International Research Journal of Agricultural Science and Soil Science Vol. 1(3) pp. 090-095 May 2011
Available online http://www.interesjournals.org/IRJAS

Full Length Research Paper

Yield and fruit quality of tomato (*Lycopersicon esculentum* Mill) as influenced by mulching, nitrogen and irrigation interval

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Accepted 11 May, 2011

Field experiments were conducted during 2004/05, 2005/06 and 2006/07 dry seasons at Shika in the Northern Guinea Savanna zone of Nigeria. The treatments consisted of mulching (No mulch, rice-straw mulch and black polythene mulch), nitrogen rates (0, 45, 90 and 135 kg/ ha^{-1}) and irrigation interval (5, 10 and 15days). These treatments were arranged in a split-plot design with nitrogen and irrigation in the main plot and mulching in the sub-plot. Mulching significantly increased fruit yield, fruit diameter and firmness over the no-mulched treatment. Fruits from plants mulched with polythene were firmest with less unmarketable fruits yield. The application of 90kgN ha^{-1} produced higher fruit yield than the control by 115%, 87% and 82% in 2004/05, 2005/06 and 2006/07 respectively. The highest fertilizer rate of 135 kg N/ha^{-1} produced the highest yield of unmarketable fruits except in 2005/06 when all the fertilizer rates produced similar unmarketable fruit yields. Increasing the irrigation interval from 5 to 10 days significantly increased fruit diameter and reduced the number of unmarketable fruits while the 15-days interval enhanced fruit firmness.

Keywords: Tomato, Yield, Mulching, Fruit quality, irrigation interval

INTRODUCTION

Tomato is the most popular vegetable crop in Nigeria dominating the largest area under production among vegetable crops (Ramalan, 1994). Though grown through out the year, the best period for production in the Nigerian Savanna is the dry season when the weather is cooler and the incidence of pests and diseases is minimal (Anonymous, 2000). Increase in demand of the commodity resulted in expanding production in both up land and low land areas. The cultural practices involved are also not only varied, but are generally characterized by indiscriminate use of fertilizer and injudicious use of water; both scarce resources. The dry season growing however, has to be fully supported by irrigation, and a 7-day irrigation interval is a common practice in the semi-arid Savannas of Nigeria (Ramalan, 1994). Since water sources for irrigation are not only becoming fewer but, those available are drying up, the need to find the optimum number of days between irrigations is paramount. Therefore, a practice like mulching will be of advantage in water conservation, soil temperature and weed control. Though mulching generally improves tomato growth and yield, its effectiveness depend on the soil type and mulching material used, in addition to fertilizer to achieve good yields. [Ramalam *et al.*(1998); Amans *et al* (2008); Hunter *et al* (1991); Teasdale and Abdul-Baki (1995)].

The soils in the Nigerian savanna are generally low in fertility and enhanced crop yield is only possible through external use of organic and inorganic fertilizer (Quinn,1980). Nitrogen is the most important nutrient in tomato production even though very high rates affect the storability of its fruits. Application of nitrogen as fertilizer to soils in the Savanna is therefore essential in order to achieve high crop yields of good quality (Upendra *et al.,* 2003).

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Table 1: Physico-chemical characteristics of soil taken from experiment site

Particle size distribution (g/kg)	2004/05	2005/06	2006/07
Sand	34	34	36
Silt	52	50	53
Clay	14	14	14
Textural class	**Silt loam**	**Silt loam**	**Silt loam**
Chemical properties			
pH in H2O	6.08	5.55	5.58
pH in CaCl2 1:25	5.13	5.50	5.25
Organic carbon (g/kg)	0.74	0.68	0.66
Available P (g/kg)	0.04	0.04	0.04
%Total Nitrogen	0.22	0.14	0.18
Exchangeable cations (g/kg)			
K	0.33	0.29	0.30
Mg	0.84	0.63	0.67
Ca	2.3	1.8	1.7
Na	0.50	0.50	0.50
CEC	6.70	6.90	6.50

Source: Analyzed soil samples at Ahmadu Bello University Agronomy department's laboratory

The study was therefore carried out to determine the optimum number of days between irrigations, suitable mulching method and nitrogen fertilizer rate for optimum yield and fruit quality of tomato in Nigerian Savanna.

MATERIALS AND METHODS

The trial was conducted during 2004/05, 2005/06 and 2006/07 dry seasons at Shika (11^0 12', 7^o33'E and 610m above sea level) in the Northern Guinea Savanna of Nigeria. The soil was silt-loam with samples taken randomly at 30cm depth before each trial and analyzed for physico-chemical properties (Table 1).

Treatments consisted of three mulch types (No mulch, rice-straw mulch and black polythene mulch), four nitrogen fertilizer rates (0, 45, 90 and 135 kg/ha^{-1}) and three irrigation intervals (5, 10 and 15days). They were arranged in a split plot design with factorial combinations of nitrogen and irrigation in the main plot and mulching in the sub-plot, and replicated three times.

The land was harrowed and prepared into sunken beds of 3.75m x 3 m (11.25m^2) separated by 0.75m irrigation channels. All beds received an equivalent of 20 and 37kg ha^{-1} of P and K during land preparation. The black polythene mulch was laid over the entire bed and water was applied over it which made it stick to the soil. Transplanting holes 60cm apart were then punched and six weeks old seedlings of UC-82B variety of tomato were then transplanted into the holes. In no mulch and rice-straw mulch, the seedlings were directly transplanted, after which a 5cm- thick rice straw mulch was laid to cover all the open spaces around transplanted seedlings. Nitrogen fertilizer treatments in the form of Urea (46% N) were applied at 1, 3 and 6 Weeks After Transplanting (WAT).

All plots were uniformly watered by flooding of basins for the first two WAT, after which the irrigation interval treatment was imposed. Weeds were controlled using hoe for the un-mulched plots, and hand pulled in the straw-mulched plots and in the planting holes of the polythene.

Fruits WERE harvested at weekly intervals when ripe and data was collected on total fruit yield, unmarketable fruit yield, which was what could not be sold due to cracks and infection on fruits, fruit diameter and firmness of fruits at ten days after harvest. The data collected was subjected to SAS statistical analysis (SAS/STAT, 2008), and the means were later compared using Duncan's Multiple Range Test (Duncan, 1955).

RESULTS

Mulching significantly increased the total fruit yield of tomato over bare plants (Table 2).The difference in yield between mulch types was however not significant. The application of 45kg ha^{-1} rate of N-fertilizer increased fruit yield by 89%, 59% and 49%, over control in 2004/05, 2005/06 and 2006/07 respectively. Doubling the nitrogen rate to 90 kg/ha^{-1} significantly increased yield by 115%, 87% and 82% over the control in those respective

Table 2: Effect of mulching, nitrogen rates and irrigation on fruit yield (t/ha^{-1}) of tomato in 2004/05, 2005/06 and 2006/07 dry seasons at Shika

Treatments	Fruit yield (t ha^{-1}) 2004/05	2005/06	2006/07	
Mulching(M)				
No mulch	11.9b	10.7b	11.1b	
Rice straw mulch	13.4a	12.2a	13.0a	
Black polythene mulch	13.3a	12.3a	13.0a	
SE $^{+}$.	0.21	0.22	0.29	
Nitrogen(N) kg ha^{-1}				
0	7.3d	7.5d	8.5c	
45	13.8c	11.9c	12.7b	
90	15.7a	14.0a	15.5a	
135	14.2b	13.4b	13.2ab	
SE $^{+}$.	0.32	0.39	0.25	
Irrigation interval(days)				
5	12.8b	11.1b	12.7	
10	13.4a	13.0a	12.6	
15	12.1c	11.1b	11.8	
SE $^{+}$.	0.32	0.34	2.04	
Interaction				
M x N	NS	NS	NS	
M x I	NS	NS	NS	
N x I	NS	NS	NS	
M x N x I	NS	NS	NS	

Means followed by the same letter(s) within a column and treatment set are not significantly different when using DMRT (P=0.05), NS= Not Significant

seasons, but its increase over the 45kg/ha rate was only marginal. Ten days irrigation interval produced significantly higher fruit yield than the 5 or 15 -day intervals in the first two seasons. The yield of unmarketable fruits was lowest in plants mulched with polythene (Table 3). It was only during the 2004/05 season that the rice - straw compared favourably with the polythene mulch otherwise, its unmarketable yields were similar to those of control.

The highest N-rate (135kg ha^{-1}) significantly increased the yield of unmarketable fruits. Though there was no significant difference in the unmarketable fruit yields obtained by 45 and 90kgN/ha^{-1} rates and the control in 2004/05. The yield of unmarketable fruits increased with each increase in fertilizer rates in 2006/07. Similarly, the 5 day irrigation interval significantly increased the yield of unmarketable fruits over the 10 or 15-day intervals.

Mulched plants produced significantly bigger fruits than un-mulched ones (Table 4). Between the mulch types, fruits from rice-straw mulch plants were bigger than those under polythene mulch in 2005/06 and 2006/07 seasons. Application of 45 kg N/ ha^{-1} increased the diameter of fruits; doubling the rates to 90 kg N/ha^{-1} enhanced fruit size only in 2004/05 and 2006/07. The higher fertilizer rates significantly reduced fruit diameter in 2006/07. The delay in irrigation intervals from 5 to 10 days significantly increased fruit diameter in each of the first two seasons with further delay to 15 days decreasing it in 2006/07.

Fruits from mulched tomato were significantly firmer than those from control in the later two seasons (Table 5). There was no difference in firmness of fruits between the two mulches in the first season. Tomato fruits were firmest in plots without fertilizer and the fruits became softer with corresponding increase in fertilizer rates. The 5-day irrigation interval produced significantly softer fruits at this stage than either the 10 or 15 day intervals.

DISCUSSION

Mulched tomato performed better than control in fruit yield and quality. The overall better yield and quality shown by tomato grown under mulch against the one grown on bare land showed the obvious benefits of mulching in better utilization of applied water and nutrients, [Teasdale and Abdul-Baki,1995; Hunter *et*

Table 3: Effect of mulching, nitrogen rates and irrigation on yield of unmarketable fruit (t ha^{-1}) of tomato in 2004/05, 2005/06 and 2006/07 dry seasons at Shika

Treatments	Unmarketable fruit (t ha^{-1}) 2004/05	2005/06	2006/07	
Mulching(M)				
No mulch	2.4a	0.5a	1.4a	
Rice straw mulch	1.3b	0.5a	1.5a	
Black polythene mulch	1.3b	0.2b	1.1b	
SE $^{+}_{-}$	0.13	0.24	0.15	
Nitrogen(N) kg ha^{-1}				
0	1.6b	0.3	0.9d	
45	1.5b	0.4	1.2c	
90	1.6b	0.4	1.5b	
135	1.8a	0.4	1.7a	
SE $^{+}_{-}$	0.14	0.13	0.09	
Irrigation interval(days)				
5	1.7a	0.4	1.5a	
10	1.5b	0.4	1.3b	
15	1.5b	0.4	1.1c	
SE $^{+}_{-}$	0.14	0.13	0.08	
Interaction				
M x N	NS	NS	NS	
M x I	NS	NS	NS	
N x I	NS	NS	NS	
M x N x I	NS	NS	NS	
SE $^{+}_{-}$				

Means followed by the same letter(s) within a column and treatment set are not significantly different when using DMRT (P=0.05), NS= Not Significant

Table 4. Effect of mulching, nitrogen rates and irrigation on fruit diameter (cm) of tomato in 2004/05, 2005/06 and 2006/07 dry seasons at Shika

Treatments	Fruit diameter(cm) 2004/05	2005/06	2006/07	
Mulching				
No mulch	4.3b	3.1c	3.0c	
Rice straw mulch	4.6a	3.9a	3.9a	
Black polythene mulch	4.5a	3.6b	3.4b	
SE +-	0.07	0.10	0.08	
Nitrogen(N) kg ha-1				
0	3.6c	2.7c	2.9c	
45	4.3b	3.6a	3.8b	
90	4.8a	3.7a	4.3a	
135	4.8a	3.7a	3.8b	
SE +-	0.10	0.14	0.14	
Irrigation interval(days)				
5	4.2b	3.6b	3.5b	
10	4.5a	4.8a	4.2a	
15	4.5a	4.7a	3.5b	
SE +-	0.09	0.12	0.12	
Interaction				
M x N	NS	NS	NS	
M x I	NS	NS	NS	
N x I	NS	NS	NS	
M x N x I	NS	NS	NS	

Means followed by the same letter(s) within a column and treatment set are not significantly different when using DMRT (P=0.05), NS= Not significant

Table 5: Effect of mulching, nitrogen rates and irrigation on fruit firmness of tomato at 10-days after harvest in 2004/05, 2005/06 and 2006/07 dry seasons at Shika

Treatments	Fruit firmness			
	2004/05	2005/06	2006/07	
Mulching(M)				
No mulch	13.8	19.4c	14.8b	
Rice straw mulch	15.1	25.7b	15.6ab	
Black polythene mulch	15.2	28.0a	16.2a	
SE $^{+}_{-}$	1.78	0.19	1.03	
Nitrogen(N) kg ha^{-1}				
0	19.0a	29.74a	17.78a	
45	14.2b	26.48b	16.00b	
90	13.7b	24.33c	14.96c	
135	11.9b	16.88d	13.33d	
SE $^{+}_{-}$	1.94	1.06	1.67	
Irrigation interval(days)				
5	13.69b	18.77c	14.06b	
10	14.81ab	25.24b	16.24a	
15	15.64a	29.17a	16.36a	
SE $^{+}_{-}$	1.68	0.92	0.98	
Interaction				
M x N	NS	NS	NS	
M x I	NS	NS	NS	
N x I	NS	NS	NS	
M x N x I	NS	NS	NS	

Means followed by the same letter(s) within a column and treatment set are not significantly different when using DMRT (P=0.05), NS= Not significant

al.,1991; and Amans *et al.,*2008]. Performance of the two mulching materials was similar, though the straw mulch had a slight edge over polythene in fruit yield. This may be because of the fact that the straw mulch had the added advantage of better air circulation below the mulch (Teasdale and Abdul-baki,1995).

Nitrogen application increased fruit yield. It confirms the critical role nitrogen plays in the nutrition of tomato. The high yield of unmarketable fruits and lower fruit firmness recorded by high N-rates resulted in fruit deterioration and reduced shelf life of fruits (Upendra *et al*., 2003).

The 10 day irrigation interval produced the best results in both tomato yield and quality. Though a 7-day interval is the common practice in the region(Ramalan,1994), this experiment showed that in soils with similar characteristics as the one used during the experiment, irrigation can be delayed by a further three days, thus saving water.

Conclusion

The study showed that 90kg N ha^{-1} and a 10-day irrigation interval are adequate for tomato growing in silt-loam soils of Nigerian Savanna. The availability, relative cheapness and ease of use of the rice-straw much, also makes it best suited for mulching in these parts of sub-Saharan Africa.

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