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Agronomic characteristics of tomato as influenced by irrigation and mulching

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ABSTRACT

Studies on the agronomic characteristics of tomato as influenced by irrigation and mulching were conducted during the drying seasons of 2009/2010 and 2010/2011 at the Teaching and Research Farm of Federal University of Technology, Minna, Nigeria. The experiment was made up of four tomato varieties viz; Roma VF, Ibadan local, Ife 1 and UC82B; four irrigation intervals and two levels of mulching viz; mulching and no mulching. It was a 4 x4 x 2 factorial experiment fitted into randomized complete block design. Rice straw was used as mulch material at the rate of 5 t ha^{-1} while irrigation water was applied at 2, 4, 6 and 8 days intervals. Equal quantity of water was applied at each irrigation event. The effect of irrigation interval on plant height was significant in 2011 while varietal effect was significant in both years. Variety and mulching did not significantly affect number of branches in both 2010 and 2011 dry seasons. Mulching and irrigation interval significantly (P≤ 0.05) affected number of trusses, flowers and fruits. The highest number of trusses, flowers and the highest fruit yield was obtained at 4 days irrigation interval.

Key words: irrigation interval, mulching, tomato varieties

INTRODUCTION

The best period for the production of tomato in the Nigerian savanna is the dry season when the weather is cooler and the incidence of pests and diseases is minimal [1]. This means tomato must be produced under irrigation. Water stress is considered one of the most important factor limiting plant growth and yield [2] and as the water resources of many river basins dwindle and the competition for water increases, feasible irrigation scheduling strategies other than those currently in practices; need to be worked out to cope with these rising challenges. In addition to feasible irrigation scheduling, there is also need to employ the use of mulching materials which conserve soil moisture, prevent erosion and increase growth and yield of crops [3, 4, 5].

Surface-applied mulches provide several benefits to crop production through improving soil moisture content, regulating soil temperature, improving nutrient status in soil, preventing soil and water loss, and weed control [6]. Mulches may be composed of plant materials or they may be synthetic mulches consisting of plastic sheets [7]. Report showed great increase in irrigation efficiency by furrow mulching while sugarbeet tonnage and recoverable sugar increased with straw mulch [8]. They also observed that mechanical furrow mulching decreased runoff, increased infiltration, increased irrigation efficiency, and decreased sediment load. Mulching was reported to have effect on growth characteristics such as height and girth. Significant increase in plant height and plant girth was observed when mechanical loosening of soil was used as mulching treatment [4]. The data indicated that all the mulching treatments had significant impact, varying in levels compared to no mulching. In a similar observation, it

was reported that mulching practice increased spike population while grains per spike and grain weight remained unaffected [9]. However, higher grain and straw yields were obtained with mulching.

Field water management practices are the most influential factors affecting crop yield particularly in irrigated agriculture in arid and semi arid regions [10]. Irrigation scheduling has been described as the primary tool to improve water use efficiency, increase crop yield and enhance the quality of soil and ground water [11]. Research had shown that irrigation interval has significant effect on the growth and yield of crops. A study on the response of lowland rice to supplementary irrigation, nitrogen fertilizer application and method of planting showed that irrigating at 14 days interval resulted in taller plants and higher grain yields. They concluded that transplanting rice at 90kg N ha^{-1} using 14 days dry season supplementary irrigation was adequate for maximum yield [12]. It was also recorded that maximum cowpea grain yield at 14 days interval [13]. Irrigating groundnut at 14 and 21 days interval significantly enhanced the canopy spread than at 7 days interval; the highest pod yield was produced when the crop was irrigated at an interval of 21 days [14]. It was also observed that application of irrigation water to pop corn at intervals of 10 to 15 days enhanced most of the growth and yield parameters than 5 or 20 days intervals [15]. Production of sweet corn (*Zea mays sacharata*) at 20 cm intra-row spacing plus 120:60:60 kg NPK ha^{-1} and 5 days irrigation interval was reported by [16] to have resulted in good growth performance of sweet corn while 7 days irrigation interval had significantly more maize plants standing than the 14 days which may be due to the effect of water stress on the plants which lead to their withering [17].

As the water resources of many river basins dwindle and the competition for water in the river basins increases, feasible irrigation scheduling strategies other than those currently in practice, need to be adopted to cope with these rising challenge. The objective of this study was to determine the effect of mulching and irrigation interval on the growth and yield of tomato grown during the dry season in a Southern Guinea savanna region of Nigeria.

MATERIALS AND METHODS

The experiments were conducted in 2009/2010 and 2010/2011 dry seasons at the Teaching and Research Farm of Federal University of Technology, Minna ($9^0$37'N and $6^0$33'E) in the southern Guinea savanna ecological zone of Nigeria. The soil was an Alfisol with a sandy clay loam surface. It had a pH (water) of 5.3 and contained 24.4 g kg^{-1} organic carbon, 0.40 g kg-1 total N, 12 mg kg^{-1} P and 0.35 cmol kg^{-1} K. The maximum ambient temperature during the study period ranged between 28 ^{0}C in December 2009 to 35 ^{0}C in April 2010. In 2011 it was 29^0C in December and 33^0C in April. The relative humidity on the other hand varied between 20% in December 2009 to 58% in April 2010 and between 19% in December and 57% in April 2011. Four varieties of tomato (Roma VF, Ife1, Ibadan local and UC82B), four irrigation intervals (2, 4, 6 and 8 days interval), mulching and no mulching were evaluated. Rice straw was used as mulching material at the rate of 5 t ha^{-1}. The experimental design was a 4 x 4 x 2 factorial fitted to randomized complete block design (RCBD) with three replications.

The land was tractor ploughed and harrowed and then divided into plots each measuring 3 m x 3 m. Each plot was separated from the adjacent by 1 m interval while the replicates were separated 2 m interval. Four weeks old tomato seedlings were transplanted at a spacing of 50 cm within the row and 75 cm between the rows, to give a plant population of 26666 plants ha^{-1}. The tomato seedlings were irrigated uniformly as at when due for two weeks to ensure good stand establishment after which the different irrigation intervals were applied. At each irrigation event, an amount of water corresponding to half of field capacity water content for 20 cm soil depth was applied. The field capacity water content of 20 cm incremental depth intervals from soil surface to 60 cm depth was computed from their saturation capacity using the fomula:

FC = 0.79 (SP) – 6.22 [18].

The saturation capacity of triplicate soil core samples from each soil depth interval was determined by saturating the soil core overnight and oven drying them.

The quantity of water applied was subsequently increased during the remaining weeks of the cropping period to increase wetting to a soil depth of 50 cm. Watering was done using a 15 liter galvanized watering can. NPK 15-15-15 was applied at transplanting to supply 50 kg ha^{-1} each of N, P_2O_5 and K_2O. Additional 50 kg ha^{-1} of N was applied six weeks after transplanting as urea (46 % N).

Data were collected on plant height, number of branches, number of trusses, number of flowers, number of fruits and fruit and seed yield. The data collected were subjected to analysis of variance using MSTAT C software package and means separated using least significant difference (LSD).

RESULTS AND DISCUSSION

Effects of irrigation interval and mulching on days to 50% flowering, plant height and number of branches

The effects of irrigation interval were significant on plant height in 2011 and on days to 50 % flowering in both 2010 and 2011 (Table 1). These results agree with the findings of [19] but contrary to that of [4]. The different results may be due to environmental differences. For instance [4] conducted the research in the semi-arid region of Pakistan and others conducted theirs in the rain forest. The varietal effect on plant height was, however significant in both years (P≤ 0.05) (Table 1). Ibadan local and Ife 1 were significantly taller than Roma VF and U C82 B. This might be attributed to inherent genetic characteristics of Ibadan local and Ife 1. The interaction effects of irrigation interval, mulching and variety were not significant (P≥ 0.05).

Table 1: Main effects of irrigation interval, mulching and variety on days to 50% flowering and tomato plant height.

Factors	Days to 50% flowering		Plant height (cm) 12 WAT	
	2010	2011	2010	2011
Irrigation interval (I) (days)				
2	41.87b	41.50c	75.50a	76.41a
4	43.25ab	41.25c	71.73a	80.55a
6	43.79ab	43.33b	69.58a	70.50b
8	45.66a	44.96a	68.58a	68.94b
SE ±	0.59	0.56	2.84	2.76
Mulching (M)				
Mulch	43.00a	42.25b	72.86a	76.43a
No mulch	44.29a	43.27a	69.73a	71.77b
SE ±	0.83	0.79	4.02	4.01
Tomato varieties (V)				
Roma VF	42.91a	41.42b	55.92b	57.57b
Ibadan local	43.33a	41.79b	85.68a	88.49a
Ife 1	44.50a	41.33a	85.70a	88.18a
UC82B	43.83a	43.50a	57.89b	62.16a
SE ±				
Interaction				
I x V	NS	NS	NS	NS
M x I	NS	NS	NS	NS
V x M x I	NS	NS	NS	NS

Means followed by the same letter(s) in the same column for each factor are not significantly different at P≤ 0.05.
WAT = weeks after transplanting

Effects of irrigation interval and mulching on number of tomato trusses, flowers and fruit

Irrigation interval significantly affected number of branches in both 2010 and 2011 dry seasons (Table 2). The highest number of branches was produced at 4 days irrigation interval. These results agree with the findings of [19] but contrary to that of [4]. The different results may be due to environmental differences. For instance [4] conducted the research in the semi-arid region of Pakistan and others conducted theirs in the rain forest. The main effect of irrigation interval on number of trusses and flowers were significant (P≤ 0.05). The highest number of trusses and fruits were produced when tomato plants were irrigated at four days interval. Highest of number of flowers was produced at eight days irrigation interval but did not translate to more flowers. This might be due to little moisture availability when compared to four days irrigation interval. Mulching significantly (P≤ 0.05) affected the number of trusses and flowers produced. Mulched plots significantly produced more number of trusses and flowers when compared to no mulching. Mulching had been reported to increase the moisture content of the soil through decreased evaporation and surface runoff with consequent increase in yield and crop yield components [20]. The varietal effect on number of trusses was significant only in 2011 while its effect on number of flowers was significant in both 2010 and 2011 dry seasons. Ibadan local significantly produced more number of trusses and flowers in 2011. This might be due to inherent genetic characteristics. The interaction effects of irrigation interval, mulching and tomato varieties were not significant.

Table 2: Main effects of irrigation interval and mulching on numbers of branches, trusses, and flowers per plant

Factors	No. of branches at 12 WAT		No of trusses/plant		No of flowers/plant	
	2010	2011	2010	2011	2010	2011
Irrigation interval (I) (days)						
2	6.20a	5.46b	16.37b	19.25a	82.12ab	94.29a
4	5.62	6.58a	17.58a	20.63	89.95ab	92.71a
6	5.32ab	5.58b	14.54bc	17.17b	78.41b	80.58b
8	5.00b	5.17b	13.62c	15.75b	103.10	78.04b
SE ±	0.35	0.34	0.75	0.65	21.97	21.08
Mulching (M)						
Mulch	5.91a	5.89a	17.45a	19.29	101.80a	91.67a
No mulch	5.18a	5.50a	13.60b	17.10b	74.97b	81.15b
SE ±	0.49	0.45	1.06	0.98	31.07	29.05
Tomato varieties (V)						
Roma VF	5.16a	5.75a	15.41a	18.04b	112.4a	86.29ab
Ibadan local	5.45a	5.54a	16.33a	20.08b	84.41b	89.92a
Ife 1	5.91a	6.04a	14.95a	17.79b	80.95b	86.58ab
UC82B	5.66a	5.45a	15.41a	16.88b	75.83b	82.83b
SE ±	0.35	0.34	0.75	0.65	21.97	21.08
Interaction						
I x V	NS	NS	NS	NS	NS	NS
M x I	NS	NS	NS	NS	NS	NS
V x M x I	NS	NS	NS	NS	NS	NS

Means followed by the same letter(s) in the same column for each factor are not significantly different at P≤ 0.05.

Table 3: Main effect of irrigation interval and mulching on tomato fruit and seed yield

Factors	No. of fruits/plant at 12 WAT		Fruit yield (kg ha^{-1})		Seed yield (kg ha^{-1})	
	2010	2011	2010	2011	2010	2011
Irrigation interval (I) (days)						
2	19.16b	23.25ab	9707b	10838b	20a	22ab
4	22.83a	23.46a	12267a	12431a	18b	27a
6	18.83b	21.71ab	8587b	9813b	15bc	17b
8	16.12c	19.29b	6853c	7296c	11c	14c
SE ±	2.20	2.18				
Mulching (M)						
Mulch	24.72a	25.68a	12747a	12889a	23a	24a
No mulch	13.64b	18.17b	6560b	7299b	14b	16b
SE ±	1.06	1.03				
Tomato varieties (V)						
Roma VF	21.50a	22.38ab	8853b	9786b	16a	17b
Ibadan local	17.37b	24.08a	14907a	14812a	19a	17b
Ife 1	20.37a	22.00ab	7200c	7738c	21a	22a
UC82B	17.50b	19.25b	10533b	8043b	15a	16b
SE ±	2.20	2.18				
Interaction						
I x V	NS	NS	NS	NS	NS	NS
M x I	NS	NS	NS	NS	NS	NS
V x M x I	NS	NS	NS	NS	NS	NS

Means followed by the same letter(s) in the same column for each factor are not significantly different at P≤ 0.05.

Fruit and seed yield

The main effect of irrigation interval on number fruit was significant (P≤ 0.05) (Table 3). The highest number of fruits was produced when tomato plants were irrigated at 4 days interval in 2010 while the least was produced at 8 days irrigation interval in 2011 but was not significantly different from others. Higher number of fruits had been reported to be associated with longer irrigation intervals such as 8 days irrigation interval or more [12, 14, 15]. The higher number of fruits obtained at four days irrigation interval in this study might be due to high temperature and low relative humidity during the study period which made the soil to dry faster. The effect of irrigation interval on fruit yield in both 2010 and 2011 dry seasons was significant (P≤ 0.05) such that 4 days irrigation interval gave higher yield while the lowest was obtained at eight days interval. In both 2010 and 2011 dry seasons mulching significantly affected the fruit yield in such away that mulched plots produced about two times more fruit yield than those without mulch (Table 3). It was reported by [21] that mulching, using any of the materials (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 viz. water holding capacity, porosity and specific gravity by mulching. The varietal difference in terms of fruit yield was also significant ($P \leq 0.05$) with Ibadan local producing the highest yield (14 t ha^{-1}) while Ife 1 produced the lowest (7 t ha^{-1}) in both years. Tomato varieties were significantly different in seed yield while the effect of irrigation interval and mulching on seed yield were also significant (Table 3). Irrigating tomato at four days irrigation interval produced more fruit while higher seed yield was obtained at two days interval. A research result showed that high fruit yield of *Cucurbita pepo* when irrigated at five days interval and claimed that increasing frequency of irrigation increased fruit number and consequently fruit yield [22]. The interaction effect of mulching, irrigation interval and variety on fruit and seed yield were not significant.

CONCLUSION

It can be concluded that irrigating tomato at four days irrigation interval gave highest yield. The yield would be increase if tomato plants are mulched. However more seeds are produced when irrigated at two days irrigation interval.

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