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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 4 °C and 3.5 °C 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.

1. Introduction

Coastal region of Bangladesh characterized by severe soil and water salinity in dry season (MoA & Fao, 2013); which seriously hampered crop growth (Ahmed, Howlader, Shila, & Haque, 2017; Haque, Jahiruddin, Hoque, Rahman, & Clarke, 2014). 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, Jharna, Hoque, Uddin, & Saleque, 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, Fan, Xu, Zhang, & Chi, 2014).

Because of low temperature in dry season after sowing often restrict maize emergence in practice (He, Li, Kuhn, Wang, & Zhang, 2010). Many studies have shown that plastic mulch is an effective

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strategy for promoting crop emergence because it can modify the soil microclimate by increasing the soil temperature (Bu et al., 2013; Dong, Li, Tang, & Zhang, 2009; Ramakrishna, Tam, Wani, & Long, 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, Wang, Li, Gao, & Tian, 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, Zhang, Dai, Wang, & Li, 2014; Song, Li, Wang, Liu, & Li, 2002).

In the global context there have some literature on the use of plastic mulch to reduce soil erosion (Zhang, Zhang, & Hu, 2013) and water conservation (Ingman, Santelmann, & Tilt, 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. Materials and methods

2.1. 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 6 m altitude. The climate is tropical in Kalapara upazila. The average annual temperature is 25.9 °C. In a year, the average rainfall is

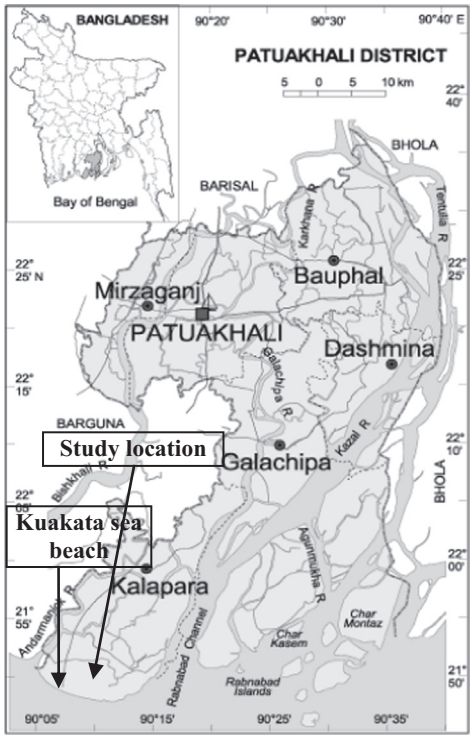

Fig. 1. Map of the study location.

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.

2.2. 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.

2.3. 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.

2.4. 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 4 m × 3 m. The plots were surrounded by 30 cm wide and 10 cm high earthen bunds. One meter wide space was kept in between two blocks.

2.5. 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 5 g) was given in the field during final land preparation to control soil born insects.

2.6. 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.