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Influence of Mulch Material and Mulching Rate on Fruit Yield and Microorganisms of Tomato Variety (*Lycopersicon lycopersicum* Mill) in Ogbomosho and Mokwa, Nigeria

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Abstract

Field experiment was conducted at the Teaching and Research Farm, Ladoke Akintola University of Technology, Ogbomosho and Niger State College of Agriculture, Mokwa, in 2014 cropping season to examine the effects of mulch materials and mulching rates on fruit yield and microorganisms of tomato variety. The experiment had fifteen treatments via: three mulch 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 as split plot arranged in Randomized Complete Block Design. Data were collected on plant height (cm), number of flowers, number of fruits and total fruit yield (t/ha). The soil micro-organisms were assessed by taken soil samples from each plot for analysis at 1, 2 and 3 months after transplanting (MAT) to determine bacterial, fungal species and population.

Data was analysed using analysis of variance (ANOVA) SAS package and treatment means compared using least significant difference (LSD) at 5% probability level. Mulching is beneficial to performance of tomato and can increase soil micro-organisms. Mulch types had no effect on fruit yield of tomato. Plants mulched with 15t ha^{-1} produced the highest yield (23.30t ha^{-1}) while control plots had the least value (8.13t ha^{-1}). Soil micro-organisms (bacterial, fungal) had the best increase at mulching rate of 15t ha^{-1}. It could be concluded that mulching is beneficial to tomato production; mulch rate of 15t ha^{-1} performed better than other rates evaluated and could be recommended for the farmers within the study areas.

Keywords: Tomato; Mulch material; Mulching rate; Growth; Yield; Bacteria; Fungal

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 [1]. 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 [2]. 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 in the world [3]. In Nigeria tomato also finds its way into almost every kitchen. Tomato crop is very important in terms of diet and economy in Nigeria both during the rainy season (rain fed) 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 [4].

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 technical term means 'covering of soil' [5]. 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 therefore prevents direct evaporation of moisture from the soil and thus limits the water losses and soil erosion over the surface [6]. 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 [7].

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 combination [8]. 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 [9]. Influence of mulching on tomato production has been reported by many researchers [10].

This practice increases the infiltration of rain water and suppress the growth of weeds. Mulching is effective in reducing evaporation, conserving soil moisture and has been known to modify the hydrothermal regime of soil [11]. Mulching of tomato plants with Lithonia divers folia 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 MA [9], three tomato varieties namely, Ratan, BARI tomato-3 and BARI tomato-6 were experimentally evaluated to identify the potential mulch 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 rain fed 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 [11]. The bad effects of water deficit could be overcome by irrigation or adopting in-situ moisture conservation techniques, such as use of mulches [12].

Mulches are effective in reducing soil moisture loss from evaporation. 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 [13]. 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 [14].

The effects of *L. Leucocephala* and *G. Sepium* mulches (and their mixtures) on the growth and yield of okra was assessed. The mulches were applied at the rate of 0, 5 and 10t 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 [15]. 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 they attributed the increase to the slight improvement in the physical properties of soil [16]. Similarly, mulches applied at very low rates e.g. 2.5t ha^{-1} or 5t ha^{-1} can significantly increase growth and yields of highly valuable vegetable and fruits crops in the field [17].

In soil management relationships, mulching has been reported to influence organic matter content, activity of microorganisms, availability of soil nutrients, control of erosion and soil compaction. Soil microorganisms are active in the plant residue types of mulches especially at the soil surface where both the soil and mulch are moist. Mulching has many outstanding biological properties. They are rich in bacteria, actinomycetes and cellulose degrading bacteria. The author reported further that earthworm castings, obtained after sludge digestion, were rich in microorganisms, especially bacteria. The organic mulches type had much larger populations of bacteria ($5.7x10^7$), fungi ($22.7x10^4$) and actinomycetes ($17.7x10^6$) compared to those of plastic mulch [18].

Bacteria are the most abundant and diverse group of organisms in soil with estimate of 10^4-10^6 distinct genomes per gram of soil. Plant growth-promoting rhizobacteria are able to colonize the root surface, survive and multiply in microhabitats associated with their plant promotion activities. Certain strains of *pseudomonas, Bacillus, Azospirillum, Azobacter, Enterobacter* or *serratia*, have been frequently described as PGPR [19]. A variety of symbiotic (*Rhizobium* sp.) and non-symbiotic bacteria (*Azotobacter*, *Azospirillum, Bacillus* and *Kdebsiella* sp etc) are now being used worldwide with the aim of enhancing plant productivity [20,21].

Bacteria and fungi, among soil organisms, actively participate in organic matter decomposition liberating chemical nutrients and furthering plant growth. Microorganism numbers varies in and between different soil types and conditions, with bacteria being the most numerous. Bacteria counts in different soils ranged from $4x10^6$ to $2x10^9 g^{-1}$ dry soils. Organic matter decomposition serves two functions for the microorganisms, providing energy for growth and supplying carbon for the formation of new cells.

Soil organic matter (SOM) is composed of the “living” (Microorganisms), the “dead” (fresh residues), and the “very dead” (humus) fractions [22]. Organic mulches contain very rich

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and diverse microbial populations. Their applications to soils may have added to the indigenous soil microorganism populations, activity and diversity resulting in much larger, richer and diverse soil microbial populations. They concluded that when organic mulches are used at a lower substitution rates can increase growth, flowering and yield of vegetable and ornamental crops [17]. Mulch materials can change the biological properties of the soil with consequences on soil fertility. Soil microorganisms play an important role in regulating soil fertility and transforming organic matter, and their activity relies on the availability of decomposable materials [23].

Despite many investigations in the area of fruit yield, knowledge on how mulching material and mulching rates influences microbial species and population on tomato plants is inadequate. This research work determined plant growth, fruit yield and soil micro-organisms of tomato variety in Ogbomosho and Mokwa, Nigeria as influenced by mulch materials and mulching rates.

Materials and Methods

The experiments were conducted at two locations; Teaching and Research Farm, Ladoke Akintola University of Technology, Ogbomosho (8°10¹N; 4°10¹E) and Niger State College of Agriculture, Mokwa (9° 18¹N and 5°04¹E), 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 2.5m x 2.0m (5.00m^2). A plot contained 25 plants. The total experimental area was 405.00m^2 (0.041 ha^{-1}). The alley way between replicates was 1.0m and within replicates was 1.0m with inter and intra-row spacing of 50cm x 50cm. Three mulch materials used included: Rice husk, Groundnut shell and Dry guinea grass while the mulching rates involved: 0, 5, 10, 15 and 20t ha^{-1}. The test crop used was UC82B tomato variety. The treatment was laid out as split plot arranged in Randomized Complete Block Design, replicated three times.

The seeds were sourced from the Department of Crop Production and Soil Science, Ladoke Akintola University of Technology, Ogbomosho and from the Department of Agricultural Technology, Niger State College of Agriculture and 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 25ml 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 plant height (cm), number of flowers, number of fruits and total fruit yield (t/ha). The soil micro-organisms were assessed by taken soil samples from each plot for analysis at 1, 2 and 3 months after transplanting (MAT) to determine bacterial, fungal species and population.

The isolation of the associated microorganisms was carried out by standard microbiological techniques. Ten grams of the samples were thoroughly mixed with 90ml of sterile distilled water. The mixtures were serially diluted and 0.1ml of 10^3 and 10^5 dilutions was used for bacterial and fungal isolation respectively. Pure cultures obtained were characterized and identified using Barnett & Hunter [24]; Onions [25]. The microbial density of the samples was done by carrying out the serial dilution fold and each sample was plated from the dilution fold on plate count agar in duplicates. They were then incubated at 35 °C for 24 hours before the plates were counted. 20g of topsoil (0.15cm) depth was collected using sterile sampling bottle. Analysis of sample was performed in the laboratory. Standard inoculums were prepared from stock culture taking one lawful of the isolate. Plates were incubated at room temperature for 24hours. Isolates were identified on the basis of their characteristics to their genetic levels by the identification schemes as prescribed by Raul JC [26]. Data collected were subjected to Analysis of Variance (ANOVA) using SAS statistical package. Treatment means were separated using the least significant difference (LSD) at 5% probability level.

Results

Plant height (cm)

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

Plant Height (Cm)						
Mulch Material	Mulching Rate (t ha^{-1})					
	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

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MR Mean	21.3	21.0	23.9	25.4	21.8	
LSD (0.05) MM	ns					
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					
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					
MR	2.80					
MM x MR	ns					

RH: Rice Husk; GS: Groundnut Shell; DG: Dry Guinea Grass; MM: Mulch Material; MR: Mulching Rate; NS: Not Significant; (P≤0.05), LSD: Least Significant Difference.

Application of different mulch 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 was significantly (P≤0.05) influenced by mulching rate at 2 WAT. The plants mulched with 15t ha^{-1} materials was significantly taller than that of 20t ha^{-1}, 5t ha^{-1} and control plots but was not significantly different from the plant mulched with 10t ha^{-1} (23.9cm).

At 4 WAT, plant height of tomato was significantly (P≤0.05) influenced by mulching rate. The plants mulched with 15t ha^{-1} (39.9cm) was significantly taller than other mulching rates while the least mean value (30.5cm) was obtained from the control plot which was not significantly different from the plants mulched with 5t ha^{-1} (31.3cm).

The plant heights of tomato was significantly (P≤0.05) increased by mulching rate at 6 WAT. The highest mean value (39.9cm) was obtained from the plants mulched with 15t ha^{-1} which was not significantly different from the plants mulched with 20t ha^{-1} (38.5cm). Also, the plants mulched with 10t ha^{-1} (35.4cm) and 5t ha^{-1} (33.6cm) were not significantly different from each other while the least mean value (29.3cm) was observed from the un-mulched plants. The interaction effects between mulch material and mulching rate at 2, 4 and 6 WAT were not significant (P≥0.05).

Number of flowers per plant

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

Mulch Material	Number of Flowers					
	Mulching Rate (t ha^{-1})					
	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					
MR	4.47					
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.

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The mean number of flowers of tomato is presented in Table 2. The number of flowers increased as the mulching rate increased and declined thereafter. The mulch material had no significant (P≥0.05) influence on the number of flowers of tomato plants. The plants mulched with 15t ha^{-1} (24.5) and 20t ha^{-1} (24.4) significantly had similar number of flowers which were significantly different from the plants mulched with 10t ha^{-1} (19.4) and 5t ha^{-1} (16.9). The plants mulched with 10t ha^{-1} was significantly higher than the plots left un-mulched (control) but significantly had similar number of flowers with the plants mulched with 5t ha^{-1}, respectively. The interactive effects of mulch material and mulching rate was not significantly (P≥0.05) influenced.

Number of fruits per plant

Table 3: Effect of mulch material and mulching rate on number of fruits per plant of Tomato plants in 2014 cropping season.

Number Of Fruits						
Mulch Material	Mulching Rate (t ha^{-1})					
	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					
MR	3.54					
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 mean number of tomato fruits is presented in Table 3. The number of fruits increased as the mulching rate increased and declined thereafter. The mulch 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 15t ha^{-1} (21.2) significantly gave higher number of fruits than the control plot (12.2), 5t ha-1 (14.0), and 10t ha^{-1} (14.6) but was not significantly different from that of 20t ha^{-1} (18.8). The interaction effects of mulch material and mulching rate was not significantly (P≥0.05) influenced.

Total fruit yield (t/ha)

Table 4: Effect of mulch material and mulching rate on total fruit yield of tomato plants in 2014 cropping season.

	Total Fruit Yield (T Ha^{-1})					
Mulch Material	Mulching Rate (t ha^{-1})					
	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					
MR	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 as shown in Table 4. The total fruit yield of the tomato was no significantly (P≥0.05) increased by mulch material treatments. The total fruit yield of tomato was significantly (P≤0.05) influenced by mulching rate. Plants mulched with 15t ha^{-1} (23.30t ha^{-1}) were significantly higher than other values of mulching rates. Mulching rate of 20t ha^{-1} (17.57t ha^{-1}) was significantly higher than the plants mulched with 10t ha^{-1} (11.90t ha^{-1}), 5t ha^{-1} (10.80t ha^{-1}) and the least was obtained from un-mulched plot (8.13t ha^{-1}). But there was no significant difference between the values of these treatments. The interactive effect of mulch material and mulching rate was not significant (P≥0.05).

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Bacteria species

Table 5: Effect of mulch material and mulching rate on bacteria species of tomato plants in 2014 cropping season.

Bacteria Species (%)						
	Mulching Rate (t ha^{-1})					
Mulch Material	0	5	10	15	20	MM Mean
1 WAT						
RH	4.7	5.9	6.2	8.7	6.6	6.4
GS	4.0	5.7	6.7	7.4	7.3	6.2
DG	4.7	6.5	6.0	9.2	8.1	6.9
MR Mean	4.5	6.0	6.3	8.4	7.3	
LSD (0.05) MM	0.31					
MR	0.33					
MM x MR	0.10					
2 MAT						
RH	5.0	5.7	6.7	12.9	9.7	8.0
GS	5.7	5.7	7.4	9.7	7.4	7.2
DG	5.3	6.9	8.0	9.8	9.5	7.9
MR Mean	5.3	6.1	7.4	10.8	8.9	
LSD (0.05) MM	0.18					
MR	0.20					
MM x MR	0.03					
3 MAT						
RH	4.9	6.5	8.9	12.4	9.4	8.4
GS	5.5	7.4	8.6	12.3	10.2	8.8
DG	6.4	8.0	8.8	10.5	9.9	8.7
MR Mean	5.6	7.3	8.8	11.7	9.8	
LSD (0.05) MM	0.24					
MR	0.26					
MM x MR	0.06					

RH: Rice Husk; GS: Groundnut Shell, DG: Dry Guinea Grass, MM: Mulch Material, MR: Mulching Rate; MAT: Months after Transplanting; NS: Not Significant; ($P \leq 0.05$); LSD: Least Significant Difference.

Mulch material, mulching rate and their interaction significantly ($P \leq 0.05$) influenced the bacteria species at all the sampling periods (Table 5). At 1 MAT, dry guinea grass mulch (6.9%) was significantly higher than that of rice husk mulch (6.4%) which was significantly higher than the groundnut shell mulch (6.2%), respectively. Mulching rate had significant influence ($P \leq 0.05$) on the bacteria species at 1 MAT. The plants mulched with 15t ha^{-1} (8.4%) was significantly higher than that of 20t ha^{-1} (7.3%) which was significantly higher than the plants mulched with 5t ha^{-1} (6.0%) and 10t ha^{-1} (6.3%) while the least bacteria species was obtained from the control plot (4.5%). The interaction of mulch material and mulching rate had significant effect on bacteria species with the highest bacteria species of 9.2% recorded from dry guinea grass mulch at 15t ha^{-1}.

The bacteria species found in tomato plants was significantly ($P \leq 0.05$) influenced by mulch material at 2 MAT. The plots mulched with rice husk mulch (8.0%) was significantly higher than the plots applied with groundnut shell mulch (7.2%) but was not significantly different from the plots treated with dry guinea grass mulch (7.9%). At 2 MAT, plants mulched with 15t ha^{-1} (10.8%) were significantly higher than other mulching rates. Mulched plants with 20t ha^{-1} (8.9%) was significantly higher than that of 5t ha^{-1} and 10t ha^{-1} while the least mean value (5.3%) was obtained from the unmatched plot.

The interaction effects of mulch material and mulching rate was significant ($P \leq 0.05$) with the highest mean value (12.9%) obtained from rice husk mulch at 15t ha^{-1}. At 3 MAT, groundnut

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shell mulch (8.8%) significantly gave higher bacteria species than that of rice husk mulch (8.4%) which had no significant difference from the plots applied with dry guinea grass mulch (8.7%). The bacteria species was significantly (P≤0.05) increased by mulching rate at 3 MAT. The plants mulched with 15t ha^{-1} (11.7%) was significantly higher than that of 20t ha^{-1} (9.8%) which was significantly higher than the mean values observed at 5t ha^{-1} and 10t ha^{-1} and the least mean value (5.6%) was obtained from the control plot. The interactive effect of mulch material and mulching rate was significant (P≤0.05) with the highest bacteria species (12.4%) obtained from rice husk mulch at 15t ha^{-1}.

Fungi species

Table 6: Effect of mulch material and mulching rate on fungi species of tomato plants in 2014 cropping season.

Fungi Species (%)						
	Mulching Rate (t ha^{-1})					
Mulch Material	**0**	**5**	**10**	**15**	**20**	**MM Mean**
1WAT						
RH	3.9	4.3	6.2	6.2	6.7	5.5
GS	4.1	5.0	5.1	7.0	5.5	5.3
DG	3.9	4.7	6.3	8.7	7.6	6.2
MR Mean	4.0	4.7	5.9	7.3	6.6	
LSD (0.05) MM	0.53					
MR	0.55					
MM x MR	0.28					
2MAT						
RH	3.7	3.8	5.6	8.7	6.8	5.7
GS	4.1	6.2	6.1	10.0	6.5	6.6
DG	4.8	5.3	7.4	10.5	8.7	7.3
MR Mean	4.2	5.1	6.4	9.7	7.3	
LSD (0.05)MM	0.68					
MR	0.70					
MM x MR	ns					
3MAT						
RH	4.2	5.0	5.1	7.9	7.0	5.8
GS	4.8	5.1	6.9	8.3	9.7	7.0
DG	4.8	6.8	6.7	9.0	8.7	7.2
MR Mean	4.6	5.6	6.2	8.4	8.5	
LSD (0.05) MM	0.57					
MR	0.59					
MM x MR	0.32					

RH: Rice Husk; GS: Groundnut Shell; DG: Dry Guinea Grass; MM: Mulch Material; MR: Mulching Rate; MAT: Months after Transplanting; NS: Not Significant; (P≤0.05); LSD: Least Significant Difference.

The fungi species was significantly (P≤0.05) increased by application of mulch material at 1 MAT (Table 6). The plots treated with dry guinea grass mulch (6.2%) was significantly higher than other mulch materials while rice husk and groundnut shell mulches had no significant difference from each other. Mulching rate had significant (P≤0.05) influence on the fungi species found in tomato plants. At 1 MAT, plants mulched with 15t ha^{-1} (7.3%) was significantly higher than that of 20t ha^{-1} (6.6%) which was significantly higher than 5t ha^{-1} and 10t ha^{-1} while the least mean value (4.0%) was obtained from the control plot. The interaction of mulch material and mulching rate had significant effects on fungi species with the highest mean value (8.7%) observed from dry guinea grass mulch at 15t ha^{-1}.

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Mulch material had significant (P≤0.05) effect on fungi species. At 2 MAT, plots treated with dry guinea grass mulch (7.3%) significantly gave higher fungi species than other mulch material treatments. This was followed by groundnut shell mulch (6.6%) and the least fungi species was observed from rice husk mulch (5.7%). The fungi species significantly (P≤0.05) increased with the mulching rate application at 2 MAT. Plants mulched with 15t ha^{-1} (9.7%) was significantly higher than that of 20t ha^{-1} (7.3%) which was significantly higher than the mean values (5.1%, 6.4%) obtained at 5t ha^{-1} and 10t ha^{-1} while the least mean value (4.2%) was received from the un-mulched plot. The interaction effects of mulch material and mulching rate was not significant (P≥0.05).

The mulch material had significant (P≤0.05) effect on fungi species at 3 MAT. The plots treated with dry guinea grass mulch recorded the highest mean value (7.2%) which was significantly higher than that of rice husk mulch (5.8%) but was not significantly different from groundnut shell mulch (7.0%). The fungi species was significantly (P≤0.05) increased by mulching rate at 3 MAT. The tomato plants mulched with 20t ha^{-1} (8.5%) was significantly higher than that of 5t ha^{-1} (5.6%) and 10t ha^{-1} (6.2%). These were not significantly different from the plants mulched with 15t ha^{-1} (8.4%) while the least mean value (4.6%) was obtained from the control plot. The interaction of mulch material and mulching rate had significant effects on the fungi species with the highest mean value (9.7%) obtained from groundnut shell mulched with 20t ha^{-1}.

Bacteria count

Table 7: Effect of mulch material and mulching rate on bacteria count of tomato plants in 2014 cropping season.

Bacteria Count (Colony Unit 10^{-6})						
	Mulching Rate (t ha^{-1})					
Mulch Material	**0**	**5**	**10**	**15**	**20**	**MM Mean**
1WAT						
RH	2.6x10^6	3. 1x10^6	3.9x10^6	4.5x10^6	3.5x10^6	3.5x10^6
GS	2.1x10^6	2.0 x10^6	2.8 x10^6	3.0x10^6	3.8x10^6	2.7x10^6
DG	2.0x10^6	2.8x10^6	3.4 x10^6	4.7x10^6	5.5x10^6	3.7x10^6
MR Mean	2.2 x10^6	2.6 x10^6	3.4 x10^6	4.1x10^6	4.3x10^6	
LSD (0.05) MM	0.35					
MR	0.37					
MM x MR	0.12					
2 MAT						
RH	1.9 x10^6	2.2 x10^6	2.5 x10^6	3.5x10^6	3.6x10^6	2.7 x10^6
GS	2.3 x10^6	2.5 x10^6	3.1 x10^6	3.5x10^6	4.5x10^6	3.2 x10^6
DG	1.8 x10^6	2.9 x10^6	3.5 x10^6	5.2x10^6	4.2x10^6	3.5 x10^6
MR Mean	2.0 x10^6	2.5 x10^6	3.0 x10^6	4.1x10^6	4.1x10^6	
LSD (0.05) MM	0.23					
MR	0.24					
MM x MR	0.05					
3 MAT						
RH	1.2 x10^6	1.6 x10^6	5.7 x10^6	7.5x10^6	5.8x10^6	4.4 x10^6
GS	1.3 x10^6	1.4 x10^6	1.7 x10^6	1.9x10^6	6.7x10^6	2.6 x10^6
DG	1.2 x10^6	2.0 x10^6	3.4 x10^6	5.1x10^6	5.4x10^6	3.4 x10^6
MR Mean	1.2 x10^6	1.7 x10^6	3.6 x10^6	4.8x10^6	6.0x10^6	
LSD (0.05) MM	0.12					
MR	0.14					
MM x MR	0.01					

RH: Rice Husk; GS: Groundnut Shell; DG: Dry Guinea Grass; MM: Mulch Material; MR: Mulching Rate; MAT: Months After Transplanting; (P≤0.05); LSD: Least Significant Difference

Mulch material, mulching rate and their interaction had significant (P≤0.05) influence on the bacteria count at all the sampling periods (Table 7). At 1 MAT, the plants treated with dry guinea grass mulch (3.7×10^6) was significantly higher than that of groundnut shell mulch (2.7×10^6) but had no significant difference from rice husk mulch (3.5×10^6). Bacteria population

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count was significantly (P≤0.05) influenced by mulching rate at 1 MAT. The highest bacteria count (4.3×10^6) was obtained at 20t ha^{-1} which was significantly higher than the mean values (2.6×10^6, 3.4×10^6) obtained at 5t ha^{-1} and 10t ha^{-1}. But was not significantly different from the mean value (4.1×10^6) received at 15t ha^{-1} and the least mean value (2.2×10^6) was observed from un-mulched plots. The interaction effects of mulch material and mulching rate was significantly (P≤0.05) influenced with the highest mean value (5.5×106) obtained at 20t ha^{-1}.

The bacteria count was significantly (P≤0.05) increased by mulch material at 2 MAT. The tomato plants mulched with dry guinea grass (3.5×10^6) was significantly higher than that of groundnut shell mulch (3.2×10^6) which was significantly higher than the rice husk mulch (4.4 ×10^6). This had significant effect on bacteria count more than the plots treated with dry guinea grass mulch (3.4×10^6) while the least mean value (2.6×10^6) was obtained from groundnut shell mulch. Mulching rate had significant (P≤0.05) influence on bacteria population count at 2 MAT. The tomato plants mulched with 15t ha^{-1} and 20t ha 1 (4.1×10^6) were significantly higher than that of 10t ha^{-1} (3.0×10^6) which was significantly higher than 5t ha^{-1} (2.5×10^6) and the least mean value (2.0×10^6) was obtained from the un-mulched plot. The interaction of mulch material and mulching rate had significant effects on bacteria count with the highest mean value (5.2×10^6) obtained from dry guinea grass mulch at 15t ha^{-1}.

Bacteria population count was significantly (P≤0.05) affected by mulching rate at 3 MAT. The plants mulched with 20t ha-1 (6.0×10^6) significantly gave higher bacteria count than other mulching rates. The plants mulched with 15t ha^{-1} (4.8×10^6) was significantly higher than 10t ha^{-1} (3.6×10^6) which was significantly higher than that of 5t ha^{-1} (1.7×10^6) and the least mean value (1.2×10^6) was observed from the control plot. The interaction of mulch material and mulching rate had significant effects on bacteria count with the highest mean value (7.5×10^6) obtained from rice husk mulch at 15t ha^{-1}.

Fungi count

Table 8: Effect of mulch material and mulching rate on fungi count of tomato plants in 2014 cropping season.

Fungi Count (Colony Unit 10-6)						
Mulch Material						
	Mulching Rate (t ha-1)					
	0	**5**	**10**	**152**	**20**	**MM mean**
1WAT						
RH	2.8x10^6	2.9 x10^6	3.6 x10^6	3.4x10^6	4.6x10^6	3.5 x1^{06}
GS	2.3 x10^6	3.2 x10^6	2.8 x10^6	4.6x10^6	3.5x10^6	3.3 x10^6
DG	2.3 x10^6	2.7 x10^6	3.3 x10^6	3.2x10^6	3.8x10^6	3.1 x10^6
MR Mean	2.5 x10^6	2.9 x10^6	3.2 x10^6	3.7x10^6	4.0x10^6	
LSD (0.05) MM	ns					
MR	0.29					
MM x MR	ns					
2MAT						
RH	1.3 x10^6	1.5 x10^6	1.6 x10^6	2.2x10^6	2.5x10^6	1.8 x10^6
GS	1.2 x106	1.5 x10^6	1.9 x10^6	4.7x10^6	2.9x10^6	2.4 x10^6
DG	1.7 x106	1.8 x10^6	2.4 x10^6	3.2x10^6	3.6x10^6	2.5 x10^6
MR Mean	1.4 x10^6	1.6 x10^6	2.0 x10^6	3.4x10^6	3.0x10^6	
LSD (0.05) MM	ns					
MR	0.71					
MM x MR	ns					
3MAT						
RH	2.6 x10^6	2.5 x10^6	3.8 x10^6	5.9x10^6	4.4x10^6	3.8 x10^6
GS	1.9 x10^6	2.9 x10^6	3.1 x10^6	4.6x10^6	4.0x10^6	3.3 x10^6
DG	2.6 x10^6	3.0 x10^6	3.8 x10^6	3.3x10^6	3.2x10^6	3.2 x10^6
MR Mean	2.4 x10^6	2.8 x10^6	3.6 x10^6	4.6x10^6	3.9x10^6	
LSD (0.05) MM	0.20					
MR	0.21					
MM x MR	ns					

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RH: Rice Husk; GS: Groundnut Shell; DG: Dry Guinea Grass; MM: Mulch Material; MR: Mulching Rate; MAT: Months after Transplanting; NS: Not Significant; (P≤0.05); LSD: Least Significant Difference.

The fungi population count increased as the mulching rate increased and declined there after (Table 8). Application of mulch material did not significantly (P≤0.05) increase fungi count at 1 and 2 MAT. Mulching rate application significantly (P≤0.05) influenced fungi population count at 1 MAT. Tomato plants mulched with 20t ha^{-1} (4.0×10^6) was significantly higher than that of 15t ha^{-1} (3.7×10^6) which was significantly higher than the mean values (2.9×10^6, 3.2×10^6) obtained at 5t ha^{-1} and 10t ha^{-1} while the least mean value (2.5×10^6) was received from the control plot. The fungi count was significantly (P≤0.05) influenced by mulching rate at 2 MAT. Plants mulched with 15t ha^{-1} ($3.4x10^6$) were significantly different from the values obtained from other treatments.

The plants mulched with 20t ha^{-1} ($3.0x10^6$) was significantly higher than the plants mulched with 5t ha^{-1} and 10t ha^{-1} while the least mean value ($1.4x10^6$) was received from the control plot. Fungi count was significantly (P≤0.05) influenced by mulch material at 3 MAT. Rice husk mulch (3.8×10^6) was significantly higher than the groundnut shell ($3.3x10^6$) and least mean value ($3.2x10^6$) was obtained from dry guinea grass mulch. The plants mulched with 15t ha^{-1} (4.6×10^6) was significantly higher than 10t ha-1 (3.6×10^6) and 5t ha-1 (2.8×10^6) and the least mean value (2.4×10^6) was obtained from the control plot. The interaction effects of much material and mulching rate at all the sampling periods were not significantly (P≤0.05) influenced.

Discussion

Reports by Liasu & Abdul Kabir [8] 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. [9] revealed that mulching tomato plants with the use of water hyacinth, straw, am-ada leaf and banana leaf showed significant effect on growth and yield components and thus increase the yield. The significant plant height of 39.9cm obtained with the mulching rate of 15t ha^{-1} from the present study agrees with the report of Liasu & Abdul Kabir [8] who stated that tomato plants subjected to mulching exhibited the highest plant height when compared with control. The above authors in their findings also stated that the tomato plants subjected to mulching exhibited the highest number of leaves per plant than the control plot.

In the current study, mulching rate of 15t ha^{-1} and 20t 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 [5] who reported that the thicker the mulch 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 mulch materials. This agrees with the report of Akhtar et al. [6] 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 agrees with those of Kayum et al. [9] 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 23.30t ha-1 produced from the plants mulched with 15t ha^{-1} in this study was at the upper value of 14.00t ha^{-1} reported by Gudugi et al. [14] and 21.47t ha^{-1} reported by Elkner et al. [27]. The results of the current study is in conformity with Ertek et al. [16] who revealed that mulching tomato plants at the rate of 10 to 20t ha-1 will give better yield using mulch materials such as green leaves, dried leaves and coconut fronds.

Results from this study showed that the groundnut shell mulch recorded the highest bacteria species (8.8%) and mulching rate of 15t ha^{-1} (11.7%) at 3 MAT. This is in conformity with the reports of Agele et al. [23]; Burd et al. [20]; Cocking [21] who stated that mulch materials can change the biological properties of the soil with the aim of enhancing plant productivity. The results from the current study indicated that dry guinea grass gave the optimum fungi species of 7.3% at 3 MAT. This is in conformity with the findings of James [28] who revealed that the effect of mulching on fungi species in tomato field is on the increase rate. Bacteria and fungi, among soil organisms, actively participate in organic matter decomposition liberating chemical nutrients and furthering plant growth.

From this study, the highest bacteria and fungi counts of 4.4 x 106 and 3.8 x 10^6 were obtained from rice husk mulch at 3 MAT. This is in agreement with Stowell [18] who reported that mulch material could enhance microorganism's activities in the soil thereby giving a better growth medium but in disagreement with the findings of Norman & Edwards [17] who reported that the organic mulches type had much larger populations of bacteria and fungi counts of 22.7 x 10^4, respectively.

Conclusion

Based on the research findings, it can be concluded that Rice husk mulch gave better fruit yield and soil micro-organism than groundnut shell and dry guinea grass mulches. More so, the plants mulched with 15t ha^{-1} gave the highest fruit yield and soil micro-organism than other treatments. It is therefore recommended for the tomato farmers within the study areas.

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