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EFFECT OF MULCHES AND IRRIGATION ON GROWTH AND YIELD OF LETTUCE IN SEMI-ARID REGION

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Adetunji I. A. *Effect of mulches and irrigation on growth and yield of lettuce in semi-arid region.* BIOTRONICS **19**, 93–98, 1990. To optimize the utilization of irrigation water for dry season lettuce production in the semi-arid region; sawdust, millet stover and groundnut shell mulches were applied under three irrigation frequencies (3, 7 and 11 day intervals). Mulching reduced the day time temperature and conserved soil moisture content. Growth and yield attributes of lettuce were significantly higher under groundnut shell and millet stover mulches than in sawdust mulch and control. Irrigating at 7 day interval is more economical, while soil temperature above 25°C is deleterious to the normal growth and yield of lettuce. The result further suggests that lettuce requires a soil moisture content corresponding to at least 60% plant available water in the 12 cm of soil for optimum yield and this can be provided with about half of the amount of water with mulching than without mulching.

Key words: *Lactuca sativa* L.; semi-arid region; mulching; irrigation; growth; yield.

INTRODUCTION

Lettuce (*Lactuca sativa* L.) is one of the most widely cultivated salad crop in the semi-arid region of northeastern Nigeria (*1*). It is grown mainly during the cool, dry harmattan season. Lettuce yield during this period is limited by soil moisture stress caused by high rate of evapotranspiration and low water holding capacity of the sandy semi-arid soil (*11*). Higher frequency of irrigation could be used to alleviate soil moisture stress and increase lettuce yields, however, the acute shortage of irrigation water in this region necessitates its economy. One way of achieving this is by mulching.

Mulching has a distinct advantage for increased crop production through its marked effect on the soil environment which increase crop growth and yield (*4, 6, 7, 9, 10, 12*). As mulching is seldom practised in semi-arid region of northern Nigeria, a mulching farming system to supplement the poor irrigation facilities and shortage of irrigation water is highly desirable to increase lettuce production. This paper examines the effect of different mulches and irrigation levels on the growth and yield of lettuce under the prevailing local semi-arid condition.

MATERIALS AND METHODS

The trial reported here was conducted on Typic Ustipsamment soil with sandy loam texture at the University of Maiduguri, Teaching and Research Farm, during the dry season of 1988/89. Maiduguri lies on latitude 11°04′N and longitude 13°05′E.

The experiment was laid out in a split plot design with irrigation levels as main plot and mulch treatments as sub-plot with three replications. The sub-plots were 3×4 m and consisted of five rows of lettuce planted at 50×50 cm. Three irrigation levels, irrigating at 3, 7 and 11 day intervals were used. These are henceforth designated as R_1, R_2 and R_3 respectively. Watering was done to field capacity at each application. Three mulches and a no-mulch (control) treatments were compared. The mulches: groundnut shell, millet stover and sawdust were laid 3.0 cm thick.

Lettuce crisphead seedlings were transplanted at 4 weeks after sowing. Fertilizer use and plant protection recommendations of Lorenz and Maynard (*5*) for both nursery and crop management were followed. Soil moisture at 12 cm depth was measured gravimetrically. The mean percentage plant available water content of the different treatments during the experimental period was determined by measuring the area under the water content—times curves and converting this to mean daily percentage available water content. Soil temperature at 12 cm depth was taken at 7.00 a.m., 2.00 p.m. and 6.00 p.m. using a Wakster thermometer model MA-160 attached to a soil probe.

Four lettuce plants were harvested at 40, 56 and 70 day after planting (DAP) and mean fresh and dry weights of whole plants and percentage dry matter were determined. Lettuce bunch were harvested as they matured and total cumulative yields per treatment were determined. The data collected were subjected to split-plot analysis of variance from which the various least significant differences (at 5% level) were calculated.

RESULTS AND DISCUSSION

Effect on soil moisture

Irrigation and mulch treatments increased the soil moisture content of 0–12 cm depth above the control (Table 1). Mulching and watering at R_1 level produced higher soil moisture content throughout the experimental period compared to mulching and watering at R_2 and R_3 levels. The soil moisture content under sawdust mulch is consistently higher than in other types of mulches because being more finely divided than others, it ensures better coverage of the soil surface thereby reducing evaporation of the soil moisture.

Mulching caused an approximately 100 percent increase in the available moisture content of the soil at each watering level (Table 2). Irrigating at R_1, and R_3 levels produced a mean available water content of 67.2, 59.8 and 32.5 percent respectively, with mulch, and only 36.1, 28.4 and 14.8 percent respectively without mulch. The 5 percent increase in available water of R_1 treatment above R_2 was

Table 1. Mean moisture content under different irrigation and mulch treatments at 12 cm depth

Irrigation (R)	Mulch type*				Irrigation mean
	SD	GS	MS	CO	
R_1	17.6	15.8	15.5	8.8	14.4
R_2	14.4	12.2	13.4	6.3	11.6
R_3	12.2	11.4	11.5	4.7	10.0
Mulch means	14.7	13.1	13.5	6.6	

* SD, sawdust; GS, groundnut shell; MS, millet stover; CO, control.

Table 2. Mean percent available water at 12 cm soil depth under different irrigation levels with and without mulch

Irrigation (R)	Mulch (M)*	Available water (%)	+M/−M
R_1	+M	67.2	
	−M	36.1	1.9
R_2	+M	59.8	
	−M	28.4	2.1
R_3	+M	32.5	
	−M	14.8	2.2

* +M, with mulch; −M, without mulch.

too small to effect a significant difference in the growth and yield of lettuce under the two treatments, whereas the 25% difference in the available moisture between R_1 and R_3 treatments was evidently enough to cause a significant difference in the performance of lettuce under the two treatments (Tables 2, 3 and 4). Irrigation at R_1 without mulching produces a mean available soil moisture content of 36% whereas irrigation at R_2 (about half the water application) with mulching produces a mean available soil moisture content of approximately 60%.

Effect on soil temperature

Soil temperature decreases with increase in irrigation frequency. Irrigation frequency and mulching did not significantly affect morning temperatures of the soil, but in the afternoon the rate of increase of soil temperature was retarded by mulch cover so that maximum temperature in mulched plot was significantly lower than in unmulched plot (Fig. 1). This was achieved by preventing direct contact of soil with dry air and sunlight rays by layer of mulches. The highest and possibly harmful heat build-up under mulches was recorded in the sawdust mulched treatments compared to groundnut shell and millet stover mulches, especially during the hottest part of the day (1300 h).

Effect on growth and yield

Higher watering frequencies (R_1 and R_2) significantly increased the mean fresh and dry weights of whole lettuce plant throughout the growth period (Table 3),

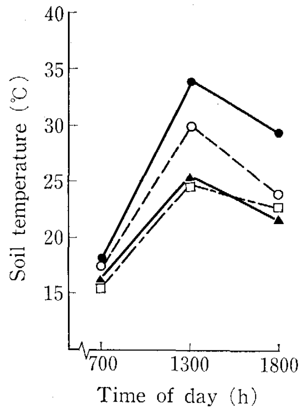

Fig. 1. Soil temperature at the 12 cm depth under different mulches. (●), unmulched; (○), sawdust mulch; (▲), groundnut shell mulch; (□), millet stover mulch.

Table 3. Effect of mulching at different irrigation levels on mean fresh and dry weight yeilds (g/plant) of lettuce

Treatments	M**	Fresh weight (g/plant)			Dry weight (g/plant)			Dry matter (%)		
		40	56	70	40	56	70	40	56	70 (DAP)*
R_1	+M	95.1	397.0	491.1	7.4	35.9	38.6	6.5	9.4	8.8
	−M	34.5	162.9	195.5	2.2	17.1	18.2	6.8	10.6	9.1
R_2	+M	81.8	249.5	293.0	4.1	25.1	28.6	5.6	10.3	9.2
	−M	32.3	101.1	134.0	2.1	10.5	13.6	6.5	10.8	9.8
R_3	+M	52.5	152.2	185.3	3.8	17.3	20.5	7.4	11.8	11.3
	−M	20.1	68.4	98.7	1.9	8.5	12.1	9.7	12.6	12.1
LSD	(0.05)	25.8	76.5	81.7	1.4	6.7	7.5	0.2	0.5	0.4

* DAP, days after planting.
** +M, with mulch; −M, without mulch.

but the difference between R_1 and R_2 was not large enough to be significant. Fresh and dry weights of lettuce were also significantly increased by mulching because the high soil moisture under mulch cover encourage optimal transpiration, nutrient uptake and rate of photosynthesis (*3*) required for plant growth.

The percentage of dry matter content of lettuce plants under different irrigation, mulched and unmulched treatments generally decreased with age (Table 3). This may be attributed to increase in moisture content as the lettuce bunch develop. Both R_1 and R_2 treatments produced plants that are significantly (P=0.05) lower in percent dry matter than plants in R_3 treatments. R_2 treatment produced plants with the lowest percent dry matter but the difference between R_1 and R_2 plant was not significant. Mulching also decreased the percent dry matter content of the plants throughout their growth period, probably through the resultant increase in soil moisture content.

Lettuce bunch yields under groundnut shell mulch were significantly higher than in other mulches and control at the higher (R_1) watering level. At lower R_3

Table 4. Lettuce bunch yield (kg/ha) at different irrigation and mulch treatments

Irrigation (R)	Mulch type (M)*				Irrigation means
	SD	GS	MS	CO	
R_1	299.5	7712.5	4324.6	1929.5	3591.6
R_2	237.0	2147.7	2651.5	1282.8	1579.7
R_3	189.2	1456.4	1500.8	830.6	994.2
Mulch means	241.9	3772.3	2825.6	1347.6	2055.2
LSD (0.05)					
Between R means			=1567.0		
Between M means			=1274.8		
Between R means at same M treatment			=1102.8		
Between M means at same R treatment			= 610.5		

* SD, sawdust; GS, groundnut shell; MS, millet stover; CO, control.

watering level there was no significant difference between the yields of lettuce under groundnut shell and millet stover mulches but these were significantly (P=0.05) higher than yields under sawdust mulch and control. The high soil temperature of 34°C in bare plots must have retarded root growth and impaired water and nutrient uptake needed for adequate growth and yield of lettuce. Thus the temperature of 34°C may be considered supra-optimal for lettuce under the prevailing local condition of the semi-arid region.

It is note-worthy that sawdust mulch with highest soil moisture content produced crops of poor growth and yield (Table 4) compared with crops under millet stover and groundnut shell mulches and control. This may be attributed to: (i) Presence of some growth retardants in the sawdust mulch, (ii) high soil temperature (31°C) under sawdust mulch and (iii) immobilization of soil nitrogen by sawdust as reported by Bollen (*2*). All these must have culminated in poor growth and yield of lettuce under sawdust mulch treatment. There were significant mulch × irrigation (M × R) interactions for lettuce bunch yield (Table 4). The increase in yield caused by the three irrigation frequencies was greater on mulched plots than bare plots and was significant for groundnut shell and millet stover mulches.

This study showed that in mulched plots, watering to field capacity at 3 and 7 day intervals maintain the critical plant available water of approximately 60% in the top 12 cm soil, whereas on bare plots an average of 32% plant available water was maintained. These correspond to a soil moisture content of approximately 70 and 40% of field capacity respectively and agrees with the findings of Vittum and Flocker (*13*) and Nieuwhof (*8*). However, the yield difference between 3 and 7 day irrigation intervals in mulched plots were not large enough to warrant watering at 3 day intervals especially under semi-arid condition where there is always a shortage of irrigation water. It is also evident that the absence of mulching could reduce lettuce bunch yield potential by 59%. Groundnut shell and millet stover mulches appear equally effective and could be used as substitutes should the need arise.

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