillage practices on performance of tomato in Nigeria. For example, while studies conducted in the Northern Guinea Savanna (Adeoti and Olarewaju, 1990) and the Derived Savanna (Babalola and Olaniyi, 1999) reported significantly higher fruit yield with conventional tillage compared to the zero tillage system, Omidiji *et al*., (1995), observed no significant yield difference between the two practices in the Southwestern Nigeria. Study conducted by Adekiya *et al*., (2009) which compared the effects of five tillage methods on soil properties, nutrient content, growth and yield of tomato on an alfisol soil on the other hand showed that ploughing plus harrowing and ridging increased tomato fruit yield by 40, 16, 24 and 62% over manual clearing, manual moulding, ploughing and ploughing plus harrowing respectively. Thus according to the authors, it appears that the effects of tillage system on tomato yield may depend on the environment and soil type. The study reported herein therefore compares the productivity of six exotic tomato introductions under two tillage systems (ploughing followed by harrowing and ridging versus ploughing plus one harrow) under two cropping systems (N-Fertilizer application and post-anthesis moisture deficit) on an alfisol soil in the Southern Guinea Savanna of Nigeria.

2. Materials and Methods

2.1 Description of experimental materials

The materials used comprised five exotic tomato introductions (MBWT-1, MBWT-6, CLN1462-B, Periodontal and Manuella) and a standard check (Roma). The varieties were obtained from the Institute of Agricultural Research and Training (IAR&T), Moor Plantation, Ibadan, Nigeria.

Three separate studies were carried out at the Teaching and Research (T&R) Farm, University of Ilorin (Lat. 8^o 29'N & 8^o 30'N; Long. 4^o 30'E & 4^o 32'E), Nigeria between April, 2007 and March 2008 respectively. The soil has been characterized as an alfisol with low inherent fertility status (0.14% Total N, 2.28% Organic matter, 0.28 cmol/kg Na, 0.45 cmo/kg K, 6.50 mg/kg available P, 1.12 cmol/kg Mg, 3.10 cmol/kg Ca and pH of 5.5).

2.2 Seedling raising in the nursery

Seedlings were first raised on nursery beds containing pulverized soil mixed with organic matter and maintained for three weeks after sprouting before transplanting to the field. The seedlings were thoroughly watered one (1) day before transplanting to the field and only healthy seedlings were used in order to ensure uniformity and avoid any bias to outcome of the studies.

2.3 Experimentation

The trials were laid out as a randomized complete block design (RCBD) with a split-plot arrangement and three replications. The main plots consisted of two tillage methods, which include: (1) a tractor ploughed, harrowed and ridged,(Ridge) and (ii) tractor ploughed and harrowed (Flat). The sub-plot made of variety combined with N-fertilizer regime (0, 30, 60 and 90 kgN/ha^{-1}) in the first experiment, seasonal variation (rainfed and irrigation) in the second trial while well-watered and post-anthesis drought moisture deficit condition comprised the sub plot in the third experiment.

Plot size was (1.8 x 1.8) m^2 with seedlings transplanted at the spacing of 0.3m within and 0.6m between the rows respectively. However, while evaluation for the normal growing seasons was carried out on raised beds, that for 2007 irrigation season was carried out on the flat. For the 2006 planting, seedlings were transplanted to the field on June, 2006 and maintained till final harvest on September, 28 2006. Fertilizer NPK 15:15:15 at the rate of $187.50kg/ha^{-1}$ was applied to boost growth before transplanting. Weeding was done manually as necessary. Plants were staked immediately after transplanting with bamboo sticks.

2.4 Data collection

Prior to data collection, three competitive plants in a plot were tagged and used for data collection on seedling height (measured as the distance from the soil level to the tip of the shoot) and number of leaves/plant on a weekly basis beginning from one week after transplanting. The averages were thereafter recorded for each measurement. Data were also collected on whole plot basis on days to first and 50% flower appearance (number of days from transplanting to the period when the first flower appeared in a plot and when half of the plants in a plot produced flowers respectively), plant height at first flower appearance (cm), days to first and 50% fruit appearance (number of days from transplanting to the period when

the first fruit appeared in a plot and when half of the plants in a plot produced fruits), days to first and 50% fruit ripening (number of days from transplanting to the period when the first fruit ripened in a plot and when half of the plants in a plot produced ripened fruits). Others included numbers of fruits/pedicel, number of fruits/plant, total number of fruits/plot and fruit weight (kg).

2.5 Data analysis

Data on fruit yield was subjected to analysis of variance, and where F – ratios were significant ($P < 0.05$); means were separated using the standard error of difference.

3. Results and Discussion

The yield of tomato was significantly influenced by tillage methods as well as differences in the yield potential of the varieties (Table 1). The conventional method of disc ploughing and one harrow followed by planting on the flat produced a significantly higher fruit yield in the three experiments except in the moisture regimes where post-anthesis moisture deficit on the flat produced a significantly lower fruit yield. Roma recorded a relatively better fruit yield under nitrogen treatment and different growing seasons while under moisture regimes, Periondonta had a significantly higher yield. Differences between the highest and lowest yielding variety under N- fertilizer regime was 3.4 t/ha representing 42.9%, 4.23 t/ha (45.6%) under different growing seasons and 5.57 t/ha (54.9%) under different moisture regimes.

The interaction effects of tillage method x varieties in each treatment were significant for fruit yield across the three experiments (Table 1, Figs .1, 2 & 3). The maximum values for fruit yields were recorded by Roma for plantings made on the flat under N-Fertilizer regimes (8.59 t/ha) and by Periondonta (12.55 t/ha) in the growing seasons -rainfed and irrigation. However, the reverse was the case under moisture regimes where Periondonta produced the maximum yield of 13.92 t/ha on the ridge.

Under N-Fertilizer treatment (Fig. 1), fruit yields were generally higher on the flat compared to the ridge except in variety Manuella where fruit yield was similar regardless of the tillage system. The check variety (Roma) showed superiority over the new introductions for fruit yield under the two tillage systems. However, while four of the varieties (MBWT-6, Manuella, CLN and Peirodonta) exhibited similar performance for fruit yield under the two tillage systems, fruit yield in varieties MBWT-1 and Roma, differed significantly under N-fertilizer treatment with higher yields obtained on the flat compared to the ridge.

Fruit yield across seasons in the six exotic tomato introductions under the two tillage systems are presented in Figure 2. Comparison between tillage systems showed that fruit yield was significantly higher in all the varieties when cultivated on the flat compared to the ridge but with Periodonta and Roma (check) exhibiting significantly higher fruit yields than the other four varieties on the flat. The other varieties exhibited similarity in productivity within a tillage system (ridge or flat) except MBWT-1, which produced the lowest fruit yield under both ridge and flat tillage systems.

The response of the six tomato introductions across two different moisture regimes (normal watering versus post-anthesis moisture deficit) is shown in Figure 3. Productivity of the tomato varieties was significantly better on the ridge system compared to the flat with Periodonta exhibiting superiority over all the other varieties on the ridge while the check

variety (Roma) showed similarity in performance. Manuella had a significantly poor yield on the flat compared to other varieties.

Plough and harrow or plough, harrow and ridge are the major types of conventional tillage methods adopted in Nigeria localities. These practices can be associated with reduced soil penetration resistance, reduced soil bulk density, increased soil moisture preservation, improved soil structure, enhanced root-soil contact and better weed growth suppressing which favorably affect root development, plant growth and plant population density, resulting in increased crop yield. In these studies, planting on the flat after ploughing and harrow, produced significantly higher fruit yields in the tomato varieties compared to planting on the ridge. While our results agree with the findings of Hemmat and Taki (2001) and Rashidi and Keshavarzpour (2008), who concluded that the conventional tillage method in arid regions had significant effect on yield, it differed from reports of Adekiya *et. al*., (2009) who recommended planting on the ridge for alfisol in the southwestern Nigeria.

4. Conclusion

Based on the above results, it could be concluded that tillage method had a significant influence on tomato fruit yield. However, plots subjected to the full complement of tillage activities; ploughing, harrowing and ridging (ridge) supported a relatively lower yield of tomato while plough and harrow (flat) plots supported the highest yield. There is however, the need for further long-term studies to find the beneficial effects of tillage methods on soil quality and yield when it is supplemented with extra nutrients or crop residue.

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Table 1. Response of fruit yield of six exotic tomato varieties on

Treatment	Experiment I	Experiment II	Experiment III
Tillage			
Ridge	5.30 [b]	5.58[b]	8.72[a]
Flat	6.30[a]	9.44[a]	5.26[b]
Sed	0.275	0.006	0.004
LSD(0.05)	0.559	0.012	0.008
Variety			
MBWT-6	4.83[cd]	6.85[e]	6.92[c]
Manuella	5.04[cd]	7.49[c]	4.57[f]
CLN 1462-B	6.10[b]	7.24[d]	7.44[b]
Periondonta	4.53[d]	9.15[b]	10.14[a]
MBWT-1	5.58[bc]	5.05[f]	6.69[d]
Roma	7.93[a]	9.28[a]	6.17[e]
Sed	0.476	0.010	0.007
LSD(0.05)	0.968	0.021	0.014
Interaction			
Tillage x Variety	*	*	*

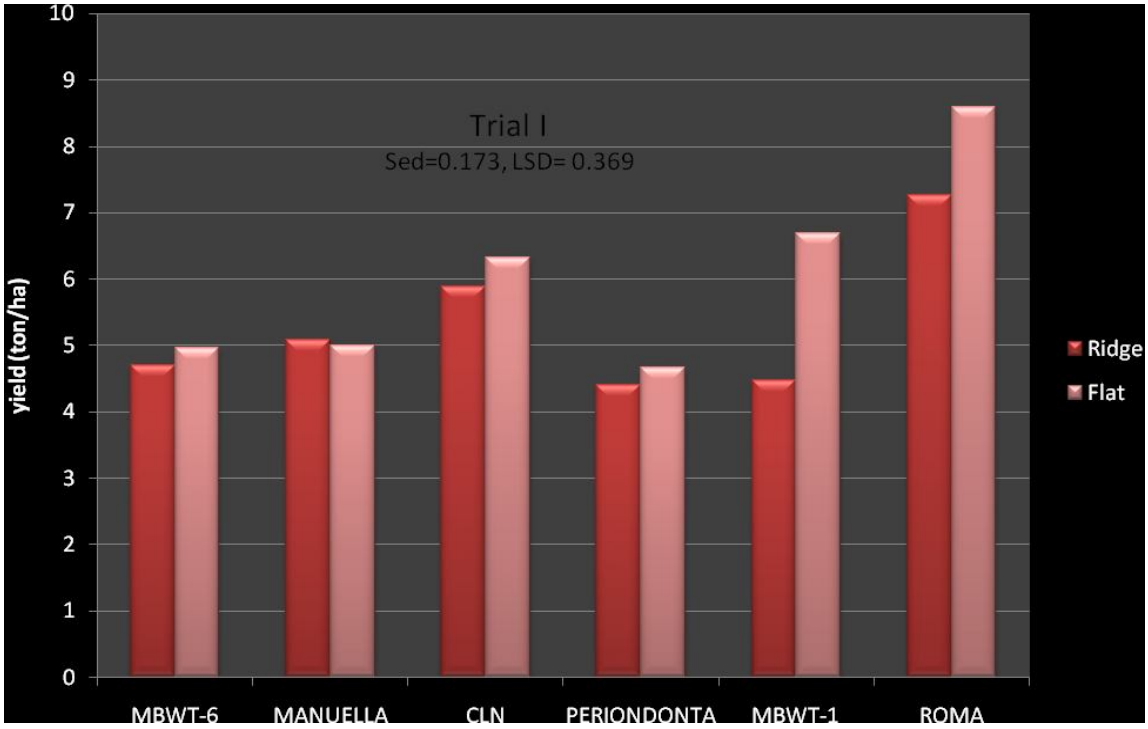

Fig. 1: Response of six exotic tomato varieties to N-Fertilizer under two tillage systems in the southern guinea savanna of Nigeria.

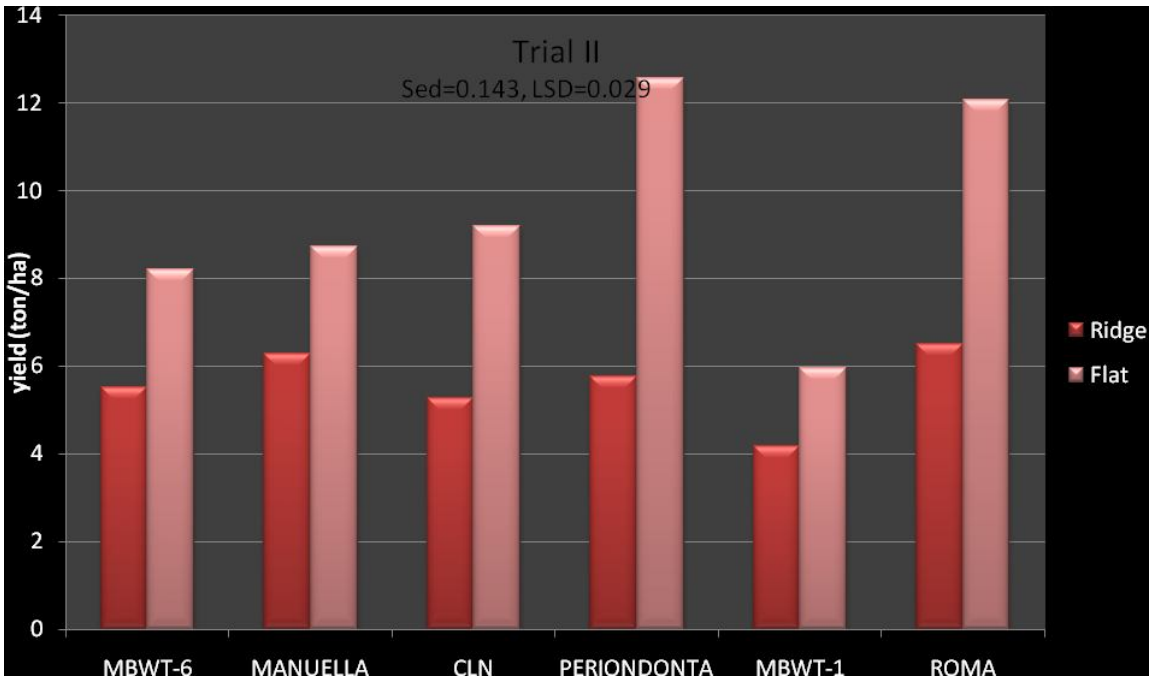

Fig. 2: Fruit yield in six exotic tomato varieties under two tillage systems in the southern guinea savanna of Nigeria.

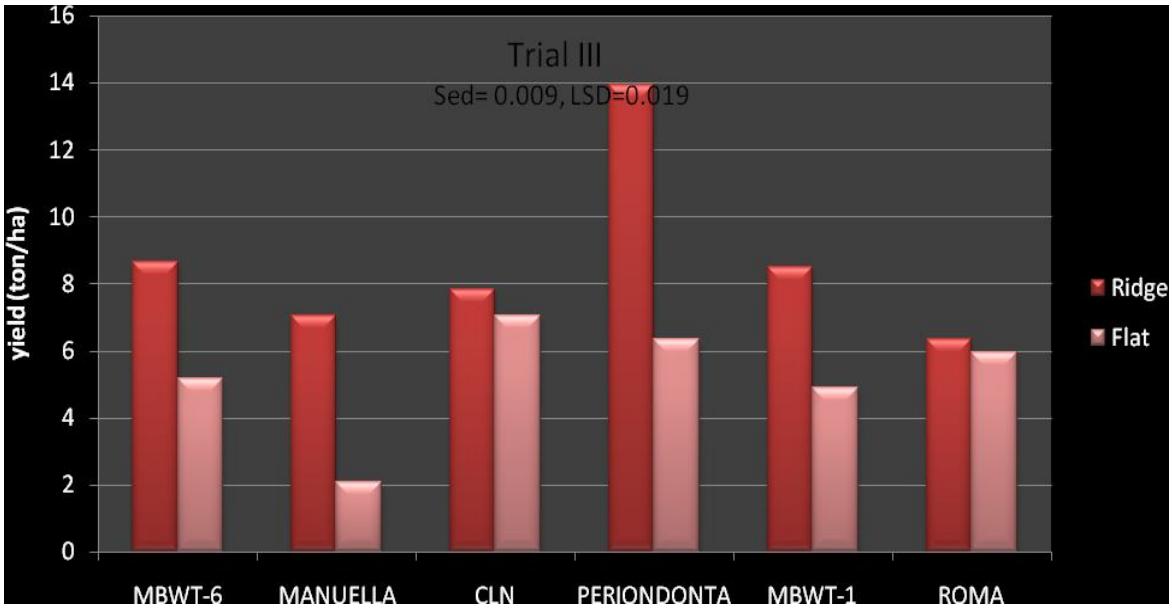

Fig. 3: Response of six exotic tomato varieties to moisture regimes under two tillage systems in the southern guinea savanna of Nigeria.