

Mulching Impact on Moisture Conservation—Soil Properties and Plant Growth

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ABSTRACT: The irrigated area of Pakistan mostly falls in the arid to semi-arid climatic region. Potential evapotranspiration is considerably higher, compared to rainfall received and hence, there is need to conserve soil moisture for better crop production/tree plantation. The experiment was carried out on silty clay soil near village Jalalpur Kangra (Sahiwal Site) District Sargodha from June, 2001 to September, 2003. The broad objective of the study was to evaluate the efficiency of different mulching materials on moisture conservation, soil properties and plant growth. The initial EC_e and SAR of 0-15 cm soil ranged between 5.38 to 8.84 $dS\ m^{-1}$ and 75.97 to 94.19 $(mmol_C\ L^{-1})^{1/2}$, respectively. The mulching treatments tested were: T_1 , no mulching; T_2 , placement of rice straw; T_3 placement of polythene sheet; and T_4 , mechanical loosening of soil. In total, twelve plots were constructed each measuring 48 x 48 ft. Sixty four saplings of *Eucalyptus Camandulensis* each at a distance of 6 x 6 ft were planted in each mulching treatment in August, 2001.

The infiltration rate of the soil increased by 30% at the end of the study *i.e.* September, 2003. A maximum decrease of 53% in EC_e of 0-15 cm soil was observed under mulching treatment T_2 , which was followed by T_4 and T_3 . Conversely, a slight increase in EC_e was found in control plots (T_1). A maximum decrease of 45% in soil SAR of 0-15 cm soil layer was also observed under treatment T_2 , which was followed by T_4 , T_3 and T_1 , indicating an overall decrease in the soil sodicity. Irrigation requirement of water was the lowest under the polythene sheet and highest under no mulching. The maximum saving of 45% irrigation water was recorded under polythene sheet followed by 30% under rice straw and 15% in mechanical loosening of soil. Maximum plant height was observed under mulching through mechanical loosening of soil (T_4) which was followed by T_3 , T_2 and T_1 , indicating that mechanical loosening of soil had some positive impact on plant height whereas non application of mulching material had the minimum plant height. Similarly, maximum plant girth was again recorded under mechanical loosening of soil which was followed by T_3 , T_2 and T_1 . Polythene sheet is more effective to reduce water losses, but it is a costly option. Rice straw is very cheap source of mulching material and can be economically utilized, for this purpose.

KEYWORDS: Mulching, Moisture conservation, Saline sodic soil, Plant growth.

INTRODUCTION

Pakistan falls in the arid to semi-arid climatic region of the world. Potential evapotranspiration is considerably higher as compared to rainfall received. High temperature promotes capillary movement of salts upwards causing deposition of salts on the soil surface. The country has one of the largest contiguous irrigation systems in the world, irrigating over about 17 million hectares (Mha), accounting for 90 percent of the

agricultural production in the country (GoP, 2002). Even then the existing canal supplies are insufficient to meet the crop water requirements. Increased pressure of population has catalysed the need to bring more area under cultivation to fulfill the food and fiber demands. To bring more area under cultivation or increase in cropping intensity, some additional water is required, but under the existing situation one of the alternative is the exploitation of the groundwater reserves, the whole quantum of which cannot be used as such because of poor water quality characteristics. The poor quality water can be used for irrigation of salt tolerant crops/tree species by adopting appropriate techniques (Chaudhry *et al.*, 2000, 2001, 2002; Aslam *et al.*,

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1998; and Gupta *et al.*, 1995). However, another option is efficient use of available water resources or to conserve soil moisture (Ahmed *et al.*, 1993; Dixit *et al.*, 1971; Ganno *et al.*, 1992; Kaseem *et al.*, 1977; Okigbo, 1980; and Sakuri *et al.*, 1995) for better crop production/tree plantation. The field experiment was carried out with the objectives to:

- (i) Test the efficiency of soil mulching materials in reducing excessive water loss/water conservation;
- (ii) Evaluate accumulation of salts in the soil; and
- (iii) Impact of mulching practices on the growth of trees.

MATERIALS AND METHODS

The study was carried out on silty clay soil near village Jalalpur Kangra, Sahiwal, District Sargodha from June, 2001 to September, 2003. The selected field was properly leveled and mulching treatments tested were: T_1 = no mulching (Control); T_2 = placement of rice straw, T_3 = placement of polythene sheet, T_4 = mechanical loosening of soil. In total, twelve plots were constructed, each measuring 48 x 48 ft. Sixty four saplings of *Eucalyptus Camandulensis* each at a distance of 6 x 6 ft were planted in each mulching treatment in August, 2001. After completing lay-out of the experiment, soil samples were collected from 0-15 and 15-30 cm depths before initiation of the study for physical and chemical analysis (U.S. Salinity Lab. Staff, 1954). The initial physical and chemical characteristics of soil are reported in Table 1.

Soil samples were also collected in September, 2002 and in January, 2003 to assess the treatments effect on salinization/sodicization. The infiltration rate of soil was measured by using standard Ringing method (Aronovici, 1955) of the start and the end *i.e.* in the month of September, 2003. The cultural operations like soil ploughing, planking, furrow making, sowing of plant saplings and irrigation water application were carried out as usual. Tube well water was used for irrigation having EC, SAR and RSC, 1.74 (dS m^{-1}), 13.49 ($\text{mmol}_c \text{L}^{-1}$)^{1/2} 3.90 ($\text{mmol}_c \text{L}^{-1}$), respectively. Depth to water table was measured at the start of experiment and further monitored twice in each month. The Agro-met mean daily temperature ranged 11 to 44°C respectively, relative humidity, pan evaporation and rainfall data (Table 2) were collected from the meteorological station adjacent to experimental site from June, 2001 to July, 2003 (Water Resources Research Institute, NARC, Islamabad). The irrigation water was measured through cut throat flume (8" x 3'). Mulching materials were applied during December, 2002. The soil samples were collected from 0-30 cm soil depth from each mulching treatment for initial moisture contents. The data on depletion of available moisture contents were collected for irrigation application (ASTM D 2216, 1990) to the mulching treatments. Tube well water was applied at 10.5% moisture level. Plant survival rate was also recorded at the start of the experiment. Effect of mulching materials on plant height and girth was recorded at different intervals during experimentation. The impact of mulching materials on conservation of moisture was also studied.

Table 1: Physical and Chemical Characteristics of Soil

A. Physical

Soil depth (cm)	Sand %	Silt %	Clay %	Textural class	Wilting point %
0-15	11	65	24	Silty clay	11.10
15-30	8	65	27	Silty clay	11.00

B. Chemical

Soil depth (cm)	pH	EC_e (dS m^{-1})	SAR ($\text{mmol}_c \text{L}^{-1}$) ^{1/2}
0-15	8.03-8.71	5.38-8.84	75.97-94.19
15-30	8.47-9.00	5.30-6.18	85.95-110.91

Table 2: Mean Daily Agro. Met Data

Months	Mean daily Temperature (°C)						Relative Humidity (%) at 9 am			Pan Evaporation (mm)			Rainfall (mm)		
	Year						Year			Year			Year		
	2001		2002		2003		01	02	03	01	02	03	01	02	03
	Min	Max	Min	Max	Min	Max									
January	-	-	11	21	6	16	-	78	70	-	47	32	-	-	16
February	-	-	13	23	7	19	-	76	60	-	72	41	-	-	68
March	-	-	22	30	14	27	-	64	35	-	15	51	-	-	12
April	-	-	30	36	20	34	-	47	68	-	22	41	-	-	-
May	-	-	-	-	23	38	-	-	90	-	-	43	-	-	-
June	38	44	-	-	30	41	56	-	87	29	-	38	12	1.4	25
July	32	39	-	-	30	38	76	-	64	21	-	40	15	89	40
August	39	41	-	-	-	-	78	-	-	21	-	-	92	62	-
September	31	36	24	34	-	-	73	48	-	150	51	-	22	46	-
October	26	33	18	32	-	-	67	32	-	11	38	-	-	1.3	-
November	18	28	14	25	-	-	68	17	-	70	51	-	-	0.50	-
December	12	23	9	23	-	-	77	44	-	45	78	-	-	17	-

RESULTS AND DISCUSSION

The effects of different mulching materials on quantum of water applied, infiltration rate of soil, EC_e, SAR, moisture conservation, plant height and plant girth are discussed as under:

Impact of Different Treatments on Infiltration Rate of Soil

The infiltration rate of soil was measured at the start and in September, 2003. During this short span of time, there was an increase of 30% in the infiltration rate of soil, indicating that there was some positive impact of mulching treatments and plant population on the infiltration rate of soil (Table 3). Plant roots pulverize the soil that improves infiltration rate of the soil.

Table 3: Impact of Different Mulching Treatments on Infiltration Rate of Soil (cm/hour)

Infiltration Rate on		% increase
26.06.2001	20.09.03	
0.50	0.80	30

Impact of Different Mulching Treatments on the EC_e (dS m⁻¹) of Soil

The impact of different mulching treatments on the EC_e of soil is presented in Table 4. The maximum decrease of 53% in EC_e of soil was observed under treatment T₂ (Rice straw) in 0-15 cm soil depth. This was followed by T₄. However, there was, slight increase in EC_e in control plots (T₁) in the both soil depths. Capillarity action under arid conditions promotes upward salt movement. Data further reveal that the decrease in EC_e in the lower soil depth *i.e.* 15-30 cm was less as compared to the upper layer.

Impact of Different Mulching Treatments on SAR of Soil

The data presented in Table 5, indicate that the maximum decrease of 45% in SAR of soil was observed under treatment T₂ (Rice straw) in upper 0-15 cm soil depth. This was followed by T₄, T₃, T₁, respectively, indicating overall decrease in soil sodicity. Here the pattern of SAR decrease is somewhat different than the decrease in EC_e of

soil. Addition of rice straw would have reduced soil SAR because of organic matter presence in rice straw, whereas, mechanical loosening of soil would have facilitated leaching of salts to lower soil layers.

Irrigation Water Saving

The data presented in Table 6 indicate that

requirement of water was the lowest under the polythene sheet and highest under no mulching treatment. The maximum saving of water was 45 % under Polythene sheet, 30% under Rice straw, and 15% in Mechanical Loosening of soil treatment. The data presented in Figure 1 clearly reveal the efficiency of each treatment in conservation /saving of irrigation water.

Table 4: Impact of Different Mulching Treatments on EC_e (dS/m) of Soil

Treatments	Depth (cm)	Initial (28.8.01) S_1	Final (5.9.02) S_2	% change in S_2 over S_1
T ₁	0-15	6.95	7.51	+8
	15-30	6.18	7.13	+15
T ₂	0-15	8.84	4.14	-53
	15-30	5.30	5.27	-1
T ₃	0-15	5.38	5.67	+5
	15-30	5.90	5.36	-9
T ₄	0-15	6.90	4.56	-34
	15-30	6.18	4.92	-20

Table 5: Impact of Different Mulching Treatments on SAR ($\text{mmol}_c \text{L}^{-1}$)^{1/2} of Soil

Treatments	Depth (cm)	Initial (28.8.01) S_1	Final (5.9.02) S_2	% change in S_2 over S_1
T ₁	0-15	75.97	70.93	-7
	15-30	94.15	84.76	-10
T ₂	0-15	84.72	46.70	-45
	15-30	85.95	69.00	-20
T ₃	0-15	80.62	80.30	-0.4
	15-30	110.91	70.29	-37
T ₄	0-15	94.19	65.60	-30
	15-30	93.32	66.00	-29

Table 6: Impact of Different Mulching Treatments on Irrigation Water Conservation/Saving

Treatments	No of irrigations applied	Total irrigation applied (%)	% conservation over T ₁
T ₁	7	100	-
T ₂	5	70	30
T ₃	4	57	45
T ₄	6	85	15

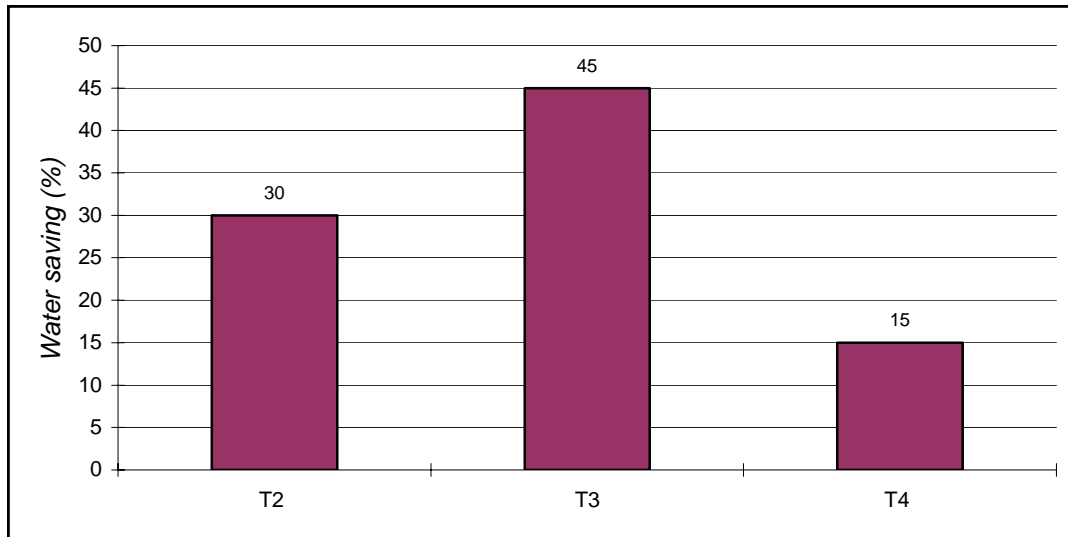


Figure 1: Impact of Different Mulching Treatments on Conservation/Saving of Irrigation Water

Impact of Salinity on Sapling Survival

The impact of salinity on the survival of Eucalyptus saplings under different treatments is given in Table 7. The data indicate that there was not much difference in survival of sapling under varying salinity/sodicity levels possibly due to higher salinity/sodicity tolerance of Eucalyptus saplings.

Impact of Mulching Treatments on Plant Height

The data presented in Figure 2 indicate that maximum height was observed, where mechanical loosening of soil (T_4) was done as mulching treatment. The plants would have

flourished well because of soil pulverization. It was followed by T_3 , T_2 and T_1 , respectively. The moisture conservation through the use of mechanical loosening of soil had some positive impact on plant height as compared to no use of moisture conservation treatment.

Impact of Mulching Treatments on Plant Girth

Like plant height, the maximum plant girth was again recorded when mechanical loosening of soil was used as mulching treatment (Figure 3) and this was followed by T_3 , T_2 and T_1 , respectively. The data indicate that all the mulching treatments have some positive impact, varying in levels compared to no mulching on plant girth.

Table 7: Impact of Salinity/Sodicity on Sapling Survival under Different Treatments

(EC_e , $dS\ m^{-1}$, SAR, $(mmol\ C\ L^{-1})^{1/2}$)

Treatments	Salinity/Sodicity Level (0-15cm)		Survival %
T_1	EC_e	6.95	100
	SAR	75.97	
T_2	EC_e	8.84	99
	SAR	84.72	
T_3	EC_e	5.38	99
	SAR	80.62	
T_4	EC_e	6.90	100
	SAR	94.19	

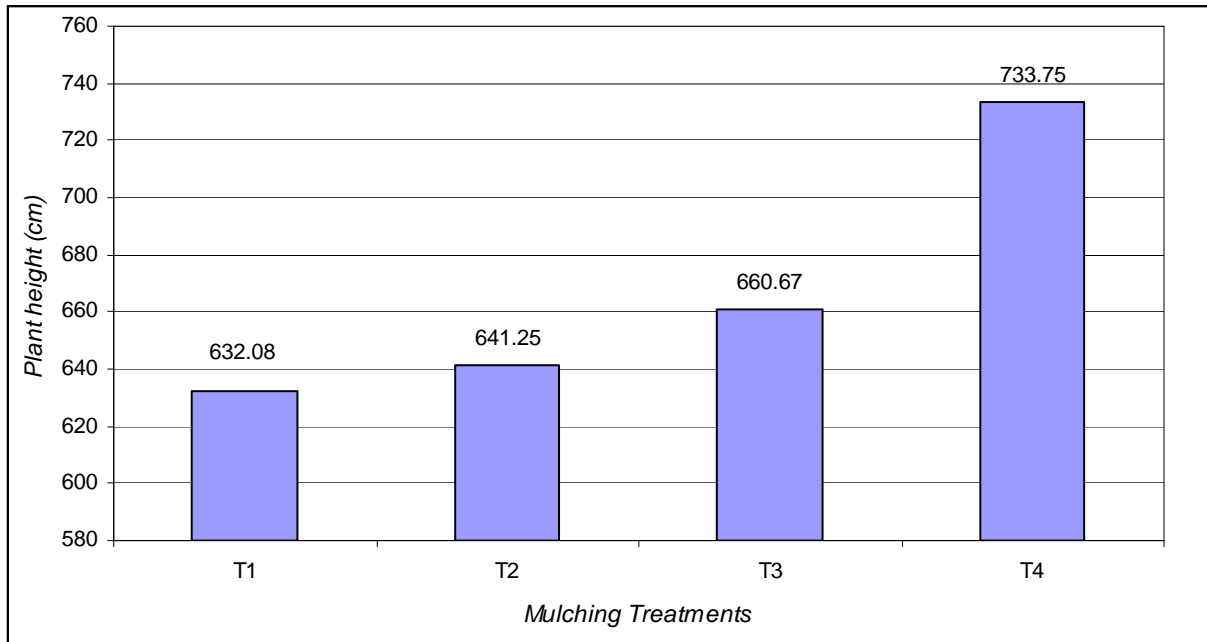


Figure 2: Effect of Different Mulching Treatments on Plant Height

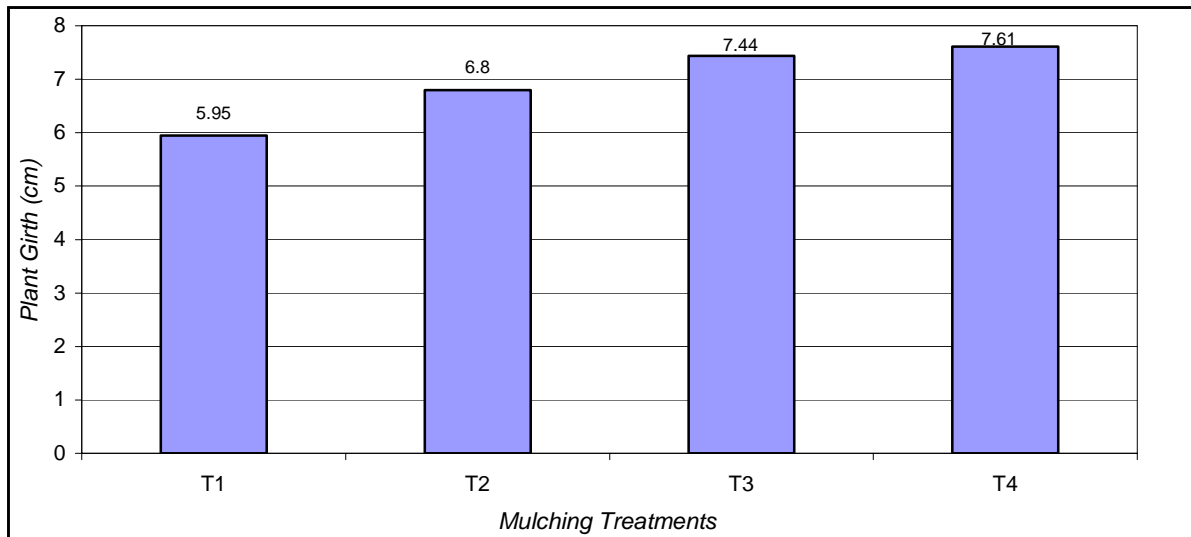


Figure 3: Effect of Different Mulching Treatments on Plant Girth

CONCLUSIONS

- On the average, infiltration rate of soil increased by 30% with mulching treatments;
- Maximum decrease of 53% in EC_e and 45% in SAR of soil was observed under T_2 (rice straw);
- The water requirement was the lowest under polythene sheet mulching and the highest under no mulching treatment;
- Maximum saving/conservation of water (45%) was observed under polythene sheet mulching treatment T_3 followed by 30%, 15% under T_2 , T_4 respectively;
- Better survival was obtained in Eucalyptus saplings up to salinity level $6.95 \text{ (dS m}^{-1}\text{)}$ and sodicity level of $94.19 \text{ (mmol}_c \text{ L}^{-1}\text{)}^{1/2}$ in all treatments;
- Maximum height and girth was obtained under mechanical loosening of soil as mulching treatment (T_4) whereas the minimum height and girth was found under T_1 (no mulching);
- Rice straw (T_2) was found to be the most economical mulching material; and
- The research was conducted under the specified context. However, changes in soil biological health in terms of micro and macro-organisms and fruit plants will be covered under similar studies in future.

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