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Growth and Yield Response of Tomato (*Lycopersicon esculentum* L.) to Organic and Inorganic Mulches

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Abstract: A field experiment was carried out at the Vegetable Research Farm of University of Arid Agriculture, Rawalpindi, during March, 2004 to evaluate the performance of tomato (*Lycopersicon esculentum* L.) under effect of organic and inorganic mulches. The treatments selected were control (control), mulching with 4 inch thick grass, mulching with 4 inch wheat straw, black polyethylene mulch (160 μm gauge) and transparent polyethylene mulch (150 μm gauge). The result reveled that maximum plant height 93 cm and maximum number of leaves 160 was observed in plot mulching with 4 inch wheat straw. Where as, maximum leaf area plant $^{-1}$ 65 cm^2 was produced with transparent polythene mulch 150 μm gauge. Maximum number of flower cluster and fruit plant^{-1} were recorded in plot with mulches 4 inch thick grass. Maximum yield 96.45 t ha^{-1} of tomato was obtained with mulching of 4 inch wheat straw while; minimum yield 55.41 t ha^{-1} was obtain in control. Wheat straw increases 43% tomato yield when compared with control. There was non-significant variation among different treatment as for as soil physical and chemical parameters are concerned. However, mulching treatment conserved 27% more moisture as compare to control. Economic comparison indicates that wheat and grass mulch were more efficient than expansive polythene mulch.

Key words: Wheat straw mulch, Grass Mulch, Black polythene Mulch (160 μm gauge), transparent polythene mulch (150 μm gauge)

INTRODUCTION

Total geographical area of Pakistan is 79.61 million ha. Area under different crops and vegetables are 22.27 and 0.329 million ha, respectively[1]. Total production of vegetables amounts 7.11 million tons, which is very low as compared to agriculturally advanced countries. Tomato occupies an important place among vegetables grown in Pakistan. Tomato is cultivated on an area of 697 ha with annual production of 8190 tons[2]. Tomato is a self-pollinated crop which is quite sensitive to high night-time temperatures, especially the large fruited fresh varieties. Environmental conditions, such as water stress, poor nutrition, unfavorable weather, or insect and disease pressure may result in abscission during or after flowering[3]. Its production is fully dependent on adequate water supply and nutrients, which are main limitation in arid areas. Mulch is any material that covers the soil surface around and under plants to protect and improve the area. Two major reasons for mulching today are to conserve moisture and to achieve optimum production.

Polyethylene mulch has been used commercially on vegetables since the early 1960s. Currently, polyethylene mulch is used on thousands of acres of vegetables in the United States and mulching practices have increased on a wide range of vegetable crops including watermelon, tomato, cucumber and eggplant[4]. Mulching with organic materials is also ideal because it covers the soil surface while conserving moisture. Plastic mulch is better because, in addition to warming the soil and eliminating weeds, it reflects beneficial spectra of light back on to the plants. However, any kind of opaque plastic will do the job adequately[5]. At present, there is need to improve vegetable production and derive ways through which maximum benefits can be obtained from the limited available water resources. In this regard under Rawalpindi conditions, there is a need to standardize production technology under local climatic and edaphic conditions so that the farmers of the area can get maximum benefits from the crop production with limited irrigation resources. So, keeping in view the economic value of tomato crop and usefulness of

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mulching in enhancing tomato yield and quality, an experiment was designed to achieve following objectives i.e. To find out the best mulching material for better growth and development of tomato crop and to explore the best mulching material which will help in saving more soil moisture for tomato crop.

MATERIALS AND METHODS

A field experiment was conducted at vegetable farm of University of Arid Agriculture, Rawalpindi, during March-June 2004. Treatments consisted of 4 mulches:

T_0: Control bare ground
T_1: Mulching with 4 inch thick grass
T_2: Mulching with 4 inch wheat straw
T_3: Black polyethylene mulch (160 μm gauge)
T_4: Transparent polyethylene mulch (150 μm gauge)

A field plot measuring approximately 120 m^2 was prepared thoroughly. Seedlings were sown by keeping plant to plant distance at 30 cm and row to row distance. Treatments were arranged in a RCBD design replicated thrice. Recommended NPK (100:80:40) were applied to all treatments in the form of Urea, Di Ammonium phosphate and Sulphate of Potash. Drip irrigation tape was installed under mulch in all plots. Recommended seedling rate was used for transplanting. The physical and chemical characteristics of experimental soil are given in Table 1.

Soil analysis: Soil samples were collected with an auger from a depth of 0-15 cm before sowing and after harvest from each treatment. The samples were air dried in the laboratory, ground in mortar and pestle, sieved through 2 mm stainless steel sieve and analyzed for Soil moisture pH, ECe, organic matter, nitrogen (N), phosphorus (P) and potassium (K)[6].

Where, ECe is the electrical conductivity of soil and pH is power of hydrogen ions concentration.

Crop data: Simple randomization of each plot was done to select eight plants and following plant parameters were recorded i.e. plant height, No. of leaves/plant, leaf area, number of days to flowering, No. of flower clusters/plant, No. of flowers/cluster, No. of fruits/cluster, No. of fruits/plant, No. of days to fruit maturity, fruit weight/plant and yield (t ha^{-1}).

Economic comparison: Benefit cost ratio for each treatment was evaluated.

Statistical analysis: The data collected for various variables were subjected to statistical analysis using Analysis of Variance (ANOVA) technique. The means were compared by applying Least Significant Difference (LSD) at test 5%[7].

Table 1: Physical and chemical characteristics of crop experimental soil

Soil characteristics	Unit	Value
Texture		
Sand	%	55.00
Silt	%	32.00
Clay	%	13.00
Textural class	Sandy loam	
pH	7.8	
ECe	dS m^{-1}	0.33
Nitrogen	g 100 g^{-1}	0.13
Available phosphorus	mg kg^{-1}	4.50
Potassium	mg kg^{-1}	118.00
Organic matter	g 100 g^{-1}	0.83

RESULTS AND DISCUSSION

Effect of treatments on vegetative growth: Maximum plant height was observed in plots mulching with 4 inch wheat straw and minimum plant height were noted with control and black polyethylene mulch, respectively (Table 2). As it was observed that the maximum number of leaves per plant were observed in plots with 4 inch wheat straw and minimum with control. The results revealed that the maximum leaf area per plant was produced with transparent polyethylene mulch (150 μm gauge) and minimum were observed in control and black polyethylene mulch, respectively. Data showed significant difference for control and black polyethylene mulch when related to the other treatments but among control and black polyethylene mulch have no significant differences. The results clearly indicated that both treatments are causing more moisture loss than the other treatments which lead to the reduction of leaf area and less production of chlorophyll. As review described that black color enhanced the loss of moisture from the soil because it increases the soil temperature and cause stress to the plant to reduce their life cycle[8].

Effect of treatments on reproductive growth: It is evident from the data in Table 3 that maximum numbers of days to flowering were taken with 4 inch wheat straw whereas,

Table 2: Effect of organic and inorganic mulches on yield and vegetative growth parameters

Treatments	Yield (t ha^{-1})	Plant height (cm)	No. of leaves/plant	Leaf area (cm^2)
T_0	*55.41d	*78.26d	*98.63d	*55.79c
T_1	95.860a	90.22b	151.63b	60.05b
T_2	96.450a	93.34a	160.04a	60.78c
T_3	78.760c	80.29c	111.47d	56.93c
T_4	93.520b	89.93b	145.71c	65.23a
$LSD_{0.05}$	17.61	1.64	3.15	2.63

NS = Non-significant
*Means with different letter differ significantly according to LSD (p= 0.05)

Table 3: Effect of organic and inorganic mulches on reproductive growth parameters

Treatments	No. of days of flowering	No. of flower clusters/plant	No. of flowers/ cluster	No. of fruits/ cluster	No. of fruits/ plant	No. of days of fruit maturity	Fruit weight/ plant (kg)
T_0	23.21b*	17.73c*	5.68	3.54b*	56.19b*	13.49b*	3.38b*
T_1	30.88a	30.38a	6.00	5.53a	89.00a	17.44a	6.13a
T_2	31.16a	29.42a	6.00	5.92a	84.99a	17.19a	5.85a
T_3	25.03b	24.93b	5.98	3.99b	75.65b	14.01b	4.35b
T_4	30.45a	29.62a	6.09	5.33a	85.37a	17.62a	6.12a
$LSD_{0.05}$	3.86	2.97	NS	6.13	5.49	1.14	0.82

NS = Non Significant * Means with different letter differ significantly according to LSD (p=0.05)

Table 4: Effect of organic and inorganic mulches on different soil parameters.

Treatments	pH	ECe (dS m^{-1})	OM (g 100 g^{-1})	Moisture (%)	P_2O_5 contents (mg kg^{-1})	K_2O contents (mg kg^{-1})	Nitrogen contents (%)
T_0	7.5	0.33	0.68	13.96b*	4.3	117	0.12
T_1	7.5	0.27	0.86	17.53a	5.31	125	0.22
T_2	7.5	0.27	.88	18.91a	5.10	127	0.36
T_3	7.5	0.32	0.90	14.53b	4.67	124	0.29
T_4	7.6	0.28	0.81	19.26a	4.70	107	0.21
$LSD_{0.05}$	NS	NS	NS	1.97	NS	NS	NS

NS = Non Significant * Means with different letters differ significantly according to LSD (p = 0.05)

Table 5: Effect of cost benefit ratio for tomato crop

Treatments	Total income (Rs. ha^{-1})	Total expenditure (Rs. ha^{-1})	Cost benefit ratio
T_0	42124	27500	1.53
T_1	68205	33800	2.01
T_2	70630	34700	2.03
T_3	52817	37900	1.39
T_4	66353	37500	1.76

minimum numbers of days to flowering were recorded with control. Further, it was noted that the maximum number of flower clusters were recorded in plants treated with mulching of 4 inch thick grass and minimum number of flower clusters were recorded with control treatment. The results for number of flower per cluster were non significant for each treatment. Maximum fruits per cluster were counted with mulching of 4 inch wheat straw and minimum fruits per cluster were counted with control. Maximum fruits per plant were recorded in mulching with 4 inch thick grass and minimum fruits per plant were maturity were recorded with transparent polyethylene mulch (150 μm gauge) while, minimum number of days were recorded with control treatments. The influence of different mulching materials on flowering, fruit set and harvest readiness were advanced by the mulching treatments. Mulching materials produced significantly higher number of flower clusters per plant and increased fruit set percentage as compared to control treatment[9].

Effect on yield: Significant differences among the treatments were noticed for yield. Maximum total weight per plant was obtained with 4 inch thick grass whereas; the minimum weight per plant was weighed with control treatment (Table 2). Maximum yield was obtained with mulching of 4 inch wheat straw while; minimum yield was obtained with control treatment Black polyethylene mulch gave yield, because it raised the soil temperature. This effect derives mostly from the suppression of latent heat loss through evaporation. The extent of the increase in soil temperature depends on the color of the film and the intensity of solar radiation[10].

Effect of treatments on soil parameters: The results revealed that mulching material did not affect soil pH, Ec_e (Table 4). This is evident from the data that use of mulches maintained organic matter in the soil. The results showed that treatments differed significantly for moisture contents per treatment These results also endorsed that maximum moisture contents were obtained with transparent polyethylene mulch (150 μm gauge) and minimum soil moisture contents were obtained with control treatment followed by black polyethylene mulch (160 μm gauge). This might be due to the reason that light reflection by the mulching material reduced the soil temperature and enable soil to retain the moisture for longer period of time than unmulched plots. Other macronutrients such as nitrogen (N), phosphorus (P) and potassium (K) in the soil were not significantly effected by the treatments before sowing and after the harvest of the crop. Grass mulching improved soil temperature and soil moisture regimes compared with bare ground and it also improves the vegetative and reproductive performance with increased fruit yield of tomato over bare ground[11].

Economic comparison: Data in Table 5 represents the benefit cost ratio of tomato crop. In plots where mulching was provided with 4 inch thick grass and 4 inch wheat straw gave maximum benefit cost ratio, respectively. Minimum benefit cost ratio shown by black polyethylene mulch (160 μm gauge) followed control treatment and transparent polyethylene mulch (150 μm gauge),

respectively. This might be due to the high cost of mulching material, which gave significant difference between the organic and inorganic mulches.

The economic importance of mulching used can be worked out for specific situation prior to the large scale adoption for commercial plant production. However, the use of mulching for better growth and higher yield could be economically attractive to reduce the drought conditions in water limiting areas. Due to high cost of inorganic mulch material, it may not be very practical to ordinary farmers but organic mulch materials showed same production level as plastic mulch materials. Besides, organic mulch material also involves less cost as compared to inorganic mulch material.

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