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Influence of mulch on soil hydrothermal regimes, leaf and soil nutrient concentrations, growth and fruit yield of brinjal grown under arid ecosystem

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Abstract: An experiment was conducted during 2002-2003 and 2003-2004 to study the effect of black and white polyethylene mulches and two organic mulches namely *Cordia* leaf and *Leptodenia* clippings on soil hydrothermal regimes, macro and micronutrient concentrations in leaf and soil, growth and fruit yield of brinjal. The mulch treatments retained more soil moisture at all the depths as compared to control. The synthetic and organic mulches conserved 55 and 36 per cent more moisture per 0.15 cm soil depth respectively as compared to control. Soil temperature was favourably moderated in mulch materials as compared to unmulched treatment. Leaf tissue-N and K were higher under *Cordia* leaf mulch and P was highest under black polyethylene mulch but micronutrient concentrations were variable. Plant height, stem girth, plant spread, no. of fruits/plant and fruit yields increased with mulch application.

Additional key words: *Mulching, soil temperature, soil water, nutrient availability, arid zone*

Introduction

In western Rajasthan, among the vegetables, brinjal (*Solanum melongena* L.) is the most important crop grown under arid condition. Arid environment, which is beset with scanty rainfall, frequent prolonged drought, high solar radiation and wind velocity seriously affect the plant production through different ways. In brinjal cultivation, mulching is commonly practised to protect the plant from high solar radiation. This is also done with an objective to moderate the soil hydrothermal regime and add nutrient into the soil especially through organic mulching. Walker (1969) reported that even a small change of 1°C in the soil temperature could influence the growth and nutritional behaviour of the plant. Such situations demand the adoption of specific soil management practices such as mulching and their evaluation in terms of moisture conservation, changes in hydrothermal regime and nutrient status of the plant, which could minimize the ill effect of these constraints towards crop yield. A few reports on the use of organic and synthetic mulches in some of the vegetable crops have also been documented (Gupta and Gupta 1983, 1986; Sterk and Spaan 1997). Since the availability of organic materials for use as mulch is progressively declining, it is necessary to look for alternate synthetic mulch materials. In the light of these observations, the present study was conducted to evaluate the comparative effect of organic and synthetic mulch materials on soil hydrothermal regime, leaf nutrient status, growth and yield of brinjal.

Materials and Methods

Field experiments were conducted during September- March 2002-2003 and 2003-2004 on brinjal (cv. local) grown as a ground storey crop in plot size 6 m X 1 m area with five mulch treatments in newly established aonla (*Emblica officinalis*) orchard at Central Institute for Arid Horticulture, Bikaner. The experimental loamy sand soil had pH 8.3-8.6; organic carbon 0.3 kg^{-1}; EC 0.18-0.20 dS m^{-1}; available N 98.0 kg ha^{-1}; P 3.0 kg ha^{-1}, K 443.0 kg ha^{-1}, DTPA-Zn 0.16 mg kg^{-1}; Fe 6.0 mg kg^{-1}; Mn 4.6 mg kg^{-1} and Cu 0.20 mg kg^{-1}, respectively. The treatments comprised of 75μ thick black polyethylene, 75μ thick white polyethylene, *Cordia* leaf, *Leptodenia* clippings and control (Unmulched). The experiment was laid out in a randomized block design with three replications. The black and white polyethylene films were spread in 6 m^2 (6m x 1m) area and *Cordia* leaf (*Lasoda* leaf) and *Leptodenia* clippings (*Kheep* grass) were applied @ 10 ton ha^{-1} (6 kg $plot^{-1}$). Uniform cultural practices were followed in all the plots. Soil temperature (at surface and 20 cm depth) was recorded at weekly interval at 1400 hr. with bimetal dial thermometers. Soil moisture content was recorded at weekly interval in 0-15 and 15-30 cm depths by neutron moisture meter. Plant growth was recorded at the full maturity of the crop, and yield components were recorded during different pickings. Mineral composition of brinjal leaves was determined 180 days after mulching (180 DAM) by Kjeldahl method. Phosphorus and potassium content was measured by colorimetric and flame photometric method (Jackson 1973), respectively, whereas micronutrient cations were determined by atomic absorption spectrophotometric method. Soil samples were analyzed for available N, P and K as per the standard methods (Jackson 1973). Micronutrient cations in soil were extracted with DTPA-$CaCl_2$ (Lindsay and Norvell 1978) and estimated in the extracts with atomic absorption spectrophotometer.

Results and Discussion

Soil temperature

Soil temperature was favourably moderated under mulched treatments comprising of black polyethylene and *Cordia* leaf. Data on weighted surface soil temperature in brinjal field (Fig. 1) during September to November

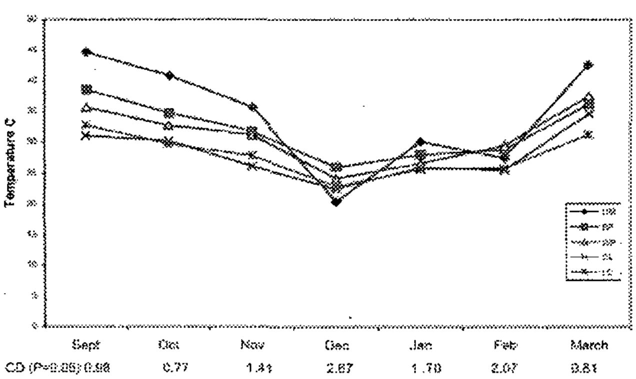

Fig.1. Mean monthly soil temperature at surface under different mulch treatment and unmulched control

indicated lower temperature regime in soils as compared to organic mulches (7.8 to 13.63°C) to synthetic mulches (3.86 to 8.97°C). Increase in soil temperature under white polyethylene mulch was attributed to its glass house effect (Mahrer *et al.* 1984). In December and January, both organic and synthetic mulch materials were observed to be equally effective in raising the surface soil temperature. At 20 cm depth, the weighted soil temperature during September to November (Fig 2) was lower in mulched than in unmulched plots. The lower temperature of mulched plots resulted from the insulation effect of mulch that prevented the high incident solar radiation and warmer air from penetrating the soil layers. During winter months of December and January, the synthetic mulches raised the soil temperature more effectively as compared to organic mulches. The results are in accordance with the findings of Gupta (1986).

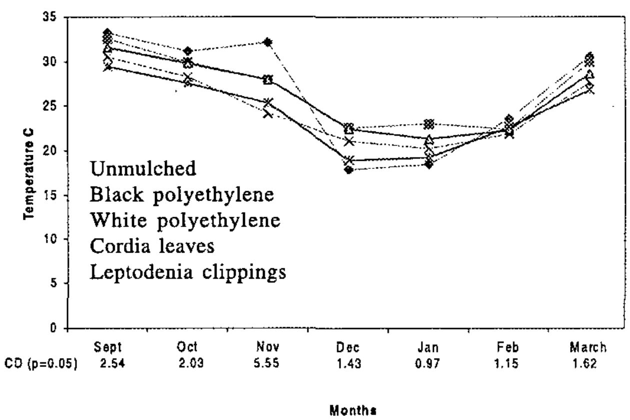

Fig. 2. Mean monthly soil temperature at 20 cm depth under different mulch treatment and unmulched control.

Soil moisture

Application of different mulch materials markedly influenced the soil moisture content at 0-15 cm depth (Table 1). During the early growth period, it was maximum (9.6%) under black polyethylene followed by white polyethylene (7.4%), *Cordia* leaf (6.0%), *Leptodenia* clippings (6.3%) and control (4.7%). Higher moisture content in mulched plots is due to insulating effect which minimized vapour diffusion to the atmosphere (Gupta and Gupta 1986). Lower soil moisture content during December to January under black polyethylene treatment might be attributed to profused growth of brinjal crop, which had resulted in more uptakes of water and increased transpiration losses. In the month of March, a sharp decline in moisture content was noted under all the treatments. The pattern of moisture retention at 15-30 cm depth (Table 1) under all the treatment followed similar trend to that at 0-15 cm soil depth. Vertical distribution of moisture was more or less uniform because of the textural uniformity of soil profile.

Nutrients content

Mulch treatments were significantly effective in increasing the leaf N, P and K concentrations. The nitrogen (3.68%) and potassium (3.65%) concentrations (Table 3) were observed to be highest in plots mulched with *Cordia* leaves. The higher leaf nitrogen and potassium status under the mulched plots was possibly due to better moisture regime and optimum soil temperature in the root zone of brinjal plant (Wein and Minotti 1987). Increased leaf phosphorus concentration under organic mulches as ascribed by Russel (1975) was because of increment of soil solution phosphorus on partial decomposition of organic mulches *inter-alia* better surface rooting of the crops and keeping the surface soil moist for a longer time.

The results (Table 3) showed that the highest leaf tissue Fe (262 mg kg^{-1}), Mn (77 mg kg^{-1}) and Cu (17 mg kg^{-1})

Table 1. Monthly average soil moisture content (%) at 0-15 and 15-30 cm depths under different mulch materials.

Treatment	Soil moisture content (%)						
	September	October	November	December	January	February	March
Black Polyethylene	7.6	7.4	9.6	6.8	7.1	8.6	2.9
	(8.0)	(7.8)	(9.7)	(6.8)	(7.1)	(8.9)	(2.8)
White Polyethylene	6.6	6.9	7.4	8.8	9.5	11.0	3.4
	(6.8)	(7.3)	(7.5)	(9.7)	(10.6)	(11.6)	(4.2)
Cordia leaves	5.8	4.6	6.0	6.5	6.1	8.6	4.2
	(6.0)	(5.2)	(6.2)	(6.8)	(6.7)	(8.6)	(4.5)
Leptodenia clippings	5.5	5.9	6.3	6.8	6.8	8.0	4.4
	(5.7)	(6.0)	(6.7)	(6.7)	(7.3)	(8.2)	(4.7)
Control	3.7	3.8	4.7	5.40	4.9	7.8	2.7
	(3.9)	(3.5)	(5.2)	(5.4)	(5.0)	(4.5)	(3.1)
C.D. (P=0.05)	0.27	0.70	0.25	0.25	0.14	0.12	0.18
	(0.83)	(1.16)	(0.48)	(0.91)	(1.82)	(0.71)	(0.87)

Figures in parenthesis represent the soil moisture content at15-30 cm depth.

Table 2. Effect of various mulches on available soil nutrient concentration

Treatments	N	P	K	Fe	Mn	Cu	Zn
	(kg ha^{-1})			(mg kg^{-1})			
Black Polyethylene	94	4.8	241	6.1	4.5	0.18	0.12
White Polyethylene	90	4.8	232	6.3	4.6	0.24	0.16
Cordia leaves	89	5.0	306	5.8	4.5	0.23	0.18
Leptodenia clippings	102	5.0	240	5.9	4.6	0.20	0.10
Control	104	4.5	445	5.7	4.5	0.18	0.10
C.D. (P=0.05)	6.0	0.4	6.0	0.1	0.4	0.02	0.03

Table 3. Effect of various mulches on leaf nutrient concentration of brinjal (180 DAM)

Treatments	N	P	K	Fe	Mn	Cu	Zn
	(%)			(mg kg^{-1})			
Black Polyethylene	3.53	0.60	3.22	240	41	10	14
White Polyethylene	2.65	0.47	3.05	263	77	17	23
Cordia leaves	3.68	0.49	3.65	252	66	14	28
Leptodenia clippings	2.40	0.38	2.35	256	70	10	17
Control	2.30	0.24	2.31	237	58	8	15
C.D. (P=0.05)	0.51	0.05	0.12	6.0	13.0	3.0	4.0

Table 4. Effect of various mulches on growth and fruit yield of brinjal.

Treatments	Growth and yield (180 DAM)				
	Plant Height (cm)	Stem Girth (cm)	Plant spread (cm)	No. of fruits/plant	Fruit yield/plant (g)
Black Polyethylene	40.0	3.4	54.0	33.0	832
White Polyethylene	32.0	3.0	45.0	24.0	596
Cordia leaves	26.0	2.9	40.0	16.0	400
Leptodenia clippings	24.0	2.7	40.0	15.0	320
Control	16.0	2.0	31.0	5.0	134
C.D. (P=0.05)	6.3	0.6	4.6	7.2	30

concentrations was recorded under white polyethelene mulch. It might be attributed to better ramification of root and higher moisture content in the rhizosphere. The leaf micronutrient concentrations under black polyethylene were observed to be *at par* with the control. The concentrations of Fe, Mn and Cu were observed to be adequate in the brinjal leaves in the light of critical limits of 50, 15 –25 and 2-5 mg kg^{-1} respectively as suggested by Jones (1991). Highest Zn content (28 mg kg^{-1}) was recorded in leaves from plot mulched with *Cordia* leaf which could be explained by possible addition of some Zn by partially decomposed *Cordia* leaf. Relatively low concentration of Zn in other treatments was attributed to low organic matter, high pH and high $CaCO_3$ content in soils. The soil available nutrient status data (Table 2) indicated that the mulch materials did not influence significantly on the soil nutrient status.

Growth and fruit yield

Organic as well as synthetic mulches significantly increased the plant height, stem girth and fruit yield over the control (Table 4). The effect of synthetic mulches was more pronounced on fruit yield than the organic mulches. Higher fruit yield under black polyethylene mulch was ascribed to favourable and integrated effect of moderation in hydrothermal regime that enhanced the root growth for better uptake of water and nutrients and thus produced more plant height and plant spread (Munguia *et al.* 1998).

References

Gupta, J.P. (1986). Effect of tillage and mulch on soil and growth and yield of cowpea grown in the arid tropics. *Arid Soil Research and Rehabilitation* **1:** 161-172.

Gupta, J.P. and Gupta, G.N. (1983). Effect of grass mulching on growth and yield of legumes. *Agriculture and Water Management* **6:** 375-383.

Gupta, J.P. and Gupta, G.N. (1986) Effect of tillage and mulching on soil environment and cowpea seedling growth under arid conditions. *Soil and Tillage Research* 7: 233-240.

Jackson, M.L. (1973). Soil Chemical Analysis. (Prentice Hall of India Pvt. Ltd.: New Delhi), 498.

Jones, J.B.Jr. (1991). Plant Tissue Analysis in Micronutrients In: Eds J.J. Mortvedt et al. Micronutrients in Agriculture. (American Society of Agronomy : Madison, Wisconsin) pp. 477-521.

Lindsay, W.L. and Norvell, W.A. (1978). Development of a DTPA soil test for iron, manganese, copper and zinc. *Soil Science Society of America Journal* **42:** 421-428.

Mahrer, Y., Naot, O., Rawitz, E. and Katan, J. (1984). Temperature and moisture regimes in soils mulched with transparent polyethylene. *Soil Science Society of America Journal* **48:** 362.

Munguia, L.J., Quezada, R., Zermeno, G.A. and Penna, V. (1998). Plastic mulch effect on the spatial distribution of solutes and water in the soil profile and relationship with growth and yield of muskmelon crop. *Plasticulture* **116:** 27-32.

Russell, E.W. (1975). Soil Conditions and Plant Growth, ELBS & Longman. Tenth Edn.

Sterk, G. and Spaan, W.P. (1997). Wind erosion control with crop residues in the Sahel. *Soil Science Society of America Journal* **61:** 911-16.

Walker, J.M. (1969). One–degree increments in soil temperatures affect maize seedlings behaviour. *Proceedings of the Soil Science Society of America Journal* **33:** 729.

Wein, H.C. and P.L. Minotti. (1987). Growth, yield and nutrient uptake of transplanted fresh-market tomatoes as affected by plastic mulch and initial nitrogen rate. *Journal of American Society of Horticultural Science* **112:** 759-763.

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