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Response of Tomato Variety (Roma F) Yield to Different Mulch Materials and Staking in Kabba, Kogi State, Nigeria

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Abstract

This experiment was carried out at student's experimental field, Kabba College of Agriculture, Horticultural Section to investigate the response of tomato variety (Roma F) yield to different mulch materials and staking. A split plot experiment was laid out in a randomized complete block design (RCBD) with three replications to randomize the staking levels and mulch materials in the main and sub-plots, respectively. The experiment comprised of two staking levels, i.e. stick staking (SST) and no- stick staking (NST) and six mulch materials, i.e. black polyethylene, white polyethylene, maize straw, palm fronts, grasses and no mulch. The parameters taken on soil physical and chemical properties are soil moisture content (%), soil temperature (^{O} C), soil pH, total nitrogen, available phosphorus and soil organic matter. Growth and yield parameters taken are as follows: average plant height, number of leaves, and number of fruits, stem girth, number of fruit per plant, fruit length, fruit diameter and yield per land area. Weeds were identified and their dry weights were measured. Data were collected from ten randomly selected plants in each plot. The data were statistically analyzed using GENSTAT. The analysis of variance (ANOVA) was performed to find out the significance of variation among the treatments while the significant difference between mean treatments were separated using Duncan's multiple range test (DMRT) at 5% level of probability. The result obtained from this study indicated that mulch materials and stick

staking affect significantly growth parameters of tomato, yield per plant and yield per land area. The result also, indicated that plot mulch with black polythene performance best in terms of growth and yield and also improved soil physical properties better than either white polythene or organic mulch in the study area. It is therefore recommended that black polyethylene should be used as mulch materials for tomato production. However, better and stable fruit yield of tomato could be obtained with the practice of mulching in combination with staking. It is recommended that mulching should be carried out together with staking for higher fruit yield and black polyethylene should be use as mulch material in the study area.

Keywords: Mulch Material, Properties, Tomato, Growth, Yield, Soil and organic

1. Introduction

Tomato *(Lycopersicon esculentum* Mill.*)* is the most important and popular vegetable crop grown commercially throughout the country. In spite of its wide cultivation in Nigeria, the average yield is still very low. In southern guinea savanna agro-ecology, inadequate soil moisture is the main hindrance for tomato production in the dry season. Use of mulches offer great hope because of its moisture conserving ability and also, its moderate soil temperature (Bhella, 1988, Kwon *et al.,* 1988; Chakarborthy and Sadhu 1994 and Hooda, *et al.,* 1999). Polyethylene mulches are widely used in vegetable production and have contributed significantly to reduction of losses due to weed competition [Uguajio and Ernest, 2004]. Film color may affect effective weed seed germination, growth, and development under the plastic (Brault *et al*. 2002). Black polyethylene plastic mulch is the standard plastic mulch used in vegetable production (Gordon *et al*., 2010). Researchers using black plastic instead of bare soil have recorded higher yields (Mirshekari *et al*. 2012); Ragablarigani amd Aghaalikhani, (2011), earlier harvests Ihara *et al*. (2010), Lamont (1993). Earlier, Sweeney *et al.* (1987) and Bhella (1988) have also reported the moisture-conserving property of polyethylene mulches. Ability of organic mulch to conserve soil moisture was appreciably lower than that of the polyethylene mulch (Chakraborty and Sadhu, 1994). The natural mulching (paddy-straw or sugarcane trash) also stimulated vegetative growth compared to un-mulched but to a lesser extent than polyethylene mulch. Different mulch materials influenced flowering and fruiting in tomato (Decoteau *et al.,* 1986). The natural mulching materials such as paddy-straw or sugarcane trash retarded the weed growth considerably compared to control (Kwon *et aI.,* 1988). Staking is a means of providing supports to ensure clean and unblemished fruits which kept fruits off from the ground, minimizing diseases and rotting of fruits thereby increasing marketable yield (Hanna and Adams, 1982). Marketable yield of tomato under wet condition was significantly increased by staking of tomato plants (Quinn, 1973). Therefore the objective of the study was to assess the influence of staking and mulching on growth and yield of tomato (Roma f) in Southern Guinea Savannah Agro- ecology of Nigeria.

2. Materials and Methods

2.1 Experimental Site

The experiment was carried out for two consecutive growing seasons (2012 and 2013) at the

Research Site of Horticultural Section, Kabba College of Agriculture, Kabba. The site is located at latitude of 07°35' N and longitude of 06°08' E and is 1000 m above sea level, in Southern Guinea Savanna Agro Ecological Zone of Nigeria, where the dry seasons are dry and hot while, wet seasons are cool. The rainfall spans between April to November with peak in June. The dry season extends from December to March. The mean annual rainfall is 1570mm per annum with an annual temperature range of 18℃ - 32℃. The mean relative humidity (RH) is 60% (Meterological data, 2011). The major soil order within the experimental site is Gleysol (Higgins, 1957; Babalola, 2010).

2.2 Determination of Soil Physical Properties

Soil moisture content was taken at 30 and 60 days after transplanting. Five undisturbed samples were collected at 0-15cm depth from each plot using core samplers and were used for the determination of gravitational moisture contents after oven dried at 100^0C for 24 hours. Soil temperature was determined at 15.00 hours (3pm) with a soil thermometer inserted to 5cm depth. Five readings were made per plot at each weekly determination.

2.3 Soil Sampling and Analysis

In order to determine some chemical properties of the soil on per plot basis, soil samples were collected from each plot at 30 and 60days after transplanting. Soil sample was analyzed in the laboratory for N, P, K, pH, organic carbon. Total N (%) was determined by the macro-Kjeldahl method (Bremner, 1982). Available P (ppm) was found using Bray I method according to Olsen (1982). Soil pH values were obtained by using a HI9813-5 portable pH/EC/TDS/℃ meter (HANNA instruments, Romania, 2002). Soil organic carbon was determined by Walkley-Black procedure (Nelson and Sommers, 1982).

2.4 Field Methods

A split plot experiment was laid out in a randomized complete block design (RCBD) with three replications to randomize the staking levels and mulch methods in the main and sub-plots, respectively. The experiment comprised of two staking levels, i.e. staking (ST) and no-staking (NST) and six mulch materials, i.e. black polythene, white polythene, maize straw, palm fronts, grasses and no mulch. The treatments were carried out on the same plots in 2012 and 2013 growing seasons. The size of each plot was 5.0 m long and 3.0 m wide. A buffer zone of 2.0 m spacing was provided between plots. In both growing seasons, one of the most commercial varieties of tomato cv. ROMA F was transplanted manually at a spacing of 60cm on a raised bed at both sides. Before transplanting, half the recommended levels of N (150 kg ha^{-1}) and recommended levels of P (100 kg ha^{-1}) and K (50 kg ha^{-1}) were used as Urea, TSP (triple super phosphate) and MOP (muriate of potassium), respectively. The remaining half recommended level of N was applied at flowering. pedimethalin (1.5L ha^{-1}) was also applied for weeds control before transplanting. Tomato was transplanted on 25th August when the soil was well watered in all treatments. Both black and white plastic-film measuring 5 m long × 3

cm wide and 0.25 mm thick was used to cover the experimental beds (raised beds, 25 cm high) of appropriate plots and was held down with forked sticks and pegs to prevent it from been blown away by the wind. Organic mulch was also spread on plots at rate of 10kg per $45m^2$. This was done one week before transplanting. Tomato plants were staked with stick measuring 65cm, 5cm base of which was inserted to the soil. During the growing season, the insecticides and fungicides were applied according to general local practices and recommendations. All other necessary operations except those under study were kept normal and uniform for all the treatments.

2.5 Weeds Characters

At 30 and 60 DAT (days after transplanting), weed samples were collected from two 50 cm × 50 cm quadrates randomly laid per plot. The weeds were identified up to species level and were clipped at soil surface, oven-dried at 80 ℃ for 48 hours and weighed to determine the dry matter (DM).

3. Results and Discussion

Effect of different mulch materials and staking on soil temperature and moisture content are presented in Table 1. Temperatures of plots mulched with black and white polythene were higher than plots with organic mulch and the control in this experiment. The plots mulched with maize straw, palm fronts and grasses are slightly higher than control (no much) (Table 1). Hooda et al. (1999) and Rajbir, (2005) reported higher temperatures with the use of different mulches. Mulch regulates soil temperature, creates suitable condition for germination, improve soil moisture (Patil and Basad, 1972). Improves soil physical conditions by enhancing biological activity of soil fauna and thus increases soil fertility (Lal, 1989). Plots with stick staking had higher soil temperature compared with no stick staking plots. The higher temperature observed could be due to ease of sun rays interception by the soil created by staking.

Table 1. Effect of Different Mulching Materials and staking on Soil Physical Properties (2013 and 2014).

Mulching methods	Soil moisture		Soil temperature	
	2013	2014	2013	2014
Black polyethylene	14.3a	16.2a	27.4a	32.6a
White polyethylene	13.6a	16.0a	29.7a	33.2a
Maize straw	11’9bc	11.6b	24.1ab	28.7b
Palm fronds	12.6ab	11.0b	23.0b	28.3b
grasses	10.8c	12.4b	23.3ab	29.9ab
No mulch	8.3d	10.1b	22.8b	28.4b
Staking methods				
Stick staking	12.6a	13.4a	26.3b	27.4b
No staking	09.3b	11.2b	29.6a	31.3a

In a column, figures bearing same letter(s) do not differ significantly at 5% level of probability by DMRT.

Higher soil moisture was observed in plot with polyethylene mulch when compared with plots with organic mulch and the control (Table 1), the result is in line with the finding of Sweeney *et al.* (1987), they reported the moisture conserving property of polyethylene mulches. Organic mulches (maize straw, palm fronts and grasses) recorded slightly higher soil moisture than the control. Chakraborty and sadhu (1994) and Singh (2005) also reported the ability of organic mulch to conserve soil moisture was appreciably lower than that of the polyethylene mulch. Plot with no mulch recorded least moisture content in this experiment. The result is in line with the finding of Bhella (1988). No stick staking plots had higher soil moisture content than stick staking plots. The observed higher moisture recorded in no stick staking plots could be due to the foliage of tomato that spread on the soil and acted like cover crop, thereby reduces the rate of soil evaporation, Agble (1975).

Table 2. Effect of Different Mulch Materials and staking on Soil chemical Properties (mean of 2013 and 2014).

Mulching materials	Soil pH	Nitrogen	Phosphorus	Organic matter
Black polyethylene	6.3a	1.63ab	2.62c	1.98b
White polyethylene	6.3a	1.54b	2.44c	2.12b
Maize straw	6,3a	1.69ab	4.11a	3.43a
Palm fronds	6.3a	1.90a	3.98a	2.91a
grasses	6.3a	1.87a	3.86a	2.74a
No mulch	6.4a	1.68ab	2.93bc	2.01b
Staking methods				
Stick staking	6.3a	1.87a	3.56a	2.67a
No staking	6.3a	1.74a	3.47a	2.56a

In a column, figures bearing same letter(s) do not differ significantly at 5% level of probability by DMRT.

Effect of different mulch materials and staking on soil pH, nitrogen, and phosphorus and soil organic matter are presented in Table 2. There was no significant difference in soil pH as result of treatments imposed. Effect of different mulch materials was significant on nitrogen, phosphorus and soil organic matter. Plots with organic mulch (maize straw, palm fronds and grasses) had similar effect on nitrogen, phosphorus and soil organic matter. These were significantly higher than plots with polyethylene mulch irrespective of their colour and no mulch plots. The highest values of nitrogen, phosphorus and soil organic matter occurred in plots treated with maize straw. Plots treated with white polyethylene recorded least values of these parameters. Effect of staking was not profound on soil pH, nitrogen, phosphorus and organic matter.

Effect of different mulch materials and staking on growth components of tomato are presented in Table 3**.** The result shows significant difference in growth parameters considered. Polyethylene mulch had significant beneficial effect on vegetative growth of tomato plants (Table 3). Gordon *et al*. (2010) reported that plastic mulch produced higher plant height, fresh weight, early and total yield when compared with other mulches. Though, organic mulches (maize straw, palm front and grasses) also stimulated vegetative growth compared to un-

mulched plots but to a lesser extent than the polyethylene mulches. Among the polyethylene mulch used, black polyethylene recorded better performance in term of plant height, number of branches, number of leaves and stem girth with mean values of 77.2cm, 6.65, 26.8 and 0.92cm respectively. Awodoyin *et al.* (2007) reported that mulched tomato plants had more branches than the un- mulched plants, which supported the present results. Hamid *et al.* (2012) opined that plants grown over plastic mulches considerably produced the most number of leaves relative to control treatment. The microclimate condition improved by the mulches might have provided a suitable condition for producing higher number of leaves in the plants. Franquere, (2011) reported that lettuce grown on red mulch had most number of leaves compared to the other coloured mulch treatment. Table (3) also presented the influenced of different mulching materials on days to 50% flowering in tomato. In general, different mulch materials influenced flowering in tomato. Flowering was earlier in all the mulch plots compared to the control. The earliest advanced flowering was observed in plots with black polyethylene (44 days). The result corroborated the findings Decoteal *et al.*, (1986) and Singh (2005). All the growth characters considered were significantly influenced by staking, tomato staked with stick had higher plant height, number of branches, number of leaves and stem girth than no staked plants. Flowering was earlier in all the staked plants compared to the no staked plants (Table 3). This could be due to better photosynthetic activity created by good arrangement of the leaves.

Table 3: Effect of Different Mulch Materials and staking on growth components of tomato (mean of 2013 and 2014).

Mulching materials	Plant height(cm)	Branches per plant	No of leaves	Stem girth (cm)	Dry weight (cm)	Day to 50% flowering
Black polyethylene	77.2a	6.65	26.8a	0.92a	265.3[a]	44[a]
White polyethylene	74.6a	4.98	23.4a	0.84a	256.4[a]	46[a]
Maize straw	62.8b	3.75	21.0ab	0.71ab	198.3[ab]	53[ab]
Palm fronds	63.4b	3.96	18.9b	0.62b	202.4[ab]	53[ab]
grasses	61.8b	3.74	19.6b	0.76ab	196.5[ab]	54[ab]
No mulch	44.6c	2.89	18.4b	0.56b	146.2[b]	57[b]
Staking methods						
Stick staking	78.6[a]	7.4[a]	26.5[a]	0.98[a]	284.0[a]	47[a]
No staking	56.4[b]	4.6[b]	19.3[b]	0.61[b]	166.4[b]	55[b]

In a column, figures bearing same letter(s) do not differ significantly at 5% level of probability by DMRT.

Number of weeds identified and dry weight of the weed are presented in (Table 4). Weeds did not grow at all, in plots mulched with black polyethylene, while other mulches allowed weeds growth even white polyethylene. Dry weight of weeds on white polyethylene, maize straw, palm fronts and grasses are 114.2, 98.4, 116.3 and 198.4 g/m^2 respectively. The result indicated that colour of polyethylene dictated the light intensity reaching the soil surface; white polyethylene did not restrict the light intensity and hence, failed to reduce the

photosynthetic activity of the weeds. Organic mulch retarded weed growth compared to control. The result confirmed with the earlier observation of Kwon *et al*. (1988) and Sadhu (1994) and Singh (2000). Effect of staking was not profound on weeds characters observed.

Table 4. Effect of Different Mulch Materials and staking on identified weed and its dry weight (mean of 2013 and 2014)

Mulching methods	Identified weeds		Dry weight of weeds identified	
	2013	2014	2013	2014
Black polyethylene	0	0	0	0
White polyethylene	5b	6b	104.2b	123.6b
Maize straw	5b	8b	98.4b	106.1b
Palm fronds	7b	11b	116.3b	187.9b
Grasses	5b	9b	198.4b	201.0b
No mulch	14a	21a	470.6a	632.8a
Staking methods				
Stick staking	8a	13a	116.0a	108.3a
No staking	6a	10a	134.2a	126.4a

In a column, figures bearing same letter(s) do not differ significantly at 5% level of probability by DMRT.

Table 5. Effect of Different Mulch Materials and staking on yield components of tomato (mean of 2013 and 2014)

Mulching methods	Fruits per plant	Fruit weight(g)	Fruit length(mm)	Fruit diameter(mm)	Yield per plant(kg)
Black polyethylene	29.6a	69.3a	58.3ab	42.1a	2.05a
White polyethylene	24.4ab	68.7a	61.8a	46.3a	1.81a
Maize straw	21.4b	64.8a	66.4a	38.6	1.39b
Palm fronds	22.8b	63.6a	60.3a	43.4a	1.45ab
grasses	21.3b	59.8ab	63.4a	37.1ab	1.27b
No mulch	16.1c	46.2b	49.3b	26.4c	0.74c
Staking methods					
Stick staking	26.7a	74.8a	62.4a	45.5a	2.16a
No staking	14.3b	41.3b	46.2b	34.6b	1.04b

In a column, figures bearing same letter(s) do not differ significantly at 5% level of probability by DMRT.

Table 5 presented the effect of different mulch materials on yield and yield components of tomato. Significant differences were observed in number of fruits per plant, fruit weight (g) fruit length (mm), fruit diameter (mm) and fruit yield per plant (kg) as influenced by different mulch materials. Black polyethylene mulch treatment gave the highest number of fruit per plant, individual fruit weight, fruit length (mm), fruit diameter (mm) and fruit yield per plant.

However, these were statistically higher than plots with organic mulches (maize straw, palm fronts and grasses) and the control (Table 5). The greatest yield was observed in plots mulch with black polyethylene and may be due to complete elimination of weeds, high soil moisture availability and moderates soil temperature during cropping seasons. The result is in agreement with observations of Ashworth and Harrison (1983) and Singh (2005) they reported higher yield under black polyethylene mulch and ascribed this to reduced nutrients losses due to weed control and improved hydrothermal regimes of soil. Similarly, white polythene produced significantly higher yield compared to the organic mulches and control. The increase is due to greater number of fruits per plant as well as their larger size. Lower yield in white polyethylene mulch compare to black polyethylene may be due to poor weed control. Among the organic mulches, palm fronts was found better for increase fruits number and fruit yield per plant (Table 5). However, fruit yield was significantly higher under organic mulches than the control. The observed results confirm the findings of Chakraborty and Sadhu (1994); Hooda *et al*., (1999) and Singh (2005). Staking significantly affect all yield characters observed, plot with stick staking recorded greater values of number of fruits per plant, fruit weight (g) fruit length(mm), fruit diameter(mm) and fruit yield per plant (kg). The result confirmed the work of Quinn (1973b) who reported that marketable yield of tomato under wet condition was significantly increased by staking of tomato plants.

4. Conclusions

Mulch moderates soil physical condition, creates suitable condition for germination, and stimulates vegetative growth, thereby increased tomato fruits which resulted in higher fruit yield of the tomato. However, better and stable fruit yield of tomato could be obtained with the practice of mulching in combination with staking.

Recommendations

It recommended that mulching should be carried out together with staking for higher fruit yield and black polyethylene should be use as mulch material in the study area. There is the need to carry out further studies especially cost benefit analysis and multi-locational trials in future studies.

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