EFFECT OF PARTIAL DECOMPOSED ORGANIC MULCH IN REDUCING SALINITY IN RHIZOSPHERE TO IMPROVE OVERALL PLANT GROWTH

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Abstract

The partially decomposed organic mulch, alone or amended with gypsum was investigated in decreasing salinity level of rhizosphere and improvement of overall growth and yield of okra plant under different salinity levels in irrigation water. The okra plants were grown in large clay pots (diameter, 30 cm) and irrigated with water of different salinity levels i.e. non-saline control (C, EC_{iw} = 0.5 dSm^{-1}), 0.15% Sea salt solution (S1, EC_{iw} = 2.0 dSm^{-1}) and 0.3% sea salt solution (S2, EC_{iw} = 4.2 dSm^{-1}). Vegetative growth (shoot height, fresh & dry biomass) and reproductive growth parameters (number of fruits, average fruit length and total fruit weight per plant) were found to be proportionally decreased under increasing salinity in irrigating water without application of mulch or gypsum treatments. The application of mulch either alone or amended with 0.2% gypsum revealed significant improvement in all the above mentioned parameters under control and both the salinity levels. Mulch alone improve total fruit yield 17%, 13% and 31% under control, S1 and S2, whereas more improvement was recorded if mulch amended with gypsum 96.8%, 68% and 53% respectively. The comparative analysis of the mulch treatments summarized as under.

Mulch & Gypsum > Gypsum > Mulch > Non-Mulch

The results suggested that application of partially decomposed organic mulch (with or without gypsum amendments) to the soil surface can increase tolerance level of okra and improve overall growth and yield of the plant.

Introduction

The progressive salinization leads to desertification of the land. About 10% of the total land surface of the globe is affected by salinity which extends throughout the all continents except Antarctica (Szabolcs, 1991). Additionally, scarcity of good quality of water and utilization of saline water for irrigation leads to secondary salinization of the agricultural land. According to FAO, (2008) it is estimated that 20% of irrigated land and 2% of dry lands of the total agricultural lands are affected by secondary salinization (due to human activities). The main cause of lowering the crop productivity and land degradation is soil salinity (Ashraf, 2009; Saleem *et al.*, 2011).

There are several management practices were described by the scientists to overcome this problem at greater extent. Surface mulching either with inorganic material (pebbles, rocks, slabs, plastic sheets etc) or organic material (farm waste, house hold waste, lawn clippings, sawdust, wood chunks etc.) to reduce salinity hazards and improve crop yield is also reported by many scientists. Rice straw and gravel mulches improved fresh and dry biomass of *Beta vulgaris* grown under saline water irrigation (Zhang *et al.*, 2009). Mulching can help in many ways, like, it can help to retain moisture for longer period of time, improve infiltration and reduce evapotranspiration rate by soil (Bond and Willis, 1969; Smika and Unger, 1986). Mulches can also releasing nutrients slowly in root zone and improve plant growth (Benitez *et al.*, 2000; Ansari *et al*, 2001). Sadegh-Zadeh *et al.*, (2009) reported more water content and lower EC values under layered mulch plot than bare soil. Lowering soil salinity by organic mulching and improve yield of F1 tomato also reported by Saeed & Ahmad (2009). The effectiveness of the organic mulch (composed of mixture of grass clippings, saw dust and cow dung manure) alone, or in combination with gypsum to grow salt sensitive plant (okra) was observed with saline water irrigation, so that farmer's can get benefit with limited resources to obtained feasible yield of okra.

Materials and Methods

Experiments were conducted at the Biosaline Research Nursery, Department of Botany, University of Karachi.

Moisture content, EC and water retention of mulch: The mulch was prepared by mixing of grass clipping, sawdust and cow dung in a ratio 1**:**2**:** 1. The mulch was allowed to decompose for about 6 months. The partial decomposed mulch was used with or without gypsum (0.2% w/w) amendments in this experiment. Moisture content, EC and water retention capability was recorded.

100 gram of the mixture was taken in a beaker; soaked with enough water and left for 8 hours under complete water saturation. The excess water was allowed to drain and the material was re-weighted to determine the weight of mulches with beaker at total (100%) saturation (TS). The material was leave at room temperature that fluctuated between 28-30^{o}C. The weighing was continued after every 48 hours until the weight of water in saturated mulch was half (50%) of that at 100 % saturation. Water content in mulch was determined by following formula,

$$\%\ \text{Moisture Content} = \frac{\text{Loss of weights in Mulch}}{\text{Dry weight of Mulch}} \times 100$$

Electrical conductivity: Mulch material was taken in a beaker, saturated with deionized water and filtered under vacuum. EC (electrical conductivity) of saturated extracts were measured by using 4510 conductivity meter (JENWAY, UK).

Plant Culture & Data Collection /Experimental Design: Five surface sterilized seeds of okra plant **(*Abelmoschous esculentus*, Moench)** were sown in each clay pot. Thinning of seedlings was done at three-leaf stage (excluding cotyledons) leaving a single well-developed seedling of similar vigor in each pot.

The pots were of 30 cm diameter, 30 cm deep with basal hole. Each pot was filled with 20 Kg of sandy loam soil and cow dung (9:1). Fertilizer was given as NPK ratio (10:6:6) vide urea, DAP (Diammonium phosphate) and SOP (sulphates of potash), per recommendation of Ayoola & Adeniyan (2006). Micronutrients (Hoagland and Arnon, 1950) were also given along with fertilizers through irrigation water. Total of 60 pots were divided into 3 sets of 20 pots each under following three salinity treatments.

Salinity Levels:

Set No. 1: = Control, irrigated with non-saline water (EC_{iw} 0.5dSm^{-1}) (C)
Set No. 2: = Irrigated with 0.15 % sea salt solution (EC_{iw} 2.0 dSm^{-1}) (S1)
Set No. 3: = Irrigated with 0.3 % sea salt solution (EC_{iw} 4.2 dSm^{-1}) (S2)

Control plants were irrigated with tap water only. Irrigation with saline water was started with gradual increase of sea salt solutions in irrigation till it reached to respective salinity level of each treatment. The salinity treatment S1 and S2 are bit higher than threshold ECe given in literature, i.e. ECe 1.0 dS m^{-1} and slope of curve of yield reduction by increasing one dSm^{-1} is 10 % for *Abelmoschus esculentus* (Bresler *et al.*, 1982). Each pot was irrigated with 3.5 litre of tap water or sea salt solutions whenever needed ensuring about 40% leaching.

Twenty pots each of the above mentioned sets were subjected to four treatments having five replicates in each. About four inch thick layer of mulch was placed on the surface of soil in each pot at 3-leaf stage. Insecticides (Laser/ Fyfanon) were used when ever required.

Mulch Treatments:

T1. Without mulch or gypsum
T2. Mulch only
T3. Gypsum only
T4. Mulch mixed with Gypsum

Vegetative and reproductive growth parameters were investigated at grand period as follows,

i. Vegetative growth parameters: Shoot height, fresh biomass and dry biomass was recorded at grand period of growth about three months after sowing.

ii. Reproductive yield components: Number of fruits per plant, average each capsule length and total yield (total weight of all pos) per plant was monitored starting from initial fruit setting till harvest.

iii. Salinity of Rooting Medium: EC of saturated extracts of soil and mulch samples were taken separately prior to and after saline water irrigation by conductivity meter (4510 JENWAY) according to Richards (1954).

Statistical Analysis: The experiment was performed in randomized complete block design with three replicates maintained for each treatment. Two-way ANOVA was used to analyze the data (SPSS, ver.16). Least significant difference ($LSD_{0.05}$) was calculated for comparison of using Duncan Multiple Range Test (Duncan, 1955).

Results and Discussion

Moisture content, EC and water retention of mulch: The data presented in **Figure 1** showed about 200% water content at full saturation of the partially decomposed organic mulch (mixture of grass clipping, sawdust and cow dung manure 1:2:1). This mulch retained 50% water of its full saturation till 21 days. Further more the application of this mulch reduces salinity status of the soil of rhizosphere as presented in **Table. 1**. The EC values were reported comparatively higher in the mulch layer than the soil beneath it. The pH values were variable, but the ranges were found within neutral limits. Khurshid, *et al*. (2006) have found betterment in soil structure and water content by mulches which improve growth of maize under arid conditions. Kimmins (1997) reported that organic mulches can reduce the water losses in mineral soils. Better corn yield was reported by Bu, *et al.*, (2002) due to reduction in evaporation and salt accumulation from the surface by straw mulching. They have reported that concrete mulch better reduce surface salinity over plastic mulch and bare soil. Makus *et al.*, (1994) found an increase in plant height and number of capsules per plant with application of loblolly and long leaf pine straw mulches during the moisture deficit period in Mississippi.

Sekhon and Bajwa (1993) have reported improvement in crop yield (rice, wheat and maize) with application of gypsum which decreased the precipitation of Calcium and increased the removal of sodium in the soil. Amelioration with gypsum has been shown to decrease dispersion, improve hydraulic conductivity and reduce crust strength with drying (Bell *et al.*, 1992). Application of calcium carbide with Nitrogen fertilizer in soil enhances green capsule yield in okra by 37% (Kashif *et al.*, 2008).

Effect of salinity on Vegetative and reproductive Growth: Data on different parameters of vegetative growth (i.e., shoot height, fresh and dry biomass) and reproductive growth (i.e., number of capsules, average length of capsule and total fruit weight per plant) under treatments of mulch, gypsum and their mixture with reference to irrigation of two different sea salt salinity levels is presented in **Figure 2 & 3**.

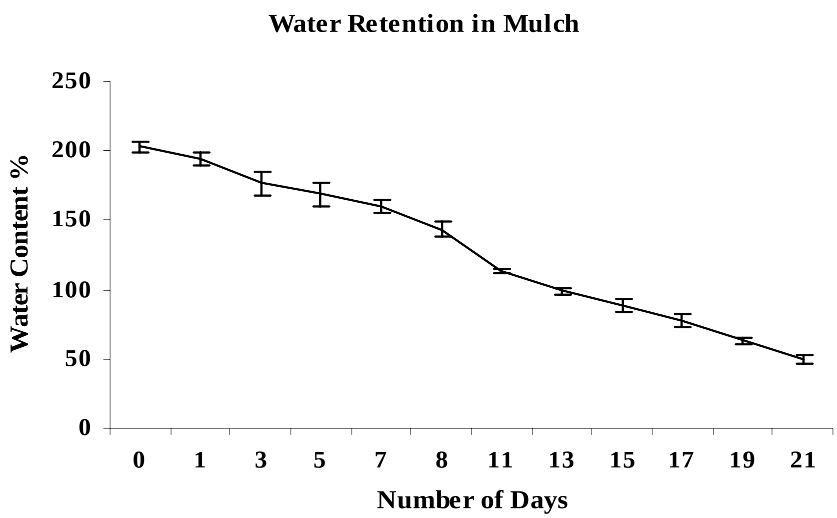


Fig. 1. Percent water retention in mulch with duration of time. Vertical bars show SE.

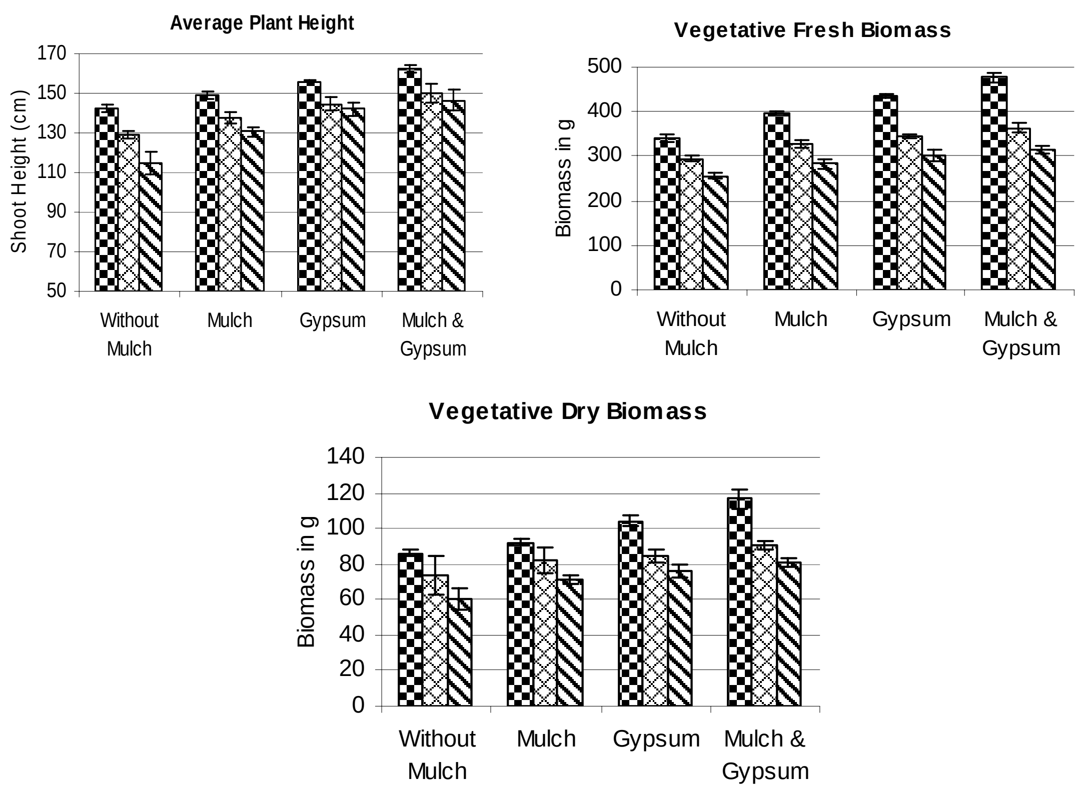
Table 1. Salinity status of rooting medium under mulch treatment.

a. Prior to the experiment

Salinity	Mulch Treatment	EC of Soil dS m^{-1}	EC of Mulch dS m^{-1}
Before use in experiment		1.41 ± 0.05	1.4 ± 0.06

b. After saline water irrigation at harvest of okra plant

Salinity	Mulch Treatment	EC of Soil dS m^{-1}	EC of Mulch dS m^{-1}
Control (0% Sea Salt) EC_{iw} = 0.5 dS m^{-1}	Without Mulch	1.8 ± 0.05	-
	Mulch	1.51 ± 0.04	1.8 ± 0.01
	Gypsum	2.8 ± 0.03	-
	Mulch & Gypsum	2.1 ± 0.08	2.9 ± 0.17
S_1 (0.15% Sea Salt) EC_{iw} = 2.0 dS m^{-1}	Without Mulch	3.11 ± 0.11	
	Mulch	2.11 ± 0.11	3.2 ± 0.12
	Gypsum	4.02 ± 0.10	-
	Mulch & Gypsum	3.6 ± 0.26	4.2 ± 0.15
S_2 (0.3% Sea Salt) EC_{iw} = 4.2 dS m^{-1}	Without Mulch	4.31 ± 0.13	
	Mulch	3.2 ± 0.06	4.6 ± 0.15
	Gypsum	5.6 ± 0.15	-
	Mulch & Gypsum	3.4 ± 0.06	5.8 ± 0.26



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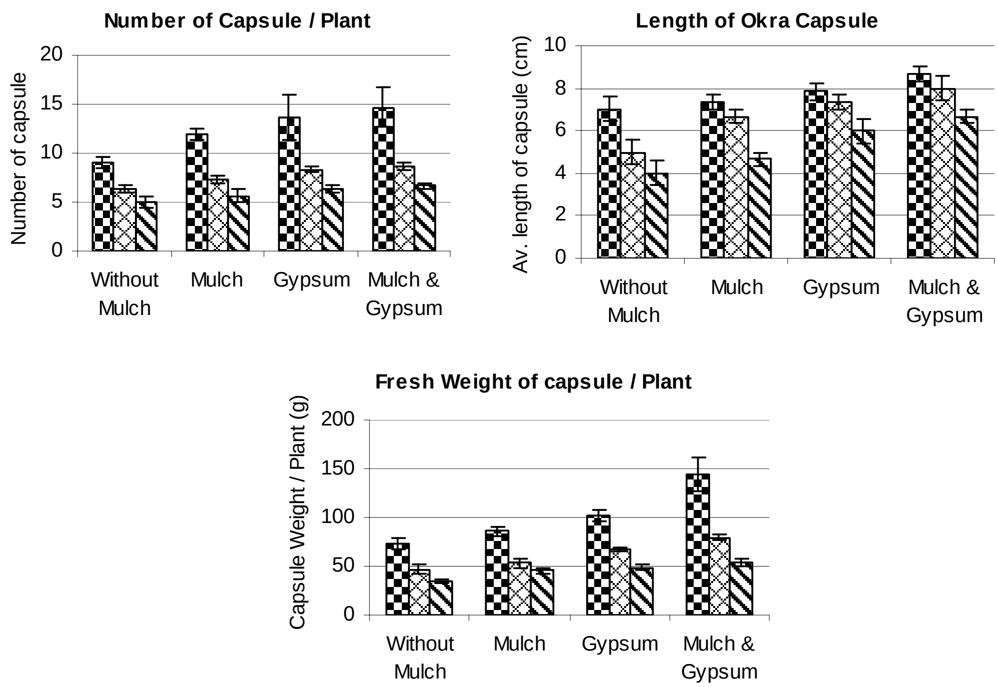
Control, EC_{iw} = 0.5 dSm^{-1} S_1 (0.15 %) EC_{iw} = 2.0 dSm^{-1} S_2 (0.3%) EC_{iw} = 4.2 dSm^{-1}

Fig. 2. Shoot height, fresh and dry vegetative biomass of okra grown under irrigation water of two different sea salt concentrations supplemented with application of mulch, gypsum, and their mixture.

Table 2. ANOVA for different parameters of vegetative growth of okra grown under irrigation of different dilutions of sea salts concentrations.

Source	Dependent Variable	F	Sig.
	Shoot Height	11.243	0.000
Salinity	Fresh Biomass	251.073	0.000
	Dry Biomass	30.160	0.000
	Shoot Height	14.833	0.000
Mulch	Fresh Biomass	67.390	0.000
	Dry Biomass	10.729	0.000
	Shoot Height	4.665	0.003
Salinity * Mulch	Fresh Biomass	5.230	0.001
	Dry Biomass	0.617	0.714



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Control, EC_{iw} = 0.5 dSm^{-1} S_1 (0.15 %) EC_{iw} = 2.0 dSm^{-1} S_2 (0.3%) EC_{iw} = 4.2 dSm^{-1}

Fig. 3. Number of capsules per plant, average capsule length and total weight of capsule per plant of okra grown under irrigation water of two different sea salt concentrations supplemented with application of mulch, gypsum, and their mixture.

Table 3. ANOVA for different parameters of reproductive growth of okra grown under irrigation of different dilutions of sea salts concentrations.

Source	Dependent Variable	F	Sig.
Salinity	No. of Capsules	45.267	0.000
	Length of Capsules	27.110	0.000
	Weight of Capsules /Plant	79.636	0.000
Treatment	No. of Capsules	6.232	0.003
	Length of Capsules	15.864	0.000
	Weight of Capsules /Plant	22.158	0.000
Salinity * Mulch	No. of Capsules	0.898	0.512
	Length of Capsules	0.766	0.604
	Weight of Capsules /Plant	3.842	0.008

Okra is salt sensitive plant having threshold value 1.0 dS m^{-1} and slope of reduction is 10% (Bresler *et al*., 1982) whereas, Unlukara *et al*., (2008) reported as moderately tolerant having threshold ECe 3.48 dS m^{-1} and slope is 4.2%. Present investigations also revealed significant reduction ($P < 0.001$) in shoot height (S1 = 9.37%, S2 = 19.4%), fresh biomass (S1 = 13.4%, S2 = 25%) and dry biomass (S1 = 14.2%, S2 = 29.68%) under increasing concentration of sea salts in irrigation water. Severely decreased shoot and root length of okra plants were reported by Shahid *et al.*, (2011). Abid *et al.*, (2002) reported depression in plant height, fresh and dry weight in okra with the increasing levels of ECiw and SARiw. The growth of okra was affected due to salinity because okra is more sensitive at earlier growth stages to salinity (Cerda *et al.*, 1982). A decrease in root length with the increments in salinity also noted by some other researchers, Kasukabe *et al.*, (2006) in Arabidopsis and Kasukabe *et al.,* (2004) in Okra.

Reproductive yield is greatly depending upon the vegetative growth and nutrients availability in rhizosphere. Results showed similar trends of reproductive growth as that of vegetative parameters. Highly significant reduction ($P<0.001$) was proportional to increasing levels of sea salts in irrigation water. Reduction in fruit number (44.4%), fruit length (42%) and total fruit weight per plants (52%) was noted at higher salinity level S2 (ECiw = 4.2 dSm^{-1}). Reduction in fruit yield under saline conditions is also reported by other scientists, Caro *et al.*, (1991) in tomato, Savvas & Lenz (2000) in egg plant, Botia *et al*, (2005) in melon. Lauchli & Grattan, (2007) have shown hastening in growth of wheat under salt stress and inhibiting development of spikes. Saeed & Ahmad (2009) have also reported reduction in vegetative and reproductive growth of F1 tomato under increasing salinity stress. Kausar *et al.*, (2012) reported proportional reduction of vegetative parameter (root and shoot lengths and fresh and dry biomass) in all the lines/varieties of sorghum with increasing level of salinity.

Effect of mulch on vegetative and reproductive growth: Data on different vegetative parameters and reproductive growth in okra with application of mulch irrigating with different concentration of sea salts in irrigation water is presented in Figure 2 & 3. The application of mulch shows highly significant increase ($P< 0.001$) at all the parameters under non-saline (control) and saline water irrigation. Addition of gypsum alone at top of the soil shows a significant increase ($P< 0.001$) at all the above mentioned parameters. Application of mulch (which is partially decomposed mixture of grass clippings, saw dust and cow dung in a ratio of 1:2:1) has offset the salinity hazards. The mulch has enhanced the growth of okra plant by increasing their overall plant growth specifically their height, fresh and dry biomass since it can retain water and provide necessary nutrients to the root zone during entire growth period. Percent promotion and reduction in comparison with non-mulch control on vegetative and reproductive parameters is presented in tables 4 & 5. The increase in capsule yield due mulch alone appears as, non-saline control = 17.35% > S_1 = 12.76% > S_2 = 31.42%. Whereas, mulch amended with gypsum showed greater promotion under salinity treatments as non-saline control = 96.8% > S_1 = 68.08% > S_2 = 53.33%. Comparatively greater promotion in vegetative parameters and reproductive attributes of okra is noticed in present investigations under mulch supplemented with gypsum as compare to mulch alone or without mulch treatments both under non-saline as well as saline conditions.

Mulch & Gypsum > Gypsum > Mulch > Without Mulch

Somewhat similar results were reported by Saeed & Ahmad, (2009) in tomato by organic mulch grown under different salinity regimes. Ali., (2011) found rice straw mulch improve maize yield by improving soil physical properties (such as bulk density, total porosity, moisture constant, hydraulic conductivity, organic content, and pore size distribution). Adekalu *et al.*, (2008) reported higher shoot height, leaf area, stem diameter, dry matter and yield for okra (variety NH99) grown under grass mulched over un-mulched plots while studying irrigation requirement by irrigating with only 30% moisture depletion and agronomic management to cultivate okra plants. Wang *et al.*, (2006) found greater okra fruit yield (48-50 g in first year, 62 to 68 g) over control (having only 27-52 g/pot in respective years) while using yard waste compost.

Conclusion

The present research revealed that partially decomposed organic mulch (mixture of grass clipping, sawdust and cow dung in a ratio of 1**:**2**:** 1) can maintain moisture content for about 21 days after full saturation. Furthermore, increase in capsule yield of okra grown even under saline water irrigation by improving salinity tolerance beyond its threshold EC values as reported earlier. The more pronounced increment in growth and yield is suggestive due to application of mulch amended with gypsum.

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