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Research Paper

Effects of selected mulches and their mulching rate on growth and fruit yield of tomato variety in the southern guinea savanna of Nigeria

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Field experiment was conducted at the teaching and Research Farm, Ladoke Akintola University of Technology, Ogbomoso and Niger State College of Agriculture, Mokwa, in 2014 cropping season to examine the effects of mulching on growth and fruit yield of UC82B tomato variety. The experiment had fifteen treatments viz: three mulching materials (rice husk, groundnut shell and dry guinea grass) and five mulching rates (0, 5, 10, 15, and 20 in t ha^{-1}) replicated three times. The experiment was laid out in Randomized Complete Block Design (RCBD) and data were collected on plant height, number of leaves, number of flowers, number of fruits and total fruit yield. Data were analysed using analysis of variance (ANOVA) SAS package and treatment means compared using least significant difference (LSD) at 5% probability level. The results indicated that plants mulched with 15 t ha^{-1} at 6 weeks after transplanting gave the tallest plant height (39.9 cm) and the least was obtained from the control plot (21.3 cm) at 2 WAT. The mulching rate of 15 t ha^{-1} produced the highest fruit yield (23.30 t ha^{-1}) while the least was obtained from un-mulched plots (8.13 t ha^{-1}). Therefore, mulching rate of 15 t ha^{-1} can be adopted by the farmers to boost food production.

Key words: Tomato, variety, mulching material, mulching rate, growth, yield

INTRODUCTION

Tomato (*Lycopersicon lycopersicum*) belongs to the *solanaceae* family. It originated in Peru and Mexico, in the present day Central and South America from where it spread to other parts of the world (Zeidan, 2005). Tomato reached Europe from Mexico in the 16th century and was initially used as ornamental plant. Its cultivation for edible fruits started at the end of the 18th century. Tomato was introduced to West Africa and Nigeria in particular, at the end of the 19th century (Villareal, 1980). It is currently considered to be one of the main vegetable crops in the world, and constitutes an economic force that influences the income of many growers (Omar, 2005). In Nigeria tomato also finds its way into almost every kitchen. Tomato is very important in terms of diet and economy in Nigeria both during the rainy season (rainfed) and dry season using irrigation facilities. It is used as a condiment in stews and soup or eaten raw in salads. Industrially, the crop is made into puree, sauce, paste and powder (Balarabe, 2012).

Mulching is the process or practice of covering the soil/

ground to make more favourable conditions for plant growth, development and efficient crop production. Mulch means 'covering of soil' (Anon, 2009). While natural mulches such as leaf, straw, dead leaves and compost have been used for centuries, during the last 60 years the advent of synthetic materials has altered the methods and benefits of mulching. When compared to other mulches, plastic mulches are completely impermeable to water; it prevents direct evaporation of moisture from the soil and thus limits the water losses and soil erosion over the surface (Akhtar *et al*., 2001). In this manner it plays a positive role in water conservation and the suppression of evaporation also has a supplementary effect; it prevents the rise of water containing salt, which is important in countries with high salt content water resources (Enan, 2004).

Mulching is a layer of material on the surface of the soil used to keep soil moist or to serve a wide variety of other purposes. Organic mulches are those derived from the dead plant and animal tissues, which apart from soil protection also serve as nutrient sources when they decay. Tomato plants subjected to mulching and fertilization exhibited the highest plant height when compared with the other treatment combinations (Liasu and Abdul Kabir, 2007). Mulching has been identified by many researchers as a method to provide a favourable soil environment by minimizing crusting at the soil surface and keep it stable (Kayum *et al*., 2008). Influence of mulching on tomato production has been reported by many researchers (Hooda *et al*., 1999).This practice increases the infiltration of rain water and suppresses the growth of weeds. Mulching is effective in reducing evaporation, conserving soil moisture and has been known to modify the hydrothermal regime of soil (Bhagat and Achanya, 1988).

Mulching of tomato plants with *Tithonia diversifolia* leaves and fertilizer application together promoted growth and development i.e. number of nodes, number of leaves and height, as well as fruit production i.e. number of fruits, number of seeds per fruit, fruit size, fruit shape and duration of fruiting activity. In the experiment conducted by Kayum *et al*., (2008), three tomato varieties namely, Ratan, BARI tomato-3 and BARI tomato-6 were experimentally evaluated to identify the role of mulching on growth and yield, where the experiment consisted of four mulching treatments: water hyacinth, straw, am-ada leaf and banana leaf with a control (no mulch). The experiment was conducted under rainfed condition. The result showed that mulching significantly had effect on growth, yield components and thus on the yield of tomato. Mulching is effective in reducing evaporation, conserving soil moisture and has been known to modify the hydrothermal regime of soil (Bhagat and Achanya, 1988). The bad effects of water deficit could be overcome by irrigation or adopting in-situ moisture conservation techniques, such as use of mulches (Walter, 1988). Organic mulches are effective, but when moisture is applied by irrigation or through rainfall, the amount should be adequate to reach the soil. Organic mulches tend to settle with time. Some are less resistant and decompose after a short time. As such, it may be necessary to add fresh material to the original layer to make it effective in retaining moisture (George, 2004). The agronomic characteristics of tomato as influenced by irrigation and mulching were examined. Mulching and no mulching were evaluated. Rice straw was used as mulching material at the rate of 5 t/ha. The mulching significantly affected the fruit yield in such a way that mulched plots produced about two times more fruit yield than those without mulch (Gudugi *et al*., 2012). The effects of l. *Leucocephala* and g. *Sepium* mulches (and their mixtures) on the growth and yield of okra were assessed. The mulches were applied at the rate of 0, 5 and 10 t ha^{-1}. The mulches did not significantly improve the chemical properties of the soil, but improved the growth rate and yield of okra. Generally, the higher the amount of mulch applied, the better the growth and yield of okra (Agbo, 2000). Mulching, using any of the materials like green leaves, dried leaves and coconut fronds significantly increased tomato fruit yield by 65.30% over the control and the increase was attributed to the slight improvement in the physical properties of soil (Ertek *et al*., 2004). Similarly, mulches applied at very low rates e.g. 2.5 t ha^{-1} or 5 t ha^{-1} can significantly increase growth and yields of highly valuable vegetable and fruits crops in the field (Norman and Clive, 2005).

Trash farming suppresses weed germination and retard growth and development of many weeds, reduces soil erosion and conserves soil moisture. In the low and intermediate rainfall areas, tomato is mulched with trash (FAO, 1999). This helps in conservation of soil moisture and fertility (Wood, 1991). Trash placed on the soil surface looses 55 – 60% of its organic matter after 270 days compared with 70 – 75% when it is incorporated in the soil (Linedale and Bull, 1995). Use of clear polythene and plastic present the potential advantage of soil solarisation (Schlesselma *et al*., 1985). Application of organic materials such as dried papaya leaves could also make the plants grow fast and retard the growth of weeds around the plants. These organic materials which are added to the soil are collectively termed as organic mulch. Others organic mulches include grass clippings, bark, sawdust and manure, hay, straw, shells, wood chips, shredded newspaper, cardboard and wool (Acayen *et al*., 2004).

Tomato is currently a popular fruit vegetable in Nigeria; however, its production in Nigeria is low compared with those of the temperate zones. Despite numerous positive effects of mulching many farmers in Nigeria do not practice it for tomato production. It is therefore, imperative that sound cultural practices like this nature which are environmentally friendly be adopted to improve soil fertility, for better growth and yield of tomato. The objective of this research work was to determine the

appropriate mulching material and mulching rate that could be adopted to increase growth and fruit yield of tomato variety.

MATERIALS AND METHODS

The experiments were conducted at two locations; Teaching and Research Farm, Ladoke Akintola University of Technology, Ogbomoso (8°10^{1}N; 4°10^{1}E) and Niger State College of Agriculture, Mokwa (9^o 18^{1}N and 5°4^{1}E), during 2014 cropping season. The experimental plot was ploughed and harrowed after which lining out was carried out. There were 45 plots with three replications. Each replicate consisted of 15 plots. Each treatment was in a bed plot size of 2.5 m x 2.0 m (5.00 m^2). A plot contained 25 plants. The total experimental area was 405.00 m^2 (0.041 ha^{-1}). The alley way between replicates was 1.0 m and within replicates was 1.0 m with inter and intra-row spacing of 50 cm x 50 cm. Three mulching materials used were: rice husk, groundnut shell and dry guinea grass while the mulching rates involved: 0, 5, 10, 15 and 20 t ha^{-1}. The test crop used was UC82B tomato variety. The treatment was arranged in a Randomized Complete Block Design (RCBD), replicated three times.

The seeds were sourced from the Department of Crop Production and Soil Science, Ladoke Akintola University of Technology, Ogbomoso and from the Department of Agricultural Technology, Niger State College of Agriculture, Mokwa. The tomato seeds were sown on nursery beds containing pulverized soil and the seedlings were raised for four weeks before transplanting to the field at the two locations. Watering in the nursery was done as at when needed. Healthy and vigorous seedlings were transplanted into the field in order to ensure uniformity. Watering was done using watering-can to supplement rainfall. Pesticide in form of cypermethrin was applied at the dosage of 25 ml per 15 litres of knapsack sprayer fortnightly to check caterpillars, worms and grasshoppers. Manual weeding was also carried out using hoe at three weeks interval starting from 2 WAT to reduce competition between weeds and plants. Data were collected on growth and fruit yield parameters from six selected plants per plot. Data collected were subjected to Analysis of Variance (ANOVA) using SAS package. Treatment means were separated using the least significant difference (LSD) at 5% probability level.

RESULTS

Application of different mulching material had no significant (p≥0.05) effect on the plant heights of tomato plants at all the sampling periods (Table 1). The plant heights of tomato were significantly (p≤0.05) influenced by mulching rate at 2 WAT. The plants mulched with 15 t ha^{-1} materials were significantly taller than those of 20 t ha^{-1}, 5 t ha^{-1} and control plots but were not significantly different from the plants mulched with 10 t ha^{-1} (23.9 cm). At 4 WAT, plant height of tomato was significantly (p≤0.05) influenced by mulching rate. The plants mulched with 15 t ha^{-1} (39.9 cm) were significantly taller than other mulching rates while the least mean value (30.5 cm) was obtained from the control plot which was not significantly different from the plants mulched with 5 t ha^{-1} (31.3 cm). The plant heights of tomato were significantly (p≤0.05) increased by mulching rate at 6 WAT. The highest mean value (39.9 cm) was obtained from the plants mulched with 15 t ha^{-1} which was not significantly different from the plants mulched with 20 t ha^{-1} (38.5 cm). Also, the plants mulched with 10 t ha^{-1} (35.4 cm) and 5 t ha^{-1} (33.6 cm) were not significantly different from each other while the least mean value (29.3 cm) was observed from the un-mulched plants. The interaction effects between mulching material and mulching rate at 2, 4 and 6 WAT were not significant (p≥0.05).

The mulching material applied on tomato did not produced significant (p≥0.05) effects on the number of leaves per plant at all the sampling occasions (Table 2). Mulching rate had significant (p≤0.05) effect on the number of leaves at 2 WAT. The plants mulched with 15 t ha^{-1} (39.8) were significantly higher than the plants mulched with 5 t ha^{-1} and the control plot, but were not significantly different from the plants mulched with 20 t ha^{-1} (39.7) and 10 t ha^{-1} (38.0). The interaction effects between mulching material and mulching rate at all the sampling periods were not significant (p≥0.05).

The mean number of flowers of tomato is presented in (Table 3). The number of flowers increased as the mulching rate increased and declined thereafter. The mulching material had no significant (p≥0.05) influence on the number of flowers of tomato plants. The plants mulched with 15 t ha^{-1} (24.5) and 20 t ha^{-1} (24.4) significantly had similar number of flowers which were significantly different from the plants mulched with 10 t ha^{-1} (19.4) and 5 t ha^{-1} (16.9). The plants mulched with 10 t ha^{-1} were significantly higher than the plants left un-mulched (control) but significantly had similar number of flowers with the plants mulched with 5 t ha^{-1}, respectively. The interactive effects of mulching material and mulching rate were not significantly (p≥0.05) influenced.

The mean number of tomato fruits is presented in (Table 4). The number of fruits increased as the mulching rate increased and declined thereafter from the plants mulched with 20 t ha^{-1}. The mulching material had no significant (p≥0.05) effect on the number of tomato fruit. The mulching rate significantly (p≤0.05) affected the number of fruits. The plants mulched with 15 t ha^{-1} (21.2) significantly gave higher number of fruits than the control plot (12.2), 5 t ha^{-1} (14.0), and 10 t ha^{-1} (14.6) but were not significantly different from that of 20 t ha^{-1} (18.8). The interaction effects of mulching material and mulching rate was not significantly (p≥0.05) influenced.

Table 1. Effect of mulching material and mulching rate on the plant height of tomato plants in 2014 cropping season.

Plant height						
Mulching rate (t ha^{-1})						
Mulching material	**0**	**5**	**10**	**15**	**20**	**MM Mean**
2WAT						
RH	18.9	20.4	25.7	23.3	23.6	22.4
GS	20.7	22.4	21.9	26.3	21.0	22.5
DG	24.4	20.1	24.0	26.7	20.8	23.2
MR Mean	21.3	21.0	23.9	25.4	21.8	
LSD (0.05) MM				ns		
LSD (0.05) MR				2.89		
MM x MR				ns		
4WAT						
RH	30.9	28.7	39.2	39.7	39.9	35.7
GS	29.2	34.9	31.7	40.9	31.0	33.5
DG	31.3	30.4	35.8	39.0	34.5	34.2
MR Mean	30.5	31.3	35.6	39.9	35.1	
LSD (0.05) MM				ns		
LSD (0.05) MR				3.65		
MM x MR				ns		
6WAT						
RH	28.6	32.4	34.6	41.1	36.3	34.6
GS	30.7	34.5	35.5	38.7	41.1	36.1
DG	28.6	34.0	36.1	39.8	38.0	35.3
MR Mean	29.3	33.6	35.4	39.9	38.5	
LSD (0.05) MM				ns		
LSD (0.05) MR				2.80		
MM x MR				ns		

RH= rice husk, GS= groundnut shell, DG= dry guinea grass, MM= mulching material, MR= mulching rate, ns= not significant ($p \leq 0.05$), LSD = least significant difference.

Table 2. Effect of mulch material and mulching rate on number of leaves of tomato plants in 2014 cropping season.

Number of leaves						
Mulching rate (t ha^{-1})						
Mulching material	**0**	**5**	**10**	**15**	**20**	**MM Mean**
2WAT						
RH	35.5	34.6	37.9	38.1	40.4	37.3
GS	33.8	35.7	36.7	41.4	41.4	37.8
DG	35.5	36.8	39.5	39.8	37.2	37.8
MR Mean	34.9	35.7	38.0	39.8	39.7	
LSD (0.05) MM				ns		
LSD (0.05) MR				3.30		
MM x MR				ns		
4WAT						
RH	50.7	46.9	61.4	55.4	79.3	58.7
GS	43.6	49.1	48.3	57.7	48.3	49.4
DG	51.2	42.6	61.6	60.1	73.5	57.8
MR Mean	48.5	46.2	57.1	57.7	67.0	
LSD (0.05) MM				ns		
LSD (0.05) MR				ns		
MM x MR				ns		
6WAT						
RH	42.3	62.1	53.7	66.5	53.1	55.5
GS	60.2	50.3	63.3	58.8	69.9	60.5
DG	42.3	66.4	55.7	79.1	74.6	63.6
MR Mean	48.3	59.6	57.6	68.1	65.9	
LSD (0.05) MM				ns		
LSD (0.05) MR				ns		
MM x MR				ns		

RH= rice husk, GS= groundnut shell, DG= dry guinea grass, MM= mulching material, MR= mulching rate, ns= not significant, ($p \leq 0.05$), LSD = least significant difference.

Table 3. Effect of mulching material and mulching rate on number of flowers of tomato plants in 2014 cropping season.

Mulching rate (t ha^{-1})	Number of flowers					
Mulching material	**0**	**5**	**10**	**15**	**20**	**MM Mean**
RH	15.6	18.4	21.3	28.6	24.6	21.7
GS	14.2	15.7	17.2	25.1	22.4	18.9
DG	14.3	16.6	19.7	22.5	26.1	19.8
MR Mean	14.7	16.9	19.4	25.4	24.4	
LSD (0.05) MM				ns		
LSD (0.05) MR				4.47		
MM x MR				ns		

RH= rice husk, GS= groundnut shell, DG= dry guinea grass, MM= mulching material, MR= mulching rate, WAT= weeks after transplanting, ns= not significant, (p≤0.05), LSD = least significant difference.

Table 4. Effect of mulching material and mulching rate on number of fruits per plant of tomato plants in 2014 cropping season.

Mulching rate (t ha^{-1})	Number of fruits					
Mulching material	**0**	**5**	**10**	**15**	**20**	**MM Mean**
RH	13.1	14.5	15.1	20.7	18.8	16.4
GS	12.6	14.3	15.1	23.7	19.8	17.1
DG	10.9	13.2	13.6	19.3	17.8	15.0
MR Mean	12.2	14.0	14.6	21.2	18.8	
LSD (0.05) MM					ns	
LSD (0.05) MR					3.54	
MM x MR					ns	

RH= rice husk, GS= groundnut shell, DG= dry guinea grass, MM= mulching material, MR= mulching rate, WAT= weeks after transplanting, ns= not significant, (p≤0.05).

Table 5. Effect of mulching material and mulching rate on total fruit yield of tomato plants in 2014 cropping season.

Mulching rate (t ha^{-1})	Total fruit yield					
Mulching Material	**0**	**5**	**10**	**15**	**20**	**MM Mean**
RH	7.80	13.70	13.40	28.80	19.30	16.60
GS	9.30	9.20	13.40	23.20	18.60	14.70
DG	7.30	9.50	8.90	17.80	14.80	11.66
MR Mean	8.13	10.80	11.90	23.30	17.57	
LSD (0.05) MM	ns				ns	
LSD (0.05) MR	5.18				5.18	
MM x MR					ns	

RH= rice husk, GS= groundnut shell, DG= dry guinea grass, MM= mulch material, MR= mulching rate, WAT= weeks after transplanting, ns= not significant, (p≤0.05), LSD = least significant difference.

The total fruit yield of tomato increased as the mulching rate increased and declined thereafter from the plants mulched with 20 t ha^{-1} as shown in (Table 5). The total fruit yield of the tomato was not significantly (p≥0.05) increased by mulching material treatments.The total fruit yield of tomato was significantly (p≤0.05) influenced by mulching rate. The plants mulched with 15 t ha^{-1} gave fruit yield (23.30 t ha^{-1}) which was significantly higher than other values of mulching rates. Mulching rate of 20 t ha^{-1} (17.57 t ha^{-1}) was significantly higher than the plants mulched with 10 t ha^{-1} (11.90 t ha^{-1}), 5 t ha^{-1} (10.80 t ha^{-1}) and the least was obtained from un-mulched plot (8.13 t ha^{-1}).

DISCUSSION

Reports by Liasu and Abdul Kabir (2007) stated that mulching is a layer of material on the surface of the soil used to keep soil moist or to serve a wide variety of purposes.Organic mulches are those derived from the dead plant and animal tissues, which apart from soil

protection also serve as nutrient sources when they decay. Findings from Kayum *et al.* (2008) revealed that mulching tomato plants with the use of water hyacinth, straw, amada leaf and banana leaf showed significant effect on growth and yield components and thus increase the yield. The significant plant height of 39.9 cm obtained with the mulching rate of 15 t ha^{-1} from the present study agrees with the report of Liasu and Abdul Kabir (2007) who stated that tomato plants subjected to mulching exhibited the highest plant height when compared with the control. In the study, it was also stated that the tomato plants subjected to mulching exhibited the highest number of leaves per plant than the control plants.In the current study, mulching rate of 15 t ha^{-1} and 20 t ha^{-1} produced number of flowers of 25.4 and 24.4 that were significantly higher than the values of other mulching rates. This may be attributed to the fact that the mulching application rate was higher thereby retaining moisture in the soil which promoted flower formation. This is in agreement with Anon. (2009) who reported that the thicker the mulching material the more water is retained in the soil to serve as a good medium for plant growth, development and efficient crop production. The results obtained from this study revealed that rice husk mulch gave higher number of fruits than other mulching materials. This agrees with the report of Akhtar *et al*. (2001) who reported that natural mulches such as leaf, rice straw, dead leaves and compost have been used for centuries to increase fruit per plant, fruit length, fruit size, average fruit weight and yield. Findings in this study also agree with those of Kayum *et al*. (2008) who stated that mulching showed significant effect on growth, yield components and thus on the yield of tomato. The significant highest total fruit yield of 23.30 t ha^{-1} produced from the plants mulched with 15 t ha^{-1} in this study was at the upper value of 14.00 t ha^{-1} reported by Gudugi *et al*. (2012) and 21.47 t ha^{-1} reported by Elkner *et al*. (1991). The results of the current study is in conformity with Ertek *et al*. (2004) who revealed that mulching tomato plants at the rate of 10 to 20 t ha^{-1} will give better yield using mulching materials such as green leaves, dried leaves and coconut fronds.

Conclusions

Rice husk mulch gave better fruit yield than groundnut shell and dry guinea grass mulches and the plants mulched with 15 t ha^{-1} gave the highest fruit yield than other treatments. The significance of this result was that the mulching material and mulching rate responded positively to the parameters evaluated. Therefore, the mulching material and the mulching rate that gave the highest fruit yield could be recommended for the farmers to boost tomato production.

Authors' declaration

We declare that this study is an original research by our research team and we agree to publish it in the journal.

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