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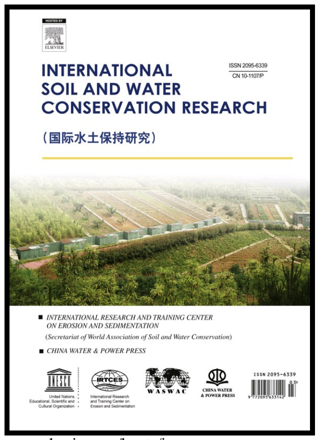


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# Effect of plastic mulch on crop yield and land degradation in south coastal saline soils of Bangladesh

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## Abstract

The experiment was conducted during dry season of 2016 and 2017 at farmer's field of Kalapara Upazila of Patuakhali district, Bangladesh to develop tools to reduce salinity impact in maize and to reduce salinity induced land degradation. There were five treatments in the experiment having three different color plastic mulch (blue, black and white) and rice straw mulch and a non mulch control (bare soil) treatment. The experiment was laid out in randomized complete block design with three replications. The treatments white, blue and black plastic film mulch, and rice straw much had 149, 109, 78 and 25 % grain yield increase in 2016, and 173, 117, 99 and 47 % in 2017 over control, respectively. The white plastic mulch treatment had 4ºC and 3.5ºC higher temperature over rice straw mulch treatment and 2.0°C higher than the control treatment in 2016 and 2017, respectively. The black plastic mulch had 0.2 and 1.0 °C, and rice straw mulch had 2.0 and 1.5 °C lower temperature than control in 2016 and 2017, respectively. Use of plastic mulch significantly reduces electrical conductivity of soil. In non-mulch treatment sulfur content was extremely high; plastic mulch rather helps to decrease the excess availability of sulfur. The overall results suggest that use of plastic mulch would be a suitable tool for enhancing maize production maintaining good soil health in saline soils.



**Keywords:**

Land degradation; maize; plastic mulch, saline soil; straw mulch

## 1.0 Introduction

Coastal region of Bangladesh characterized by severe soil and water salinity in dry season (MoA and FAO, 2013); which seriously hampered crop growth (Haque *et al.*, 2014; Ahmed

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*et al*., 2017). The magnitude and extent of soil salinity are increasing with time, being 0.83 mha in 1973, 1.02 mha in 2002 and 1.06 mha in 2009 (SRDI, 2010). These changes reducing crop productivity as well as soil fertility by degrading the soil quality (Haque *et al*., 2008). Most of the agricultural land remains uncultivated in southern coastal Bangladesh during the dry season due to safe irrigation water crisis. In Bangladesh recently maize has been appeared as an important fodder crop as well as feed for poultry. Growing maize in the coastal fallow lands in dry season is considered as very promising. Unfortunately high osmotic pressure due to rainless period from December to May makes impossible to grow maize in the south coastal region. An appropriate irrigation water management technology is therefore needed to compensate the crop losses occurred by salinity. Irrigation with deep or shallow tubewell water is not possible in this area due to high underground water salinity. Some canals and homestead ponds bear little amount of sweet water which generally used for domestic purpose, can also be a potential source of irrigation water. A judicious and efficient use of this water in irrigation purpose can facilitate to grow maize in south coastal saline soils of Bangladesh. A low water requirement irrigation system for cultivation of maize is therefore required for optimum use of this limited water resources. Use of plastic mulch may overcome this problem.  As an important farming technique, plastic mulching has been used widely due to the significant benefits it confers in terms of yield increase and water conservation (Sun *et al*., 2014).

Because of low temperature in dry season after sowing often restrict maize emergence in practice (He *et al*., 2010). Many studies have shown that plastic mulch is an effective strategy for promoting crop emergence because it can modify the soil microclimate by increasing the soil temperature (Bu *et al*., 2013; Dong *et al.*, 2009; Ramakrishna *et al*., 2006). Elevated soil temperatures can quicken crop emergence and growth to achieve the desired population structure at an earlier growth stage (Liu *et al*., 2014); this can in turn maximize the absorption of solar radiation and enhance the yield (Li *et al*., 2013). Plastic mulch can retain precipitation, reduce water loss, and increase the water use efficiency (Bu *et al*., 2013). Plastic mulch increase the amount of soil-available water by restricting evaporation and elevating deepwater by capillarity and vapor transfer to the layer usable for roots under arid and semi-arid conditions (Qin *et al*., 2014; Song *et al*. 2002).

In the global context there have some literature on the use of plastic mulch to reduce soil erosion (Zhang *et al.*, 2013) and water conservation (Ingman *et al.*, 2015*)* but its effect to manage saline soil is not well documented. By reducing evaporation loss of water from the soil plastic mulch may protect salinization of surface soil by underground water. The experiment is therefore undertaken to investigate the effect of plastic mulch to reduce salinity effect on maize crop and arrest the land degradation in relation to soil salinity

## 2.0 Materials and Methods

### *Location*

The experiment was carried out in the farmer's field of Tajepara village of Kalapara upazila, Patuakhali district, Barishal division, Bangladesh during winter season in two consecutive years at 2016 and 2017. The experimental site was very closer to Kuakata sea beach (Fig 1). The experimental site located at about 21.9861° north latitude and 90.2422° east longitude having only 6m altitude. The climate is tropical in Kalapara upazila. The average annual temperature is 25.9ºC. In a year, the average rainfall is 2647 mm. Generally monsoon starts on May and ends on October; more than 92% rainfall occur in these months. April–May is susceptible to storm surges. Winter starts on November and ends on February. The winter is short, excessively dry and rainfall less than 75 mm which is lower than the evaporation. Plants enjoy severe drought in the dry season. In wet season (June-November) transplanted Aman is the only one crop and in dry season/Rabi season (December-May) most of the lands remain fallow due to salinity.

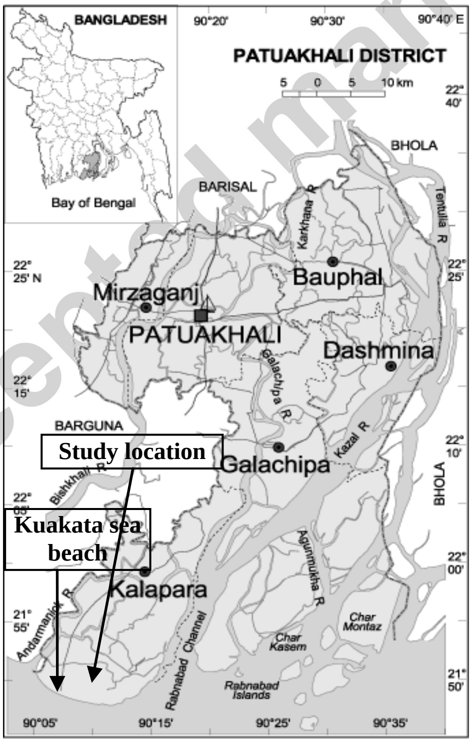


Fig1. Map of the study location.

***Field characteristics***

Experimental field was a medium high land under the AEZ 13, Ganges Tidal Flood Plain Soil (FRG 2012). Texturally the soil was loam having 26.9 % sand, 52.5 % silt and 20.6 % clay. The initial soil collected in December 2015 just after drained out of monsoon water, contained 5.8 pH, 1.12 % organic matter, 0.09 % total nitrogen (N), 8.9 mg $kg^{-1}$ available phosphorus (P) and 39.4 mg $kg^{-1}$ available sulfur (S). The soil is deficient in N and P.

***Corp variety***

The test crop was maize and the crop variety was BARI Hybrid Maize-7. This is a popular maize variety released by Bangladesh Agricultural Research Institute.

***Treatment and design***

The experiment was laid out in a randomized complete block design with three replications. There were five treatments: bare soil (no mulch control) ($T_1$), rice straw mulch ($T_2$), blue color plastic mulch ($T_3$), black color plastic mulch ($T_4$) and white (semi transparent) color plastic mulch ($T_5$). The treatments were randomly distributed to the plots in each block. The size of the experimental plot was 4m × 3m. The plots were surrounded by 30cm wide and 10cm high earthen bunds. One meter wide space was kept in between two blocks.

***Experiment setup***

Three ploughing and two laddering were done to prepare the experimental field every year. In plastic mulch treatments soils were covered with respective color plastic sheet so that evaporation loss of water remains the minimum. Regarding straw mulch treatment rice straw @ around 6 t/ha was spread over the soil surface so that soil could not be visible. Seeds were sown following dibbling method on 12 January 2016 and 10 January 2017 within the 5 cm diameter round-cut hole of the plastic sheet. The hole on plastic sheet was made by a sharp end wooden stick. The plant spacing was 25×60 cm. For non plastic mulch treatments seeds were also sown in rows maintaining above mentioned spacing. Granular insecticide (Furadan 5g) was given in the field during final land preparation to control soil born insects.

***Fertilizer application***

Every plot received equal amount of N, P, K, S, B and Zn @ 200, 70, 100, 45, 2 and 6 kg/ha, respectively. The source of N, P, K, S, B and Zn were urea, triple super phosphate (TSP), muriate of potash (MoP), gypsum, boric acid and zinc sulfate, respectively. In all the experimental plots triple super phosphate (TSP), muriate of potash (MoP), gypsum, boron and zinc were applied during final land preparation. Urea was applied in three equal splits at final land preparation, 25 and 50 days after sowing. Regarding plastic mulch treatments urea was applied in the root rhizosphere zone using round cut hole of the plastic sheet.

***Irrigation***

An amount of 500 ml irrigation water was given in root rhizosphere area of each plant four times at 20, 30, 40 and 50 DAS, and 1000 ml per plant once at 60 DAS. In the experiment intention was to avoid flood irrigation and apply minimum amount of irrigation water and get maximum crop yield. In the coastal region farmers generally harvest rain water during monsoon in pond for their domestic use. In the experiment irrigation was made using this pond water. Pond water samples were collected periodically and analyzed for determination of electrical conductivity (EC) values. For comparison water samples were also collected from nearby earthen-well (around 2m wide and 3m deep) which could be represents the underground water.

***Data collection***

Crops were harvested at maturity on 12 May 2016 in first year and 23 May 2017 in second year. Growth and yield contributing data were recorded from randomly selected 5 plants of each plot. Yield data was recorded by harvesting central 20 plants from each plot. Soil temperature was measured using celcious thermometer from 2 to 4 cm soil depth on 10$^{th}$ March both years. Post harvest soil was collected from root rhizosphere area and analyzed for determination of pH (Jackson, 1973), electrical conductivity (Petersen, 2002) and sulfur (S) contents (Fox *et al*., 1964).

***Data analysis***

Data recorded on crop characters were subjected to statistical analysis through computer based statistical program STAR (Statistical Tool for Agricultural Research) following the basic principles, as outlined by Gomez and Gomez (1984).

**3.0 Results**

3.1 Growing season weather condition

During the study period based on the monthly average temperature May and January were the warmest and coolest month, respectively. Maximum temperature in 2016 and 2017 ranges from 30 to 37 ºC and from 31 to 38 ºC, respectively (Fig. 2). Similarly minimum temperatures were 19 to 29 ºC and 18 to 29 ºC, respectively. The average air temperature in

January, February, March, April, May and June were 26, 30, 33, 33, 34 and 33 ºC in 2016 and 26, 30, 30, 32, 35, and 33 ºC in 2017, respectively. Very little rainfall was recorded in the month of January and February. The amount of rainfall progressively increased with the passes of time, and at the month of May-June it reached to its peak (Table 1). The wind speed in the month of January in 2016 and 2017 were 5.4 and 6.5 mph, respectively. It was also progressively increased with the passes of time. Both the years, highest wind speed was observed in the month of April thereafter it was further declined. The humidity was lowest in January and highest in June over the reporting period.

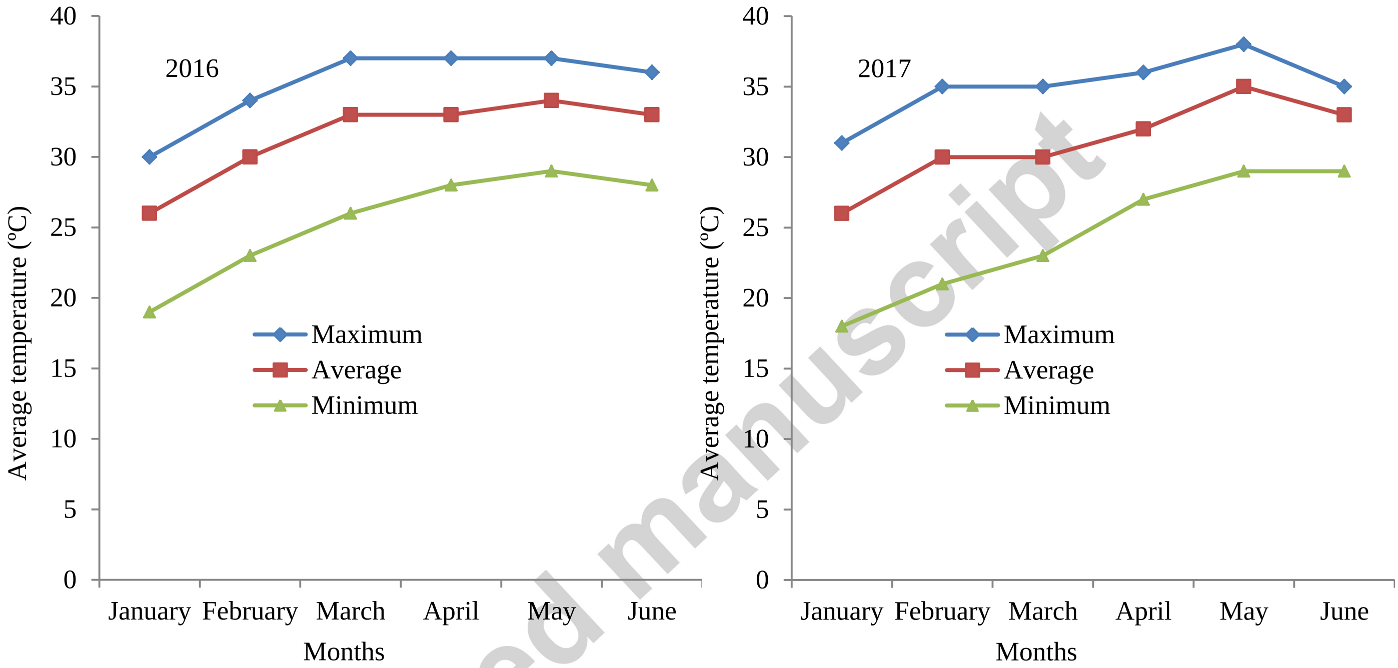


Fig. 2. Monthly average air temperature in 2016 and 2017 at Kuakata sea beach, Kalapara upazila, Patuakhali district, Bangladesh



Table 1. Monthly average climatic variables at Kuakata sea beach, Kalapara upazila, Patuakhali district, Bangladesh

| Month of the year | Precipitation (mm) | | Wind speed (mph) | | % Humidity | |
|---|---|---|---|---|---|---|
| | 2016 | 2017 | 2016 | 2017 | 2016 | 2017 |
| January | 3.0 | 0 | 5.4 | 6.5 | 48 | 40 |
| February | 15.0 | 1.4 | 6.3 | 5.6 | 54 | 49 |
| March | 44.6 | 66.3 | 8.5 | 7.6 | 55 | 64 |
| April | 37.3 | 47.2 | 15.0 | 11.2 | 69 | 70 |
| May | 32.4 | 86.4 | 11.0 | 9.6 | 70 | 66 |

| | | | | | | |
|---|---|---|---|---|---|---|
| June | 155.0 | 392.1 | 9.8 | 10.5 | 72 | 74 |

Source: https://www.worldweatheronline.com/kuakata-weather-averages/bd.aspx

3.2 Irrigation water salinity

The irrigation water (pond water) salinity in mid January was only 1.09 dS/m, but it was sharply increased with the passes to time. At 20 April sampling the irrigation water salinity was 3.05 dS/m. The underground (earthen-well) water EC value in mid January was 1.86 dS/m and it was progressively increased with passes of time and attained to 6.03 dS/m by 20$^{th}$ April.

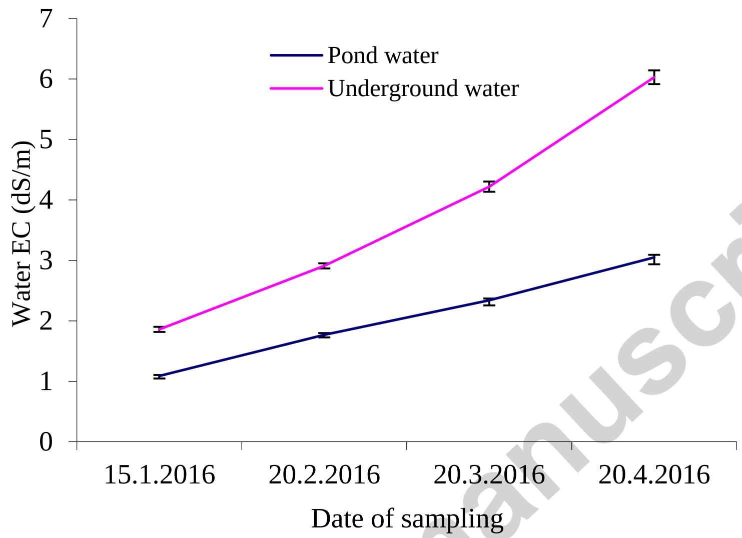


Fig.2. Irrigation water salinity in different sampling dates

(Vertical bar indicates standard deviation)



3.3 Growth, yield and yield components of maize

All the growth, yield and yield components of maize in 2016 and 2017 were significantly influenced by different mulch treatments, except number of leaves/plant and number of seed rows/cob in 2017 (Table 2). Most of the cases control treatment had the lowest performance or statistically similar with rice straw mulch treatment. In 2016 over the treatments plant height ranged from 160.6 to 219.5 cm; which was 204 to 232.4 cm in 2017. Both the years plant height found in white, blue and black plastic mulch was statistically similar. The number of leaves per plant varied from 11.8 to 14.3 in 2016 and 11.6 to 12.4 in 2017, respectively (Table 2). Leaf blade length varied from 46.9 to 84.7 cm in 2016 and 82.4 to 98.4 cm in 2017 (Table 2). The leaf blade length found in 2016 in blue, black and white plastic mulch treatment was statistically similar. Stem circumference varied from 5.9 to 7.2

cm in 2016 and 6.8 to 7.5 cm in 2017, respectively (Table 2). Both the years stem circumference found in blue, black and white plastic mulch was identical.

The cob length ranged from 12.2 to 16.5 cm in 2016 and 12.0 to 17.6 cm in 2017, respectively (Table 2). Both the years white plastic mulch treatment had the highest and blue plastic much had the second highest cob length. During 2016 grain rows per cob varied with the range of 13.1 to 14.9 and that of 15.4 to 15.9 in 2017 over the treatments (Table 2). Both the years' plastic mulch treatments had very closer number of grain rows per cob and was higher than rice straw mulch treatment. Soil salinity severely hampered the grain filling of maize. Reproductive growth was more affected than vegetative growth. The bare soil (control) treatment produced only 22.5 fertile grains/row in 2016 and that of 17.6 in 2017 (Table 2). Both the years white plastic mulch had highest rank of 31.9 in 2016 and 36.4 in 2017 which was 42 and 107 % higher than the respective control treatment. Both the year blue plastic mulch had the second rank (28.7 in 2016 and 31.0 in 2017). In 2016, 1000-grain weight ranged from 204.5 to 235.5 g which was 250.5 to 274.5 g in 2017 (Table 2). Both the year highest 1000-grain weight was found in white plastic mulch treatment which was statistically similar with blue plastic mulch treatment. The performance of rice straw was always worse than the plastic mulch treatments.

Among all the growth, yield and yield contributing characters grain yield was extremely influenced by different mulch treatments. Considering letter grade both the years the treatments had letter grade-a to grade-d that means that this parameter is highly influenced by the treatments. Table 2 shows that grain yield in 2016 ranged from 3.464 to 8.633 t/ha; the lowest obviously in control treatment which is the outcome of adverse effect of salinity (Table 2). The straw much treatment had the statistically similar grain yield of control treatment. In the second year trial (2017) similar trend was observed where highest of 9.54 t/ha grain yield produced by white plastic mulch treatment. Both the years white, blue and black plastic mulch had the 1$^{st}$, 2$^{nd}$ and 3$^{rd}$ rank. The performance of straw mulch was consistently lower than the plastic mulch treatments. There was found a strong correlation between grain yield and number of grains per row (r value being 0.993 in 2016 and 0.990 in 2017) (Table 4). The straw yield ranged from 2.911 to 7.138 t/ha in 2016 and 7.92 to 10.70 t/ha in 2017 (Table 2). There was found a significant and positive correlation of straw yield with number of grains per row (r=0.889) and grain yield (r=0.881) of maize in 2016 (Table 4).

Both the years (2016 & 2017) highest root yield was found in white plastic mulch treatment (Table 2). In 2016 blue plastic mulch recoded similar root yield of white plastic mulch treatment. Production of root yield had a significant and positive correlation with number of grains per row of cob (r=0.993) and grain yield (r=0.900) in 2016, and with straw yield both in year 2016 (r=0.963) and 2017 (r=0.994) (Table 4). The results clearly evidenced that plastic mulches especially white plastic mulch were sufficiently capable to reduce salinity effect and increase yield and yield components of maize.

**Table 2. Effects of different mulch treatments on growth, yield and yield components of maize in 2016 and 2017**

| Treatments | Plant height (cm) | No. of leaves / plant | Leaf blade length (cm) | Stem circumference (cm) | Cob length (cm) | No. of grain-rows /cob | No. of fertile grains/row | 1000-grain wt. (g) | Grain yield (t/ha) | Straw yield (t/ha) | Root yield (t/ha) [a] |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **2016** | | | | | | | | | | | |
| $T_1$: Control | 160.6 c | 11.8 d | 46.9 c | 5.9 b | 12.2 c | 13.1b | 22.5 c | 218.0 b | 3.464 d | 2.911 c | 9.20 c |
| $T_2$: Rice straw mulch | 187.7 b | 12.7 c | 62.1 b | 6.6 ab | 13.9bc | 13.5 b | 24.5 bc | 204.5 c | 4.315 d | 5.339 b | 14.29 b |
| $T_3$: Blue plastic mulch | 210.5 ab | 13.7 ab | 84.4 a | 7.2 a | 15.7 ab | 14.3 a | 28.7 ab | 231.0 a | 7.254 b | 7.138 a | 17.60 a |
| $T_4$: Black plastic mulch | 219.5 a | 14.3 a | 84.7 a | 7.2 a | 15.6 ab | 14.7 a | 27.9 ab | 213.0 b | 6.179 c | 6.591 a | 14.60 b |
| $T_5$: White plastic mulch | 216.4 a | 13.3 bc | 82.4 a | 7.2 a | 16.5 a | 14.9 a | 31.9 a | 235.5 a | 8.633 a | 7.016 a | 17.81 a |
| CV (%) | 6.65 | 3.12 | 5.08 | 7.42 | 7.30 | 2.74 | 8.69 | 1.38 | 6.22 | 5.65 | 8.11 |
| Significance level | ** | *** | *** | * | ** | ** | ** | *** | *** | *** | *** |
| SE (±) | 7.638 | 0.237 | 2.113 | 0.292 | 0.624 | 0.223 | 1.361 | 1.755 | 0.307 | 0.189 | 10.33 |
| **2017** | | | | | | | | | | | |
| $T_1$: Control | 204.0 c | 11.6 | 82.4 c | 6.8 b | 12.0 c | 15.4 | 17.6 d | 259.0 bc | 3.487 d | 7.92 b | 9.19 c |
| $T_2$: Rice straw mulch | 216.8 b | 12.0 | 96.2 a | 6.8 b | 13.9 b | 15.7 | 22.5 c | 250.5 c | 5.147 c | 10.57 a | 13.64 ab |
| $T_3$: Blue polythene mulch | 220.9 ab | 12.4 | 89.4 b | 7.3 a | 15.4 b | 15.9 | 31.0 b | 266.5 ab | 7.580 b | 9.49 a | 11.85 b |
| $T_4$: Black polythene mulch | 223.6 ab | 12.2 | 98.4 a | 7.5 a | 14.8 b | 15.9 | 26.3 c | 270.0 a | 6.967 b | 10.64 a | 14.16 ab |
| $T_5$: White | 232. | 12.0 | 98.0 | 7.5 a | 17.6 a | 15.7 | 36.4 a | 274. | 9.540 | 10.70 | 14.4 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| polythene mulch | 4 a | | a | | | | | 5 a | a | a | 8 a |
| CV (%) | 2.89 | 4.8 | 5.46 | 4.40 | 5.95 | 4.99 | 8.55 | 1.93 | 10.07 | 7.58 | 9.96 |
| Significance level | ** | NS | * | * | *** | NS | *** | ** | *** | ** | ** |
| SE (±) | 5.18 | 0.4718 | 4.23 | 0.2578 | 0.7163 | 0.6405 | 1.87 | 4.168 | 0.5383 | 0.6101 | 1.03 |

Similar letters in a column are not significantly different at 5% level by DMRT
*= Significant at 5% level of probability, **= Significant at 1% level of probability, ***= Significant at 0.1% level of probability, NS= Not significant
CV- Coefficient of Variation, SE-Standard Error
[a] Root yield is expressed as fresh weight basis

### 3.4 Soil temperature

Soil temperature was measured in 10 March of both 2016 and 2017. Different kinds of mulch had remarkable influence on temperature of soil. Table 3 shows that the control, rice straw, blue plastic, black plastic and white plastic mulch treatment had soil temperature of 32.0, 30.0, 33.7, 32.2 and 34 °C, respectively in 2016 and that of 31.0, 29.5, 33.0, 32.0 and 33.0 °C in 2017. The white plastic mulch treatment is therefore had 4ºC and 3.5ºC higher temperature in 2016 and 2017, respectively over rice straw mulch treatment. Compared to control treatment the white plastic mulch treatment had 2.0°C higher temperature both the years. The black plastic mulch had 0.2 and 1.0 °C, and rice straw mulch had 2.0 and 1.5°C lower temperature than control in 2016 and 2017, respectively. Therefore rice straw favors to keep the soil cool, and white and blue plastic mulch keeps the soil worm. Black plastic mulch had comparable soil temperature of control.

**Table 3. Effects of different mulch treatments on some soil properties in maize field**

| Treatments | Soil temperature (ºC) | Soil pH | Soil electrical conductivity (dS/m) | Sulfur content (ppm) |
|---|---|---|---|---|
| | | **2016** | | |
| $T_1$: Control | 32.0 b | 5.23 | 13.60 a | 292.9 a |
| $T_2$: Rice straw mulch | 30.0 c | 5.45 | 9.21 b | 260.7 b |
| $T_3$: Blue plastic mulch | 33.7 ab | 5.35 | 6.73 c | 164.3 c |
| $T_4$: Black plastic mulch | 32.2 ab | 5.34 | 7.94 bc | 242.9 b |
| $T_5$: White plastic mulch | 34.0 a | 5.35 | 5.61 c | 143.6 d |
| CV (%) | 3.24 | 2.793 | 14.38 | 4.97 |
| Significance level | * | NS | *** | *** |
| SE (±) | 0.856 | 0.035 | 1.01 | 8.97 |
| | | **2017** | | |
| $T_1$: Control | 31.0 bc | 4.50 | 12.80 a | 484.1 a |
| $T_2$: Rice straw mulch | 29.5 c | 4.76 | 8.25 b | 225.1 b |
| $T_3$: Blue polythene mulch | 33.0 a | 4.68 | 5.15 c | 85.2 d |
| $T_4$: Black polythene mulch | 32.0 ab | 4.63 | 6.55 bc | 142.2 c |

| | | | | |
|---|---|---|---|---|
| $T_5$: White polythene mulch | 33.0 a | 4.93 | 4.90 c | 106.8 d |
| CV (%) | 3.23 | 3.51 | 12.04 | 13.41 |
| Significance level | * | NS | *** | *** |
| SE (±) | 0.836 | 0.121 | 0.741 | 22.84 |

Similar letters in a column are not significantly different at 5% level by DMRT
*= Significant at 5% level of probability, **= Significant at 1% level of probability, ***= Significant at 0.1% level of probability, NS= Not significant
CV- Coefficient of Variation, SE-Standard Error
Interpretation of pH value: Very strongly acid <4.5, strongly acid 4.5-5.5, slightly acid 5.6-6.5, neutral 6.6-7.3, slightly alkaline 7.4-8.4, strongly alkaline 8.5-9.0
Interpretation of EC value: Non saline 0-2, Slightly saline 2-4, Moderately saline 4-8, Saline 8-12, Highly saline >12 dS/m
Interpretation of S content: Very low <9.0, low 9.1-18.0, medium 18.1-27.0, optimum 27.1-36.0, high 36.1-45, very high >45.0

3.5 Soil pH

For determination of pH soil samples were collected from 0-10 cm soil depth on harvesting date: 12 May 2016 (First year trial) and 23 May 2017 (Second year trial). In the first year trial (2016) the pH value ranged from 5.23 in control treatment to 5.45 in rice straw treatment (Table 3). The white, blue and black plastic mulch had identical pH value. In the second year the pH value ranged from 4.50 to 4.93, lowest was in control and highest was in white plastic mulch treatment. Although the pH values were not significantly varied by the treatments, a general increment in mulch treatments was evidenced.



3.6 Electrical conductivity of soil

Electrical conductivity (EC) is the measurement of soil salinity. Higher the EC value higher the soil salinity. In the first year trial the post harvest soil EC value ranged from 5.61 to 13.60 dS/m over the treatments; lowest being in white plastic mulch and highest in control treatment (Table 3). During second year (2017) white plastic mulch further recorded the lowest EC (4.90 dS/m). The blue and black plastic mulch and rice straw mulch had 5.15, 6.55 and 8.25 dS/m EC value. The results clearly indicated that white plastic mulch can potentially maintain the lower level of EC value which is quite safe for crop production. The correlation study (Table 4) indicated that all the growth and yield parameters studied were reduced with the increase of electrical conductivity. In 2016 there was found significant negative correlation of electrical conductivity with number of grains per cob row (r=-0.933), grain yield (r=-0.921), straw yield (r=-0.980) and root yield (r=-0.985). In 2017 significant negative correlation of electrical conductivity was found with number of grains per cob row (-0.914), grain yield (-0.929) and root yield (r= -0.910) (Table 3).

3.7 Sulfur content of soil

The sulfur (S) content was found very high in the post harvest soil with ranging from 143.6 to 292.9 ppm in 2016 and 85.2 to 484.1 ppm in 2017 over the treatments (Table 3). The lowest sulfur content in 2016 was found in white plastic mulch treatment where it was in blue plastic mulch in 2017. Both the years highest sulfur contents were in bare soil (control) treatment. Sulfur content of soil had negative correlation with all the parameters studied except electrical conductivity of soil (Table 4). In 2016 sulfur content of soil had significant negative correlation with number of grains per cob row (r=-0.932), grain yield (-0.962) and root yield (r=-0.917) and positive correlation with electrical conductivity (0.892) of maize. In 2017, significant negative correlation was found with number of grains per cob row (-0.855), grain yield (-0.877), and that of positive correlation with electrical conductivity (0.992).

Table 4. Correlation between different plant and soil parameters in 2016 and 2017

| Parameters | Grains/row | 1000-grain wt. | Grain yield | Straw yield | Root Yield | Soil temp. | pH | EC |
|---|---|---|---|---|---|---|---|---|
| | | | | **2016** | | | | |
| 1000-grain wt. | 0.722 | 1.000 | | | | | | |
| Grain yield | 0.993** | 0.784 | 1.000 | | | | | |
| Straw yield | 0.889* | 0.454 | 0.881* | 1.000 | | | | |
| Root Yield | 0.895* | 0.551 | 0.900* | 0.963** | 1.000 | | | |
| Soil temp. | 0.752 | 0.962** | 0.806 | 0.513 | 0.537 | 1.000 | | |
| pH | 0.248 | -0.308 | 0.202 | 0.532 | 0.571 | -0.383 | 1.000 | |
| EC | -0.933* | -0.517 | -0.921* | -0.980* | -0.985** | -0.534 | -0.552 | 1.000 |
| S content | -0.932* | -0.835 | -0.962** | -0.837 | -0.917* | -0.796 | -0.244 | 0.892* |
| | | | | **2017** | | | | |
| 1000-grain wt. | 0.767 | 1.000 | | | | | | |
| Grain yield | 0.990** | 0.804 | 1.000 | | | | | |
| Straw yield | 0.599 | 0.280 | 0.667 | 1.000 | | | | |
| Root Yield | 0.641 | 0.363 | 0.712 | 0.994** | 1.000 | | | |
| Soil temp. | 0.778 | 0.923* | 0.769 | 0.090 | 0.156 | 1.000 | | |
| pH | 0.560 | 0.117 | 0.482 | 0.292 | 0.312 | 0.373 | 1.000 | |
| EC | -0.914* | -0.616 | -0.929* | -0.763 | -0.910* | -0.630 | -0.500 | 1.000 |
| S content | -0.855* | -0.546 | -0.877* | -0.789 | -0.787 | -0.561 | -0.399 | 0.992*** |

*=Significant at 5% level, **=Significant at 1% level, ***=Significant at 0.1% level



## 4.0 Discussion

4.1 Irrigation water salinity

According to Bangladesh standard (MoEF 1997) safe irrigation water EC value is 1.2 dS/m, and El-Swaify (2000) reported EC value greater than 3 may cause severe hazard in crops. In our experiment at January the irrigation water EC value was lower than the permissible limit. In the experiment last irrigation was given in 12 March 2016. At 20 March 2016 the irrigation water EC value was 2.34 which were relatively tolerable for plants. In dry season

(January– May), the depth to groundwater table remains within 0–1.5 m in coastal region of Bangladesh (Salehin *et al*., 2018). The main source of water supply to the crop comes from the groundwater, reaching the roots by capillary rise. Different kinds of mulch materials check the evaporation of moisture from the soil and reduced the salt accumulation in the surface of the soil. Moreover we have given irrigation water in the foot of each plant which perhaps helps to keep root zone salt free. All the approaches simultaneously help plants to survive in the salt affected areas of Bangladesh using very limited amount of irrigation water.

4.2 Growth, yield and yield components

With few exception most of the growth, yield and yield contributing characters in both 2016 and 2017 were significantly influenced by mulch treatments. All the cases bare soil (no mulch control) had the lowest performance. Rice straw much treatment had slightly better (some cases statistically similar, some cases significantly higher) performance than control treatment. All the plastic mulch treatments had significantly higher performance than control and rice straw mulch treatment. Variation among the plastic mulch treatments were maximum cases not remarkable.

The treatments white, blue and black plastic film mulch, and rice straw much had 149, 109, 78 and 25 % grain yield increase in 2016, and 173, 117, 99 and 47 % in 2017 over control, respectively. Xu *et al*. (2015) recorded 15-26% and Liu *et al*. (2015) recorded 70% yield increase in maize by plastic film mulching over without mulching treatment. The higher yield in plastic mulch treatments were attributed by all the growth and yield contributing parameters which had better performance. Plant height, leaf number, leaf length, cob length, number of grains per cob row, 1000-grain weight was all significantly greater when mulch was used relative to no mulch. Several studies have shown the beneficial effects of mulches on quantity and quality of yield in different crops. For example, Pang *et al.* (2010) showed that plastic mulch combined with drop irrigation on the lemon tree increased the yield from 9 to 15 kg/tree compared to the control group. Combined application of plastic mulch and straw layer burial plot had the highest seed and biomass yield, 100-seed weight and head diameters of sunflower (Zhao *et al*., 2016).

Among the plastic mulch treatments white plastic mulch had the best performance in relation to grain yield production. Blue plastic mulch had the second and black plastic mulch had the third position. However, all the plastic mulch treatment had better performance than rice straw mulch treatment. Sedaghati *et al*. (2016) also found better performance of mulch treatments but no significant differences between the white and black plastic mulches in yield.

The white, blue and black plastic mulch and rice straw mulch had 141, 145, 126 and 83 % increase in straw yield in 2016 and that of 35, 20, 34 and 33 % in 2017, respectively. Similar letter grade of plastic mulch treatments indicated that different kinds of mulch treatment had no significant variation on straw yield production, although mulch treatments had tremendous effect over control. Higher straw yield in mulch treatments were attributed to the higher growth performance like plant height, leaves per plant, leaf blade length and stem circumference in mulch treatments. Over the control treatment root yield was 94, 91, 59 and 55 % higher in 2016 and 58, 29, 54 and 48 % higher in 2017 in white, blue and black plastic mulch, and rice straw mulch, respectively. The positive and significant correlation of root yield with straw yield indicates that with the increase of straw yield root yield also increased.

4.3 Soil Temperature

In the experiment among the plastic mulch treatments, soil covered with white plastic film mulch (semitransparent) had the highest temperature, blue plastic mulch had the second, while soil covered with black plastic film mulch had the lowest temperature, which agreed with the studies of Park *et al*. (1996), Subrahmaniyan and Zhou (2008), and Sun *et al*. (2015). Tegen *et al*. (2015) recorded lowest soil temperature under grass mulch treatment compared to plastic mulch treatments. In our experiment we also compared the temperature of plastic mulch treatments with rice straw mulch treatment. We found that all the plastic mulch treatments had higher temperature than rice straw mulch even rice straw treatment had lower temperature than the bare soil (control) treatment. Deshmukh *et al*. (2013) found maximum soil temperature under black plastic mulch followed by without mulch and paddy straw mulch at 5 and 10 cm depth. In the experiment there was found a strong correlation between soil temperature and 1000-grain weight; the significant r value being 0.962 in 2016 and 0.923 in 2017 which otherwise indicates larger grain size in high temperature producing treatments. Although plastic mulch treatments had higher yield and higher temperature, unfortunately there was found no significant correlation between temperature and grain yield. It was probably due to comparatively lower temperature with higher grain yield in rice straw mulch treatment than control treatment.



4.4 Electrical conductivity

Mulch treatments had a tremendous effect to reduce salinity of soil. During 2016, in relation to control treatment the EC value reduced by 51, 43, 42 and 47 % in white, blue and black plastic mulch, and rice straw mulch, respectively. In 2017, the EC value reduced by 62, 60, 49 and 35 % in white, blue and black plastic mulch, and rice straw mulch, respectively. Dong *et al*. (2008) reported that plastic mulching reduced salinity and increased soil temperature. Sedaghati *et al*. (2016) showed that the use of plastic mulch decreased the soil surface salinity from 30.8% to 51.8% compared to the control and 0-120 cm soil depth it reduced from 20.4% to 27.7% compared to the no mulch treatment. In our experiment the correlation study indicates that the grain filling and root growth consistently seriously hampered due to increasing level of EC value which ultimately reduce the grain yield.

4.5 Sulfur content

In the experiment sulfur content was found unusually high. According to FRG (2012) greater than 45 ppm S is considered as very high level in soil. Among the treatments lowest sulfur content of post harvest soil in 2016 was 143.6 ppm and in 2017 it was 85.2 ppm where critical limit is only 10 ppm (FRG 2012). The results clearly evidenced that the general level of sulfur in south coastal saline soils of Bangladesh is extremely high. In the experiment where mulch was not used S content was extremely high. The presence of extremely high level of sulfur in soil is an indication of the presence of acid sulfate soil in the study area. The excess sulfur may create S toxicity in plant. Use of plastic mulch, especially white plastic mulch potentially reduces the S toxicity which may be the probable cause of higher yield in this treatment. The correlation table indicates that all the parameters studied except EC value were negatively influenced by increasing soil sulfur content. It was probably happened due to their presence in excess, although it is identified as an essential plant nutrient element. There was found a significant positive correlation between sulfur content and EC value (r value being 0.892 in 2016 and 0.992 in 2017).



**5.0 Conclusion**

Plastic mulch had a tremendous effect to increase plant growth and yield in saline soils where generally plant growth is very poor. Plastic mulch potentially reduces the soil salinity by reducing the evaporation loss of moisture from the soil. It increases soil temperature and reduces soil electrical conductivity. Plastic mulch is very effective to reduce excess availability of sulfur in soil.

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