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Polythene Mulch and Irrigation for Mitigation of Salinity Effects on Maize (*Zea mays* L.)

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Abstract

A pot experiment was conducted at the net house of Patuakhali Science and Technology University during *rabi* season 2014-15 to estimate the contribution of polythene mulch and irrigation on reducing of salinity effect on maize (*Zea mays* L.). The experiment was laid out in a three factors randomized complete block design with three replications. The factors were salinity (two levels: without and 5 dS/m salinity), mulch (two levels: without and with polythene mulch) and irrigation (three levels: 125, 250 and 500 ml water/irrigation). BARI hybrid maize-7 was the test crop. Every pot received the same amount of fertilizer nutrients. Crops were harvested at tassel initiation stage. Mulch increased soil temperature by 2 to 4.5°C (with average of 3.1°C) over without mulch. In without mulch condition, salinity reduced shoot fresh and dry, and root fresh and dry weight by 28.3, 10.3, 39.4 and 30.6%, respectively. In with mulch condition, however, these reductions were 1.0, 7.2, 12.3 and 12.1 %, respectively. Polythene mulch reduced salinity induced reduction of the above parameters by 96.5, 30.1, 68.8 and 60.5 %, respectively. Under 125, 250 and 500 ml water/irrigation treatment, salinity reduced shoot fresh weight by 14.2, 19.3 and 6.7 %, respectively; shoot dry weight by 15.4, 6.6 and 5.0 %, respectively; and root fresh weight by 27.5, 20 and 11.6 %, respectively. Thus, the effect of salinity in maize was gradually decreased with the increasing amounts of irrigation water. Soil salinity reduced phosphorus and increased sulphur content in maize plants.

Keywords: Coastal Bangladesh, irrigation, maize, mulch, salinity.

1. Introduction

The coastal region of Bangladesh is under the constant threat of soil and water salinization (MoA and FAO, 2013). Both magnitude and extent of soil salinity have been increasing with time as being 0.83, 1.02 and 1.06 mha in 1973, 2002 and 2009, respectively (FRG, 2012). This changes created negative impact on soil fertility and crop productivity (Haque *et al.*, 2008), which underpins the rural economy of coastal Bangladesh. The average cropping intensity (%) in the coastal areas has not been increased keeping pace with that of floodplain agriculture. About 30-50% of net cropped area remains fallow in Rabi and Kharif-1 seasons in the coastal region. Intensive irrigation with light saline surface water in such areas further complicated the problem, leaving behind huge salt deposits after evaporation, leading to secondary salinization and alkalinization (Roychoudhury and Chakraborty, 2013). The salinity increases in dry months showing a peak in March-April and decreases in wet months

with the minimum in July-August (Haque *et al.*, 2014). The prevailing salinity intrusion vis a vis climate change has severely affected the crop productivity in the saline regions of Bangladesh. The situation calls an urgent need to improve crop productivity. Introduction of new crops and/or crop varieties in the fallow lands of the coastal regions might be the scholastic technique for improvement of system productivity.

Maize (*Zea mays* L.) is the third most important cereal crop after rice and wheat, and is grown under a wide spectrum of soil and climatic conditions of Bangladesh. It is reported as a moderately sensitive crop to salt stress (Chinnusamy *et al*., 2005). Considering the yield potentiality and national demand, maize can be introduced in the coastal saline soils of Bangladesh. However, in the salt-affected soils, the excessive build up of sodium and chloride ions in the rhizosphere led to severe nutritional imbalance in maize due to their strong interference with other elements, such as potassium, calcium, nitrogen, phosphorus, magnesium, iron, manganese, copper, and zinc (Karimi *et al.*, 2005; Turan *et al.*, 2010).

Sulphur is reported to be an essential macro element deficient in most of the soils of Bangladesh (FRG, 2012). Presumably, the salinity also interferes the entry of S into plant like that with other negatively charged elements, though the proposition demands logical study. Nonetheless, growing maize in *Rabi* season is seriously hampered by soil and water salinity in the southern coastal region. Irrigation with deep or shallow tube-well water is not a common practice in this area due to high underground water salinity. Some canals and homestead ponds bear little amount of sweet water, which can be a potential source of irrigation water. A judicious and efficient use of this water in irrigation purpose can improve the tolerance capacity of maize to soil salinity in *Rabi* season. A low water requirement as well as low cost irrigation technology is therefore essential for optimum use of this limited water resource for cultivation of maize in the saline soil. Use of polythene mulch presumably overcome this problem to some extent. As an important farming technique polythene mulch is used widely all over the world for its significant benefits that confers for crop yield increase and water conservation matters (Sun *et al*., 2014).

Use of polythene mulch might potentially reduce the capillary rise and evaporation loss of water from the soil, the salinization of surface soil by underground water, and the amount and frequency of irrigation required for maize cultivation. Moreover, polythene mulch is reported to be an effective strategy for promoting crop emergence by modifying the soil microclimate through increasing the soil temperature in winter (Bu *et al*., 2013; Dong *et al*., 2009; He *et al*., 2010). According to Bu *et al*. (2013), polythene mulch can retain precipitation, reduce water loss and increase the water use efficiency of crop plants. Despite some works been reported on the use of polythene mulch to reduce soil erosion (Zhang *et al*., 2013) and water conservation (Ingman *et al*., 2015), the effect of the mulch on managing saline soil for potential maize production has poorly been understood. The experiment was therefore conducted to estimate the contribution of polythene mulch and irrigation water for the mitigation of salinity effect on maize cultivation in the saline area of Bangladesh.

2. Materials and Methods

The pot experiment was conducted at the net house of the Patuakhali Science and Technology University (PSTU) during *Rabi* season 2014-2015. The pot soil was collected from PSTU research farm. Soil clods were broken with a wooden hammer. Thirty six plastic pots were decorated in the net house. Ten kilogram well prepared soil was taken in each pot. The general soil type of the experimental soil was Non-calcareous Grey Floodplain soils under the AEZ 13 (Ganges Tidal Floodplain). The soil was silt loam and initial soil had the following properties at 0–15 cm depth: sand 375 g kg^{-1}, silt 525 g kg^{-1}, clay 100 g kg^{-1}, 6.8 pH, 0.16 dS/m electrical

conductivity ($EC_{1:5}$), 1.14% organic matter, 1.12 mg g^{-1} total N, 7.29 mg kg^{-1} available P (Olsen), 0.06 cmol kg^{-1} exchangeable K and 10.0 mg kg^{-1} available S contents.

The experiment was conducted in a three - factor randomized complete block design with three replications. The factors were salinity (two levels: without salinity and 5 dS/m salinity), polythene mulch (two levels: without-polythene mulch and with-polythene mulch) and irrigation (three levels: 125 (I_1), 250 (I_2) and 500 (I_3) ml water/irrigation). Salinity (5 dS/m) was given in soil during filling of pot with soil using crude salt. The amount of salt required for 10 kg soil was calculated and mixed thoroughly with soil. Total eighteen pots received salt and were labeled as S_1. The pots not received salt was labeled as S_0.Eighteenplastic pots were covered with white polythene sheet (semi transparent film) as a lid of each pot at 10 DAS and labeled as P_1(mulch).Before covering, a central 3 cm diameter hole was made on the sheet. During covering, the young maize seedling was kept middle of this hole.

According to the treatments and layout, three levels of irrigation was given in the respective pots. Irrigations were made when plant leaves started to wilt down. The total amount of irrigation water given in I_1, I_2 and I_3 treatment was 1875, 3750 and 7500 ml, respectively. The total number and amount of irrigation under treatment I_1, I_2 andI_3 were maintained same for mulched and non-mulched pots so that every pot received similar environment. Two seeds were sown in central position of each pot on 10 January 2015. At 10 DAS one seedling were thinned out keeping one seedling per pot. The crop was maize and crop variety was BARI hybrid maize-7.Every pot received equivalent to 250, 70, 120 50, 4 and 1 kg/ha N, P, K, S, Zn and B as urea, triple super phosphate, muriate of potash, gypsum, zinc sulphate and boric acid respectively. Except urea, all the fertilizers applied during pot preparation. Urea was applied in three equal splits at pot preparation, 30 and 60 days after sowing.

Crops were harvested at tassel initiation stage on 6th April 2015. Observation was made on fresh and dry weight of shoot and root, plant height, leaves per plant, leaf length and, phosphorus and sulphur contents. Leaf length data were recorded by measuring largest leaf of a plant. Phosphorus was determined colorimetrically using molybdovanadate solution yellow colour method (Yoshida *et al.*, 1976) and the S concentration by turbidity method (Chapman and Pratt, 1964). Data were statistically analyzed following F-test and the mean comparisons were made by DMRT (Gomez and Gomez, 1984).

3. Results and Discussion

3.1 Soil temperature

Soil and air temperatures of the with- and without-polythene mulch treatments were recorded during March 9, 2015 to April 3, 2015 at every alternate day. Over the sampling dates soil temperature in without-polythene mulch treatment ranged from 35 to 39 °C against in the with mulch treatment from 36 to 42 °C (Table 1). It indicated that under mulch treatment soil temperature fluctuated more compared to without polythene mulch treatment. The mean temperature of soil in without mulch and with-mulch treatment was 36.4 and 39.5 °C, respectively. Thus the results clearly evidenced that use of transparent polythene mulch can increase soil temperature by 3.1°C. The air temperature was found 1 to 2 °C lower than the soil temperature during the entire data recording periods with mean of 34.5°C. Aragüés et al. (2014) reported that mulches accelerate crop development in cool climates by increasing soil temperature.

3.2 Plant height

Salinity significantly reduced, while polythene mulch and irrigation treatments increased the plant height (Table 2). The plant height under non saline condition was 106.2 cm and under saline condition that was 95.8 cm. It showed that salinity reduced plant height by 9.8 %. A distinct effect of polythene mulch was found on plant height. In without-polythene mulch treatment the

plant height was 93.2 cm and that of 108.8 cm under with-polythene mulch treatment (Table 2). The results indicated that polythene mulch increased plant height by 16.7 %. The irrigation effect was also very prominent. At harvest the plant height was found as 93.9, 98.8 and 110.4 cm in I_1, I_2 and I_3 treatments, respectively.

The salinity and polythene mulch interaction effect on plant height is presented in Table 3. When polythene mulch was not used, application of 5 dS/m salinity reduced plant height by 10.9 cm but when polythene mulch was used these reduction was 9.9 cm. The result indicated that the polythene mulch maintain plant height closer to non saline condition. Irrigation × salinity interaction effect on plant height is presented in Table 4. Application of salinity reduced plant height by 6.8, 13.5 and 10.8 cm in irrigation treatments I_1, I_2 and I_3, respectively.

3.3 Leaf length

Leaf length of maize was significantly influenced by different levels of salinity, polythene mulch and irrigation. Leaf length was 71.8 cm in non saline condition and that was 66.6 cm in saline condition, respectively (Table 2). Thus leaf length was reduced by 7.2 % due to salinity. In without-polythene mulch treatment the leaf length was 64.9 cm whereas the length was 73.4 cm in with polythene mulch treatment (Table 2). Polythene mulch was therefore increased leaf length by 13.1 %. Among the irrigation treatments, the lowest length (65.2 cm)was found in I_1 treatment. The leaf lengths inI_2 and I_3treatments recorded 68.3 and 74.1 cm, respectively.

Polythene mulch × salinity interaction effect on leaf length is presented in Table 3. When salinity was not given, the without-polythene mulch treatment gave leaf length of 68.3 cm, but application of salinity in without polythene mulch treatment reduced leaf length by 6.8 cm.

Table 1. Periodic soil and air temperature as influenced by polythene mulch

Dates	Soil temperature (°C)		Air temperature (°C)
	Without polythene mulch	With polythene mulch	
9.3.2015	35	37	32
11.3.2016	36	40	32
13.3.2017	36	40.5	34
15.3.2018	36	40.2	36
17.3.2019	36	39	32
19.3.2020	37.5	39.5	35
21.3.2021	39	42	36
23.3.2022	37	41.5	37
25.3.2023	37	39	34
27.3.2024	37	41	35
30.3.2025	33	36	34
1.4.2015	36	38	35
3.4.2015	38	40	36
Mean	36.4	39.5	34.5

Table 2. Single effect of salinity, polythene mulch and irrigation on different plant characters of maize

Treatments	Plant height (cm)	Leaf length (cm)	No. of leaves per plant	Shoot fresh wt. (g)	Shoot dry wt. (g)	Root fresh wt. (g)	Root dry wt. (g)
Single effect of salinity							
Non-saline	106.2 a	71.8 a	13.3 a	192.6 a	69.0 a	19.0 a	6.60 a
Saline	95.8 b	66.6 b	12.4 b	168.0b	63.3 b	15.5 b	5.44 b
SE (±)	1.074	0.701	0.253	2.453	1.094	0.359	0.105
Significance level	***	***	*	***	**	***	***
Single effect of polythene mulch							
Without Polythene mulch	93.2 b	64.9 b	12.7	142.4 b	46.9 b	10.8 b	3.29 b
With Polythene mulch	108.8 a	73.4 a	12.9	218.3 a	85.4 a	23.7 a	8.75 a
SE (±)	1.074	0.701	0.253	2.453	1.094	0.359	0.105
Significance level	***	***	NS	***	***	***	***
Single effect of irrigation							
125 ml/irrigation	93.9 c	65.2 c	12.0 b	133.1 c	54.0 b	12.2 c	4.29 b
250 ml/irrigation	98.8 b	68.3 b	13.1 a	175.3 b	58.6 b	17.6 b	5.16 b
500 ml/irrigation	110.4 a	74.1 a	13.3 a	232.6 a	85.8 a	22.0 a	8.61 a
SE (±)	1.3156	0.859	0.310	3.004	1.340	0.439	0.129
Significance level	***	***	*	***	***	***	***
% CV	4.51	4.30	8.39	5.77	7.07	8.82	7.44

Table 3. Interaction effects of salinity and polythene mulch on different plant characters of maize

Treatment combinations	Plant height (cm)		leaf length (cm)		No. of leaves per plant		Shoot fresh wt. (g)		Shoot dry wt. (g)		Root fresh wt. (g)		Root dry wt. (g)	
	S_0	S_1	S_0	S_1	S_0	S_1	S_0	S_1	S_0	S_1	S_0	S_1	S_0	S_1
P_0	98.7	87.8	68.3	61.5	13.2	12.2	165.8	118.8	49.4	44.3	12.6	8.9	3.89	2.70
P_1	113.8	103.9	75.2	71.6	13.3	12.5	219.4	217.2	88.6	82.2	25.3	22.2	9.31	8.18
SE (±)	1.519		0.992		0.358		3.469		1.547		0.508		0.149	
Significance level	NS		NS		NS		***		NS		NS		NS	

S_0- Non-saline, S_1- Saline, P_0- Without polythene mulch, P_1-With polythene mulch

Table 4. Interaction effects of salinity and irrigation on different plant characters of maize

Treatment combinations	Plant height (cm)		Leaf length (cm)		No. of leaves per plant		Shoot fresh wt. (g)		Shoot dry wt. (g)		Root fresh wt. (g)		Root dry wt. (g)	
	S_0	S_1	S_0	S_1	S_0	S_1	S_0	S_1	S_0	S_1	S_0	S_1	S_0	S_1
I_1	97.3	90.5	68.1	62.1	12.3	11.6	143.3	123.0	58.5	49.5	14.2	10.3	5.00	3.57
I_2	105.5	92.0	70.8	65.8	14.0	12.3	194.0	156.6	60.6	56.6	19.5	15.6	6.31	4.01
I_3	115.8	105.0	76.3	71.8	13.5	13.1	240.6	224.5	88.0	83.6	23.3	20.6	8.48	8.75
SE (±)	1.8606		1.215		0.439		4.249		1.895		0.622		0.183	
Significance level	NS		NS		NS		*		NS		NS		***	

S_0- Non-saline, S_1- Saline, I_1- 125 ml/irrigation, I_2-250 ml/irrigation, I_3- 500 ml/irrigation

The use of polythene mulch under saline condition reduced leaf length by 3.6 cm, over non saline condition. Thus, the effect of polythene mulch to reduce salinity effect was found very consistent. The salinity × irrigation interaction data on leaf length are presented in Table 4. The irrigation treatments I_1, I_2 and I_3gave leaf length of 68.1, 70.8 and 76.3 cm, respectively under non saline condition, but these values were 62.1, 65.8 and 71.8 in saline condition, respectively. It indicates that at lower amount of irrigation, the salinity induced detrimental effect was higher and the effect was reduced gradually with the increase of the rate of irrigation water (salinity reduced leaf length by 8.81, 7.06 and 5.90 % in I_1, I_2 and I_3 treatment, respectively).

3.4 Number of leaves per plant

There was a significant single effect of salinity on number of leaves per plant. As observed in Table 2 under non-saline condition the number of leaves per plant was 13.3 and that of 12.4 in saline condition, respectively. Thus, the number of leaves per plant reduced by 6.7 % due to salinity. Polythene mulch had no significant effect on number of leaves per plant. Regarding single effect, in without and with polythene mulch condition the number of leaves per plant was 12.7 and 12.9, respectively (Table 2). Considering interaction effect, the without salinity × without polythene mulch interaction gave leaves per plant of 13.2 which reduced by 7.6 % in salinity × without polythene mulch treatment (Table 3). Use of polythene mulch in saline condition reduced leaves number only by 6.0 % over non saline condition. The results, therefore, indicated that use of polythene mulch had positive effect on maintaining leaves number in saline condition closer to non saline condition.

3.5 Shoot fresh weight

Shoot fresh weight was significantly influenced by single effect of salinity, polythene mulch and irrigation treatments. An amount of 192.6 g/plant shoot fresh weight was recorded in the non saline treatment, which was168 g/plant in saline treatment (Table 2). Shoot fresh weight is therefore reduced by about 13% due to salinity (Table 2). Farooq *et al*., (2015) reported that salinity reduces shoot growth by suppressing leaf initiation and expansion in maize, as well as internodes growth, and by accelerating leaf abscission. Salt stress rapidly reduces leaf growth rate (Munns, 1993) due to a reduction in the number of elongating cells and/or the rate of cell elongation (Szalai and Janda, 2009). As a salt-sensitive crop, shoot growth in maize is strongly inhibited in the first phase of salt stress (ElSayed, 2011). De Costa *et al.* (2007) observed stunted maize growth with dark green leaves without any toxicity symptoms during the first phase of salt stress.

Without-polythene mulch treatment had shoot fresh weight of 142.4 g/plant and it increased to 218.3 g/plant (53% increase) in with-polythene mulch treatment. Juang *et al.* (2015) suggests that plastic film mulching tends to significantly increase surface soil water availability by restraining the formation of a dry soil layer during the early maize-growth stage primarily under dry conditions, and thus enhances maize productivity in the semiarid Loess Plateau of China. Irrigation treatments also had tremendous effect on shoot fresh weight. The lowest of 133.1 g/plant shoot fresh weight was found in I_1 treatment and was 175.3 and 232.6 g/plant in I_2 and I_3 treatment, respectively.

There was a significant interaction effect between salinity and polythene mulch on shoot fresh weight of maize. When polythene mulch was not used salinity reduced shoot fresh weight by 28.3% (from 165.8 to 118.8 g/plant). But, in the case of using polythene mulch the weight was reduced only 1.0% (from 219.4 to 217.2) (Table 3). The results clearly evidenced that if polythene mulch was used, salinity could not hamper the plant growth. Regarding salinity and irrigation interaction, it was found that salinity reduced shoot fresh weight by 14.2, 19.3 and 6.7% in I_1, I_2 and I_3 treatment, respectively (Table 4). Thus it found that I_3 treatment had

best performance to retain shoot fresh weight of maize.

3.6 Shoot dry weight

Considering single effect, under non saline condition shoot dry weight was found as 69.0 g/plant and that of 63.3 g/plant in saline condition (Table 2). The shoot dry weight is therefore reduced by about 8% due to salinity. Polythene mulch showed a remarkable effect on shoot dry weight being 46.9 g/plant in without polythene mulch treatment and 85.4 g/plant in with polythene mulch treatment (Table 2). Polythene mulch was therefore contributed for about 82% higher dry biomass per plant. Regarding irrigation effect 54, 58.6 and 85.8 g/plant dry biomass was found in I_1,I_2 and I_3 treatment, respectively.

Considering interaction effect, when polythene mulch was not used salinity reduced shoot dry weight by 10.3% and when polythene mulch was used salinity reduced plant dry weight by 7.2% (Table 3). Irrigation water can potentially reduce the effect of salinity (Table 4). In case of using lower rate of irrigation water, the salinity effect on dry weight production was higher (15.4 % in I_1). The reduction rate was gradually decreased with the increase of the rate of application of irrigation water (5% in I_3treatment). However Leogrande *et al*. (2016) found no significant difference for grain yield between the irrigation treatments, whereas water productivity decreased significantly with increasing irrigation rates.

3.7 Root fresh weight

Root fresh weight was significantly influenced by single effects of salinity, polythene mulch and irrigation treatments. When salinity was not imposed root fresh weight was 19.09 g/plant. But under salinity treatment the root fresh weight was 15.5 g per plant (Table 2). Thus use of 5 dS/m salinity can reduce maize root fresh weight by about 18%. A superior and clear cut performance of polythene mulch was found on root fresh weight. In without polythene mulch treatment the root fresh weight was only 10.8 g/plant. Whereas, in with polythene mulch treatment it was 23.7 g/plant (Table 2). So polythene mulch had about 119% higher root fresh weight over without polythene mulch treatment. The root fresh weight was also varied due to different amounts of irrigation water. When 125 ml/irrigation (I_1) was given the root fresh weight was 12.2 g/plant and it increased to 17.6 g/plant in 250 ml/irrigation (I_2) treatment (Table 2). The highest of 22.0 g/plant root fresh weight was recorded in 500 ml/irrigation treatment.

Regarding interaction effect, when polythene mulch was not used under non saline condition root fresh weight was 12.6 g/plant but it reduced by 39.4% (8.9 g/plant) under saline condition (Table 3). When polythene mulch was used root fresh weight was reduced by 12.3% due to salinity. It indicates that polythene mulch can reduce the salinity effect in a considerable extent. Irrigation treatments also have contribution to reduce salinity effect (Table 4). With the increasing of the rate of irrigation water, the rate of salt induced crop loss was rather reduced (Table 4).

3.8 Root dry weight

As other parameters, root dry weight was significantly influenced by single effect of salinity, polythene mulch and irrigation treatments. Under non-saline condition root dry weight/plant was 6.60 g and it reduced to 5.44 g under saline condition (Table 2), thus the reduction was found as 18%. When polythene mulch was not used the root dry weight was obtained as 3.29 g/plant. But in case of using polythene mulch it was 8.75 g/plant. Here, polythene mulch contributed 166% higher root yield compared to non- mulch treatment. Regarding irrigation treatment, 4.29 g/plant root was recorded by I_1 treatment. The second and third irrigation treatment gave 5.16 and 8.61 g/plant root dry weight, respectively (Table 2).

The salinity × polythene mulch interaction (Table 3) indicated that without polythene mulch × without salinity the plant produced root dry weight of 3.89 g/plant which was reduced by

30.6% in without polythene mulch × with salinity condition. Whereas with polythene mulch × without salinity the plant gave root dry weight of 9.31 g/plant which reduced only by 12.1% in with polythene mulch × with salinity condition. It indicates that use of polythene mulch can reduce salinity effect by 18.5% (30.6 minus 12.1). There was a significant salinity × irrigation interaction on root dry weight. When salinity was imposed on I_1 treatment, root dry weight reduced by 28.6% over respective control and in I_2 treatment this reduction value was 36.5% (Table 4). Interestingly in I_3 treatment the root dry weight was rather slightly (3.2%) increased due to application of salinity.

3.9 Shoot phosphorus content

Shoot phosphorus (P) content was significantly influenced by single effect of salinity, polythene mulch and irrigation treatments. The mean shoot P content for saline and non- saline treatment was 0.252% and0.292%, respectively. Shoot P content was therefore reduced by about 14% due to salinity (Table 5). Without polythene mulch treatment the recorded shoot P content was 0.260% and it increased to 0.284% in with polythene mulch treatment. Thus polythene mulch increased shoot P content by about 9%. Irrigation treatments also had tremendous effect on shoot P content. The lowest of 0.261% shoot P content was found in I_1 treatment and was 0.269 and 0.287 % in I_2 and I_3 treatment, respectively (Table 5).

There was a significant interaction effect between salinity and polythene mulch on shoot P content of maize. When polythene mulch was not used, the non-salinity treatment gave shoot P content of 0.282% which reduced by 15% in salinity treatment (Table 6). When polythene mulch was used, non-salinity treatment gave shoot P content of 0.303% and it reduced to 12% due to application of salinity. Regarding salinity irrigation interaction, it was found that salinity reduced P content from 0.276 to 0.246 %, 0.276 to 0.262 % and 0.325 to 0.249 % in I_1, I_2 and I_3treatment, respectively over without salinity treatment (Table 7).

3.10 Root phosphorus content

Root P content was also significantly influenced by single effects of salinity, polythene mulch and irrigation treatments. Root P content was 0.133 and 0.112 % in without and with salinity treatment, respectively (Table 5). Thus 5 dS/m salinity can reduce maize root P content by about 16%. A superior performance of polythene mulch was found on root P content. In without polythene mulch treatment the root P content was only 0.116%. Whereas, in with-polythene mulch treatment it was 0.129% (Table 5). So, plants with polythene mulch had about 11% higher root P content over without-polythene mulch treatment. The root P content was also varied due to different amounts of irrigation water. When 125 ml/irrigation was given the root P content was 0.109% and it increased to 0.114% in I_2 treatment (Table 5). The highest of 0.145% root P content was recorded in 500 ml/irrigation treatment.

Table 6 shows the salinity-polythene mulch interaction effect on root P content of maize. When polythene mulch was not used, under non saline condition, root P content was 0.127% but it reduced by 17% (0.105%) under saline condition. But when polythene mulch was used root P content was reduced by 14% (0.119% P) due to salinity. It indicates that polythene mulch can reduce the salinity effect in a considerable extent. Irrigation treatments also had contribution to reduce salinity effect (Table 7). Under non saline condition I_1, I_2 and I_3 treatment had P content of 0.104, 0.139 and 0.155 %, which was 0.112, 0.090 and 0.134 % in saline condition, respectively.

3.11 Shoot S content

Salinity, polythene mulch and irrigation had significant effect on shoot S content of maize. Under non-saline and saline condition the mean shoot S content was found as 0.155% and 0.202%, respectively (Table 5). The mean shoot S content is therefore increased by about 30% due to salinity. Polythene mulch showed a remarkable effect on shoot S content being 0.159% in without polythene mulch treatment

and 0.198% in with polythene mulch treatment (Table 5). Polythene mulch is therefore contributed for about 25% higher S content. Regarding irrigation effect the lowest of 0.166% S content was found in I_1treatment. In I_2 and I_3treatment, the shoot S content was 0.184 and 0.186 %, respectively (Table 5). Salinity and polythene mulch interaction effect on shoot S content is presented in Table 6. Without polythene mulch × without salinity had shoot S content of 0.144%, which in without polythene mulch × salinity had 0.173% (increased by 10.3%). Similarly in with polythene mulch × without salinity shoot S content was 0.165% and it increased to 0.230% in with polythene mulch × with salinity treatment (increased by 39% over non saline condition).

Table 5. Single effect of salinity, polythene mulch and irrigation on phosphorus and sulphur content of maize

Treatments	Shoot P content (%)	Root P content (%)	Shoot S content (%)	Root S content (%)
Single effect of salinity				
Non-saline	0.292	0.133	0.155	0.176
Saline	0.252	0.112	0.202	0.194
SE (±)	0.0012	0.0034	0.0018	0.0014
Significance level	***	***	***	***
Single effect of polythene mulch				
Without Polythene mulch	0.260	0.116	0.159	0.175
With Polythene mulch	0.284	0.129	0.198	0.195
SE (±)	0.0012	0.0034	0.0018	0.0014
Significance level	***	*	***	***
Single effect of irrigation				
125 ml/irrigation	0.261 b	0.109 b	0.166 b	0.186 b
250 ml/irrigation	0.269 b	0.114 b	0.184 a	0.179 c
500 ml/irrigation	0.287 a	0.145 a	0.186 a	0.190 a
SE (±)	0.0015	0.0042	0.0022	0.0018
Significance level	***	***	***	**
% CV	1.85	11.8	4.19	3.31

Table 6. Interaction effects of salinity and polythene mulch on phosphorus and sulphur content of maize

Treatment combinations	Shoot P content (%)		Root P content (%)		Shoot S content (%)		Root S content (%)	
	S_0	S_1	S_0	S_1	S_0	S_1	S_0	S_1
P_0	0.282	0.239	0.282	0.239	0.144	0.173	0.164	0.185
P_1	0.303	0.266	0.303	0.266	0.165	0.230	0.165	0.203
SE (±)	0.0017		0.0048		0.0025		0.0020	
Significance level	NS		NS		***		NS	

S_0- Non-saline, S_1- Saline, P_0- Without polythene mulch, P_1-With polythene mulch

Table 7. Interaction effects of salinity and irrigation on phosphorus and sulphur content of maize

Treatment combinations	Shoot P content (%)		Root P content (%)		Shoot S content (%)		Root S content (%)	
	S_0	S_1	S_0	S_1	S_0	S_1	S_0	S_1
I_1	0.276	0.246	0.276	0.246	0.140	0.190	0.165	0.207
I_2	0.276	0.262	0.276	0.262	0.156	0.211	0.142	0.216
I_3	0.325	0.249	0.325	0.249	0.168	0.203	0.220	0.160
SE (±)	0.0021		0.0059		0.0031		0.0025	
Significance level	***		***		*		***	

S_0- Non-saline, S_1- Saline, I_1- 125 ml/irrigation, I_2-250 ml/irrigation, I_3- 500 ml/irrigation

3.12 Root S content

As other parameters, root S content was significantly influenced by salinity, polythene mulch and irrigation treatments. Under non-saline condition mean root S content was 0.176% and it increased to 0.194% under saline condition (Table 5). When polythene mulch was not used the root S content was obtained as 0.175%. But in case of using polythene mulch the root S content was 0.195%. Here, polythene mulch contributed 11% higher root S content compared to non mulch treatment. Regarding irrigation treatment 0.186% root S content was recorded by I_1 treatment. The second and third irrigation treatment gave 0.179 and 0.190% root S content, respectively (Table 5).

The salinity × polythene mulch interaction (Table 6) indicates that without polythene mulch × without salinity gave root S content of 0.164% which was 0.185% (increased by 12.8%) in without polythene mulch × with salinity condition. Whereas with polythene mulch × without salinity gave root S content of 0.165 %which was 0.203 % in with polythene mulch × with salinity condition (increased by 23.0%). It indicates that use of polythene mulch can increase S content by 10.2% (23.0 % minus 12.8 %). There was a significant salinity × irrigation interaction on root S content. Under I_1 treatment, application of salinity increased root S content by 25.5% and 250 ml water/irrigation this increase value was 52.1% (Table 7).

4. Conclusions

Use of polythene mulch increased soil temperature which created favorable environment for growing maize in Rabi season. Salinity reduced all the growth parameters like plant height, number of leaves per plant, root and shoot fresh and dry weights. Whereas, use of polythene mulch increased all these parameters to a greater extent. Irrigation treatment also had positive impact on these parameters and those increased with the increase of the amount of irrigation water. Shoot and root P content was reduced due to salinity. However, it was increased due to use of polythene mulch. Irrigation treatment had positive effect to this parameter. Sulphur content of root and shoot was increased in greater extent due to application of salinity. It was also increased to some extent due to use of polythene mulch. Use of polythene mulch may be recommended to reduce salinity effect and increase yield of maize.

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