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EFFECT OF MULCHES ON HYDRO-THERMAL ENVIRONMENT OF SOIL AND CROP PRODUCTION IN ARID WESTERN RAJASTHAN

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ABSTRACT

The application of grass mulch at the rate of 6 t/ha decreased maximum temperature of the soil by 1 to 9°C, reduced evaporation loss and increased emergence of the pearl millet during the hot month of June. During *khar'f* (July to September), the magnitude of temperature reduction however, narrowed down to 1–6° C: polyethylene mulch, on the contrary, raised it by 1 to 3° C. The mulches also suppressed weed growth improved moisture status of the soil and thus, increased production of the pearl millet (*Pennisetum typhoides* (Burm,t) Stapf & C. E. Hubb). and okra *Abelmosehus esculentus* (L.) Moeneh. With increase in the application rate of grass mulch. There was also reduction in the water status of the soil and plant, and improvement in the root growth and nodulation. Mulch application @ 6 t/ha led to 40% production of the green gram over control i. é. without mulch. These mulches, can, therefore, be used to manipulate the soil environment for increasing crop production under arid conditions.

INTRODUCTION

Deficiency of water and high thermal regimes of the soil are the two most important factors which adversely affect crop production. These factors can be taken care of by the use of mulches which favourably modify hydro-thermal reg mes of the soil and thereby increase crop production (Vanwijk *et al.*, 1959; Fritschen and shaw, 1960; Adams, 1962; Moody *et al.*, 1963; and Bansal *et al.*, 1971). Most of the available information on the use of mulches pertains to the medium soils and semi-arid conditions. Recent studies (Gupta, 1978 and 1980) on the use of mulches in sandy soil under arid conditions have shown reduction in the evaporation and improvement in the growth and yield of the pearl millet. With the objectives to have more information on their effect on moisture and thermal environment of the soil, and production of various crops e. g. pearl millet, lagumes and vegetables, the present study was conducted.

MATERIAL AND METHODS

Field trials on the three crops i.e. pearl millet, green gram and okra were conducted on loamy sand soil (sand 85.2% Silt 4.8% and Clay 9.9%) at the Central Research Farm of the Central Arid Zone Research Institute, Jodhpur during 1978 to 1980. The data on weather conditions are presented in Table 1. The details of the trials are as under.

1. Pearl millet. The trials on the pearl millet (*Pannisetum typhoides* cv. BJ 104) were conducted in 3×2 m plots during the summer 1979 and during *kharif* 1978. During *kharif* four treatments namely polyethylene, grass and straw mulches, and control (no mulch) were replicated four times in a randomized block design. The polyethylene mulch was a white transparent sheet of 400 gauge thickness. Other mulches i. e. grass and straw were spread over the soil @ 6 t/ha. Fertilizers were applied in the form of urea, superphosphate, and muriate of potash to supply 80 kg. N/ha, 60 kg. $P_2 0_5$ /ha and 30 kg. k_2 o/ha, respectivily. The crop was sown on july 13 in 1978. In the summer experiment only grass mulch was applied and its effect on diurnal variations in the soil temperature and moisture and the seed germination was studied.

2. Legumes. These trials were conducted in 4×3 m plots during *kharif* 1979 and 1980. Five levels of the grass mulch application (0, 3, 6, 9 and 12 t/ha) were replicated four times in a randomized block design. Green gram (*Vigna radiata* cv.S-8) was sown on July 13, 1980. Superphosphate and muriate of potash were applied to supply 60 kg $P_2 0_5$ /ha and 40 kg K_2 0/ha. respectively. After 52nd day of the sowing (3.9.80), roots were removed from a 30 cm^3 block of the soil by washing it with a jet of water. The nodules were counted and oven dry weight of roots recorded. Plant samples were also collected for determining their water status and dry matter production.

3. Vegetables. The trial was conducted in 2×2 m plots during *kharif* 1979. Three treatments (control i. e. no mulch, polyethylene and grass mulch) were replicated five times in a randomized block design. Okra (*Abelomosehus esculentus* cv. Pusa sawni) was the test crop.

Depthwise soil samples were collected during the crop growth period and their mosture contents were determined gravimetrically. Soil temperatures were measured with Aplab telethermometer probes. After harvest, the grain and straw yields of crops, and the dry matter production of weeds were recorded.

RESULTS AND DISCUSSION

1. HYDRO-THERMAL ENVIRONMENT AND PEARL MILLET PRODUCTION

Effect of summer crop

Fig. 1 shows diurnal soil moisture oscillations occuring in the soil with and without mulches. These oscillations were more predominat in the soil surface layer upto 15 cm depth below which these were of very low magnitude. In the surface leayer the soil moisture status was higher at 0400 hours while it was lower at 1400 hours, showing thereby, movement of moisture under the influence of thermal gradients. Throughout the study period (June 28 to July 6), highest moisture status of the soil was observed in the mulched plots and lowest in the no mulch plots. During this period total moisture loss from the mulched plots was about 2 mm less than the no mulch plots.

Table 1. Weather data during growth period of crops

Particulars	1978			1979			1980		
	July	August	Sept.	July	Angust	Sept.	July	August	Sept.
Total rainfall (mm)	160	110	25	471	205	5	150	4	29
Total pan evaporation (mm)	191	230	231	331	181	254	265	231	247
Mean max. temp. (°C)	33.6	33.8	34.4	36.1	33.4	36.0	35.8	34.8	36.5
Av. ralative humidity (%)	73.4	69.8	60.0	60.0	69.5	51.0	65.2	63.1	51.4

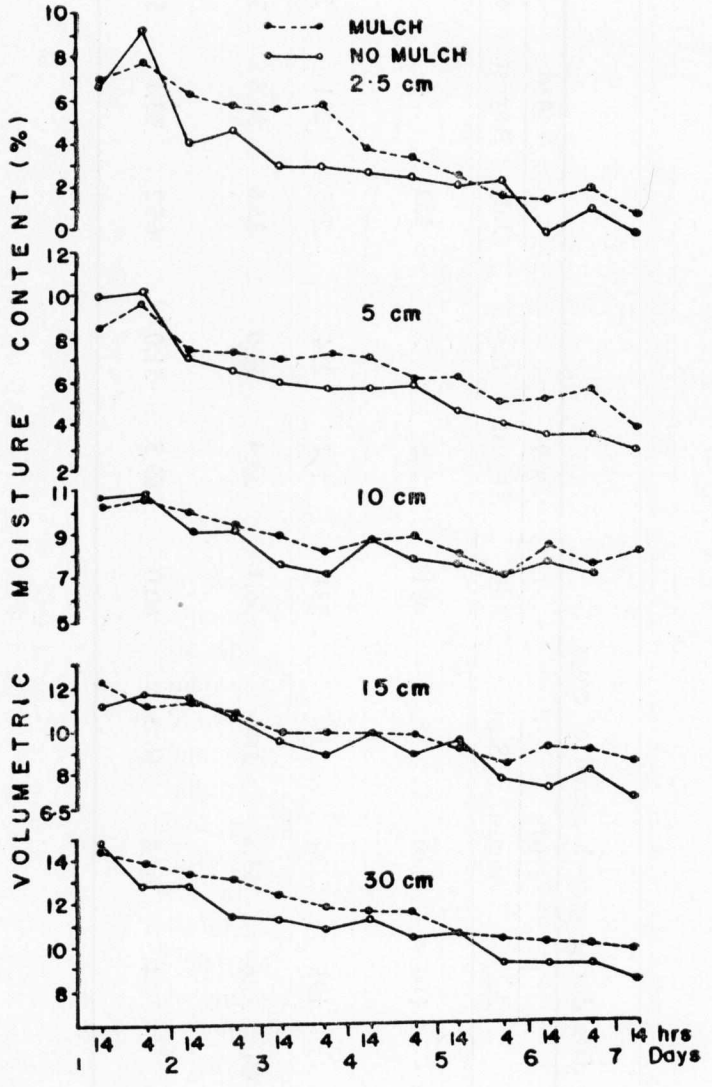

Fig. 1 Duirnal variations in soil moisture as effected by mulches.

Mean maximum temperature at 5 cm depth of the mulched plot was about 8 °C lower than the no malch plot (Table 2). Maximum temperature ranged from 37-45 °C in the no mulch plots. No difference in the minimum temperature of the mulched and the no mulch plots was observed. Rapid loss of the moisture coupled with higher temperatures in the no mulch plots, reduced the emergence of seedlings. Mehta and Parihar (1973) also reported higher germination percentage of the soybean and cotton under straw mulch conditions.

Effect on kharif crop

Soil temperature. Polyethylene mulch raised temperature of the soil at 10 cm depth by 1 to 3°C while organic mulches i. e. grass and straw, lowered it by 1 to 6°C (Fig. 2). There were, however, no significant differences in the soil temperature under grass and straw mulches. The soil temperature ranged from 30 to 35 °C during the crop growth period. Higher production obtained on the soil under polyethylene mulch showed that the soil temperature upto 38 °C was not a critical factor in the growth of the pearlmillet, it rather helped in improving growth and yield of the crop. Reduction in the maximum soil temperature by organic mulches has also been reported by several workers (Moody *et. al.*, 1963; Bansal *et. al.*, 1971; Grewal and Singh 1974 and Khera *et. al.*, 1976). The magnitude of reduction was, however, more in the *kharif* season.

Soit moisture. The soil under the polyethylene mulch contained 5 to 35 mm, and under the organic mulches, 5 to 25 mm more moisture than the control (Fig. 3). However, there were no significant differences in the moisture status of the soil under the grass and the straw mulch. Higher moisture status of the soil under mulches was due to the reduction in evaporation and the weed population. The maxium dry matter production (3.8 q/ha) of weeds was observed in the soil without mulch, while it ranged from 0.2 to 1.2 q/ha in the mulched plots (Table3),showing thereby, reduced crop-weed competition for moisture in the mulched plots. This seems to be an important factor for higher crop yields obtained from the mulched plots.

Crop yields. Mulches increased grain and straw production of the pearl millet(Table 3). The soil under the polyethylene mulch produced highest grain yield (15.5 q/ha)followed by the grass mulch (8.9p/h), the straw mulch (7.2 q/ha) and the control (6.0 q/ha). No wide variations in the water use of the crop under different mulches were observed. However, it was higher in control plots. Water use efficiency of the crop was maximum under the polyethylene mulch followed by the grass straw and the control treatments. The maximum water use efficiency with the polyethylene mulch was due to its imperviousness to vapours leading to moisture conservation and thereby increasing the crop production. Better growth and increase in the wether use efficiencey of crop under the polyethylene and straw mulches have also been observed by various workers (Fritschen and Shaw, 1960;

Table 2. Effect of grass mulch application on soil temperature moisture loss and seedling emergence

Treatments	Temperature range (5 cm depth)		Mean maximum soil temperature (5 cm depth)		Moisture loss	Seedling emergence
	Max.	Min	Max.	Min	mm	%
No mulch	38–54	25–35	48.6	29.4	17.0	63
Grass mulch	37–45	26–35	40.3	29.8	14.7	70

Table 3. Effect of mulches on weed growth, water use and yield of pearlmillet (1978)

Treatment	Grain yield (q/ha)	Straw yield (q/ha)	Weed yield (q/ha)	Water use (mm)	WUE kg/mm/ha (grains)
Polyethene	15.5	38.1	0.25	289	5.37
Grass	8.9	27.6	0.92	286	3.11
Straw	7.2	25.1	1.23	276	2.61
Control	6.0	24.9	3.77	294	2.04
L.S.D. (0.05)	0.98	10.12			

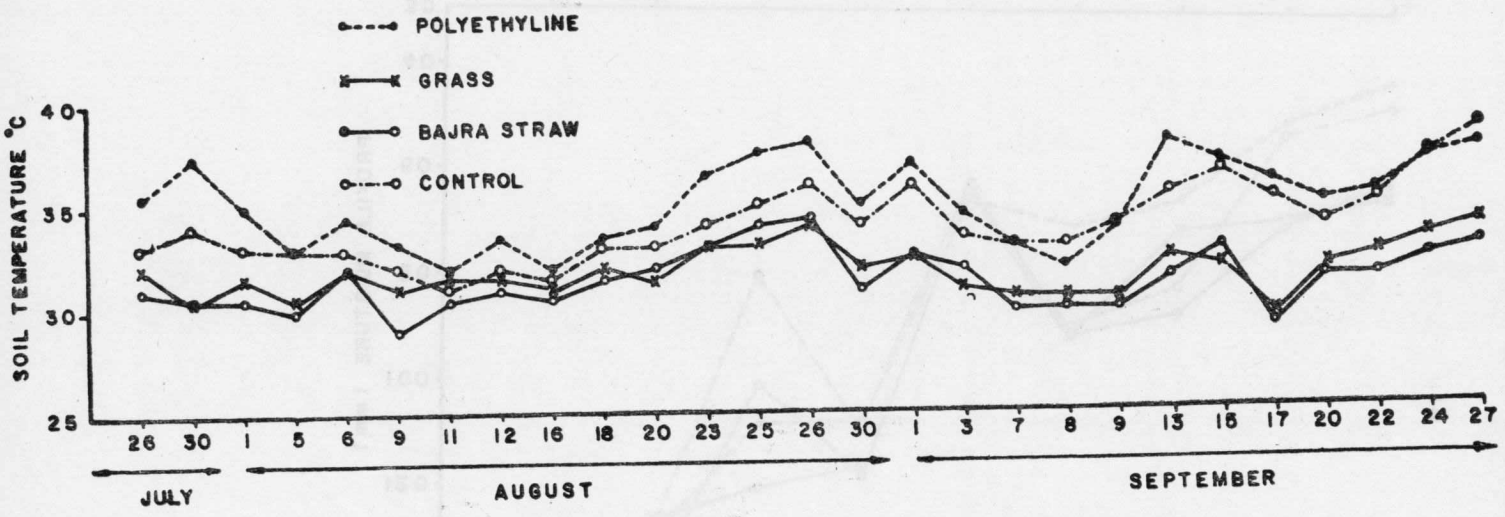

Fig. 2 Thermal regime of soil under mulches.

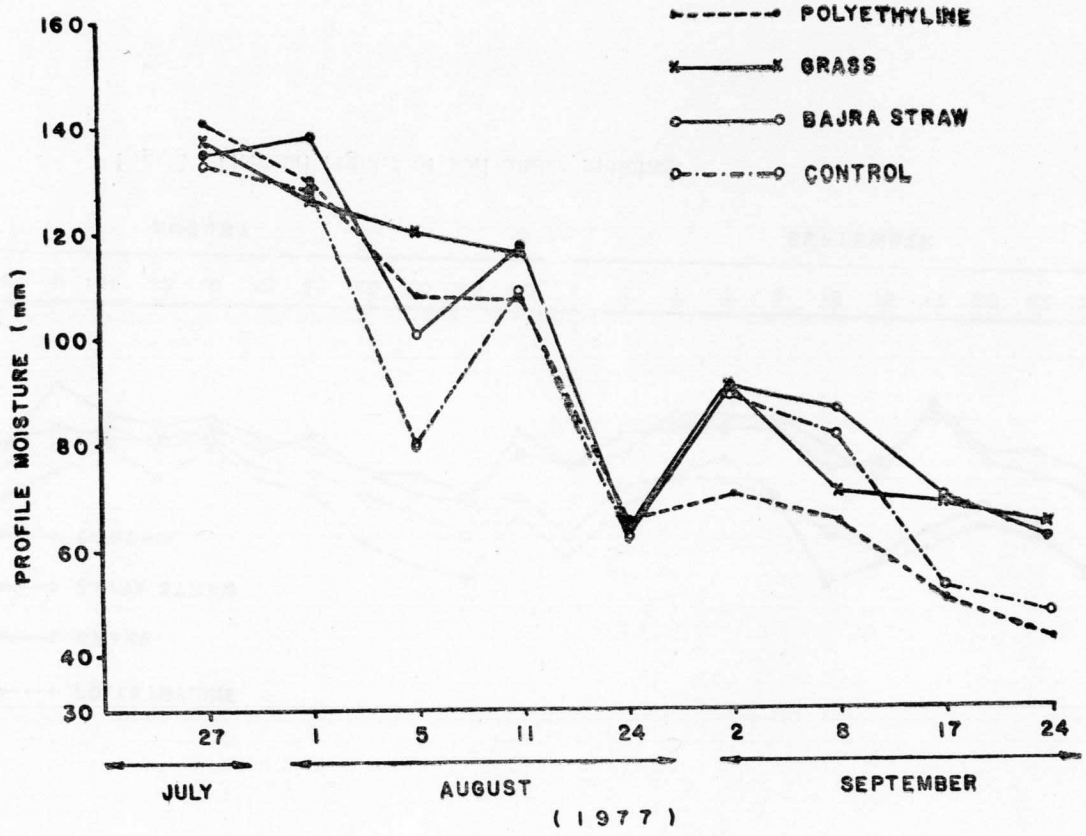

Fig. 3 Moisture regime of soil under mulches.

Adams, 1162; Moody *et. al.*, 1963 and Bansal *et. al.*, 1971).

II. *HYDRO-THERMAL ENVIRONMENT AND LEGUME PRODUCTION*

Soil temperature Wide variations in the soil temperature ranging from 36 to 44 °C in the no mulch and 32 to 41°C in the mulched plots were observed during growth period of the green gram (Fig. 4). With increase in the level of grass mulch applica tion there was decrease in the mean maximum weekly soil temperature with maximum reduction at 12 t/ha level. The grass mulch application at 6 t/ha level reduced the mean maximum weekly temperature by 2 to 3 °C and thus, increased the root and shoot growth and nodulation. Philpotts (1967) reported 6-8 °C decrease in the maximum soil temperature under 2.5 cm thick straw mulch and thus, increase in nodulation and dry matter yield of the cowpea.

Water use and crop production :

With increase in the level of the grass mulch application, there was drastic reduction in the weed growth (Table 4). There were, however, no significant differences in evapo-transpiration (ET) loss from the mulched and the no mulch plots. Water use efficiency of the crop was, therefore, higher in the mulched than the no mulch plots. Although there was very little rainfall during July and August, 1980 and the drought conditions persisted,there was higher plant water status, and dry matter production in the mulched than in the no mulch plots. Production of the green gram increased with the mulch application upto 6 t/ha level, beyond which yield decreased. This seems to be due to delay in the maturity of the crop. Anderson and Russel (1964) reported delay in the maturity and reduction in the yield with higher quantities of mulch. Mulch application at 6 t/ha level increased the average production of the green gram by 40% more than the control. Though there was higher crop production during the good rainfall year of 1979, the crop responses to mulches were more during the deficitrainfall year of 1980 (Table 1), Masefield (1957) reported three-fold increase in the nodule weight of the cowpea and increase in the dry weight with the use of grass clippings as mulch.

III. *EFFECT ON VEGETABLE PRODUCTION*

Application of the grass mulch @ 6 t/ha reduced the mean maximum temperature of the soil at 10 cm depth by about 2 °C while polyethylene mulch did not bring about any change during the crop growth period (Table 5). There was maximum evapo-transpiration (ET) loss (110 mm) from the 60 cm soil profile of the control plot followed by the grass mulch (106 mm) and the polyethylene mulch (90 mm). The grass and the polyethylene mulches, respectively increased the production of okra by 15% and 46% over control. Though there were no differences in the soil temperature of the control and the polyethylene mulch plots, significant increase in the crop yield indicates more moisture conservation under polyethylene mulch This also shows that temperature variations caused by the

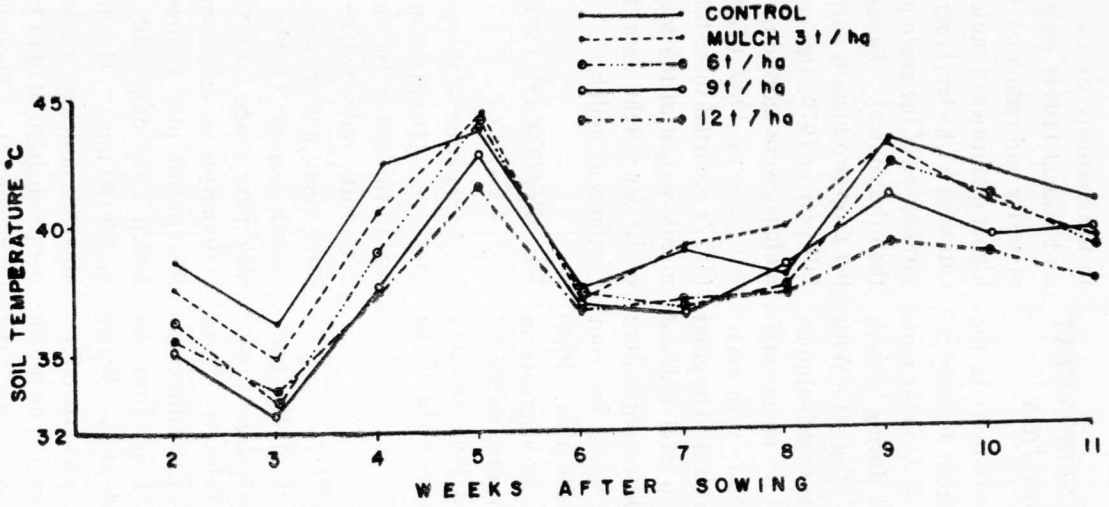

Fig. 4 Mean maximum weekly soil temperature as effected by different rates of mulch application (1980)

Table 4. Effect of different rates of grass mulch application on soil environment and production of green gram

Grass mulch application	ET loss from 60 cm soil profile mm		Mean max. soil temperature at 10 cm °C		Root growth dry weight g/plant		Nodule number/ plant		Plant water status (%)	Dry matter production (g/plant)	Weed production (q/ha)	Yield q/ha		Mean yield q/ha
	1979	1980	1979	1980	1979	1980	1979	1980	1980	1980	1980	1979	1980	
0	98.6	128.6	41.8	40.3	0.78	0.63	18	15	70.5	5.2	4.3	8.37	2.43	5.40
3	87.8	131.4	40.1	40.3	1.42	0.48	30	37	71.3	4.2	2.5	8.88	3.48	6.18
6	81.7	126.6	39 1	38.7	1.50	0.77	39	42	74.5	5.3	1.6	10.41	4.36	7.38
9	85.7	122.4	38.6	38.2	1.45	1.12	21	36	72.8	8.6	1.3	8.14	4.80	6.47
12	86.3	128.8	39.0	37.8	1.50	1.53	32	35	75.8	12.1	0.9	9.41	3.60	6.50
LSD (0.05)												0.84	0.46	

Table 5. Effect of mulches on moisture loss and yield of lady's finger (1979)

Mulches	Water loss from 60 cm profile mm	Mean maximum soil temperature °C	Yield q/ha
No mulch	110.0	40.8	26.3
Grass	106.2	37.8	30.4
Polyethylene	90.0	40.0	38.4

grass and the polyethylene mulches did not have any significant effect on the yield of okra, and the temprature as high as 40 °C was not critical for the crop growth.

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