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Performance of mulching on the yield and quality of potato

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ABSTRACT

To find out a suitable mulch material for potato production is an important issue for the farmers. The aim of the present study was to effect of mulching on yield and quality of potato. A field experiment was conducted at Tuber Crops Research Sub Centre (TCRSC), Munshiganj during rabi season 2014-2015 to evaluate the performance of mulching on potato production. For meet up the demand six treatments viz. Rice straw, Water hyacinth, Saw dust, Black polythene and, White polythene along with Control (no mulch) were used to find the best materials that can help the farmers to improve their production practice. Now a day's mulching has become an important factor for potato production. All the mulches have significant influence on the growth, yield and yield contributing characters. The result indicated that the highest yield (34.21 t/ha) was found in the black polythene mulch that was statistically different from other mulch materials. The lowest yield (25.64) was found in control (no mulch) treatment.

INTRODUCTION

Potato is a staple food in the developed countries and which accounts for 37% of the total potato production in world (FAO, 2013). Considering the trend of population growth and consequently the increase demand for food in country and dwindling cultivable land area the potato is likely to play very important role in future. Bangladesh is a developing country of about 156.4 million people inhabiting in its 147,570 km^2 area and is primarily an agriculture-based economy (Ferdous et al., 2016).Potato is one of the most important crops in Bangladesh (Anowar et al. 2015). Owing to promotional effort of government it is being placed as a third crop next to rice and wheat (Haq and Matin.2006). Potato is the third largest food crops of Bangladesh (Ferdous et al. 2014). Potato is a popular and very important vegetable in Bangladesh. It is used as main vegetable for the whole year. Mulch is a preventive layer covering the surface of the soil and it contains organic and inorganic materials (Singh et al., 2015). Organic matter is essential to maximize potato production and sustain agricultural production while minimizing negative impacts on the soil fertility (Ferdous et al., 2017a). Soil mulching which covers the soil at the base of cultivated plants with a layer of protective material (Bégin et al., 2001) has been widely used in the world for growing crops like potatoes. The benefits of mulching potatoes include saving irrigation water (Singh et al., 2015; Wang and He, 2012), reducing soil erosion (Edwards et al., 2000) and leaching of fertilizer (Bégin et al., 2001), controlling weeds or reducing the dose of herbicide (Ferdous et al. 2017b; Kasirajan and Ngouajio, 2012), enhancing early growth, harvest (Zhao et al., 2014) and increasing yields (Ferdous et al., 2017b; Singh et al., 2015; Zhao et al., 2014). Soil temperature and moisture has depended on the physical properties of mulch, e.g. thermal conductivity, and their interaction with environmental condition.

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Mulching practice affects crop growth and development in various ways. It decreases the amount of water loss due to evaporation (Li et al., 2013), enhances soil water infiltration (Gan et al., 2013), distributes soil moisture again and therefore relieves water stress to some degree (Chakraborty et al., 2008). Owing to many advantages, mulching improves crops yields both in quantity or quality (Ferdous et al. 2017b; Wang et al., 2008), and increases water use efficiency (Ferdous et al. 2017b; Wang et al., 2008). The mulching was effective in enhancing the topsoil temperature in the early growing season when temperatures are low in spring (Gan et al., 2013). The effect of mulching on topsoil temperature gradually diminishes with plant development for some crop, especially in potato (Zhao et al., 2012).

Living mulches effectively reduced potato weed infestation. Changes in the dynamics of weed populations' result from both chemical and other methods limiting weed infestation (agrotechnological, mechanical and biological). When seeking to prevent the negative effects caused by weeds, yield losses and economic issues as well as ecological aspects and the maintenance of habitat biodiversity should be also considered. Activities aimed at sustainable development favor the introduction of other methods to regulate weed infestation. One of these is the cultivation of cover crops including living mulches (Hartwig and Ammon, 2002). The ability to suppress weeds by various plant species sown as living mulches is presented in the literature and ranges widely from 34 to 96% (Mohammadi, 2010). The positive role of living mulches is not limited to weed suppression. Their favorable effect has been observed, among others, on limiting soil erosion, the improvement of the biological activity and structure of soil, preventing nutrient leaching into the soil profile, limiting soil evaporation, diminishing daily soil temperature amplitude and limiting some pest populations (Steenwerth and Belina, 2008). The plants that form living mulches grow simultaneously with the crop and compete with it for light, water and nutrients, as do weeds, so therefore, crop yields are lower (Carof et al., 2007).

We know that mulching is an important operation for crops in respect moister holding, weed control as well as soil physiology which are very important for potato as a rabi crop. In case of potato production farmers of Munshigonj as well as over the country are widely used the mulch materials (Rice straw, water hyacinth), But they have no any guide line what mulch material would be beneficial for them, what would not be that they are presently used. Therefore it is a time bound question to know the effect of mulching on the tuber yield and quality of potato in Munsigonj region of Bangladesh.

MATERIALS AND METHOD

Site description and experimental design

The study was initiated at the research field of Tuber Crops Research Substation Munsigonj, Bangladesh Agricultural Research Institute, Muunsigonj, Bangladesh during October 2014 to March 2015 cropping season to find out the suitable mulching materials for potato production. The experiment was carried out in a randomized complete block design (RCBD) with 3 replications. Six different mulch materials i.e. T_1) Rice straw, T_2) Water hyacinth, T_3) Saw dust, T_4) Black polythene and, T_5) White polythene along with T_6) Control (no mulch) were used in the experiment. The study area is located at 23°49' N latitude and 90°41' E longitude with 16 m above mean sea level. The soils of this region are moderately acidic, low in organic matter content. Overall, the fertility level is low to medium, but the status of K and CEC is medium in most of the places (Ahmed et al 2017). The land was well prepared by tractor driven disc plough followed by laddering. The experiment was conducted on 2nd December, 2014 with variety Diamant at the research field of the Tuber Crops Research Sub Centre, Munshigonj during 2014-2015 potato growing season.

Crop management

Well-sprouted tubers were planted in the furrows as per treatment. The source of N, P, K, S and B was urea, triple super phosphate, murate of potash, gypsum and boric acid, respectively. Applied fertilizers and planted tubers were covered with soils properly making a ridge. Then two furrows at a depth of 5-6 cm were made 10-12 cm apart from

furrow having planted tubers where half of N and all other fertilizers applied. The crop was planted on 3-6 December in 2014 and maintaining 60 cm X 25 cm plant spacing. Weeding was required once to keep the plots weed free. Irrigations were provided at stolonization (22-23 days after planting (DAP), tuberization (33-35 DAP) and bulking (55-56 DAP) period, respectively. Earthing up was done once followed by top dressing of remaining N was applied at 30-32 DAP. Preventive measures were taken to control virus and blight diseases applying appropriate insecticides and fungicides. Carbofuran 5 G at the rate of 15 kg $ha^{-1}$was applied in furrows (depth 5-6 cm) to control cut worm. Mancozeb, Mancozeb+ Metaloxil and Malathion applied at the rate of 2 kg, 1.5 kg and 1 L, respectively. Mancozeb, Mancozeb+ Metaloxil was applied twice while malathion was applied four times. Plants were dehaulmed at 100 DAP and tubers were harvested at 7 days after dehaulming.

Data collection and statistical analysis

After maturing randomly 5 plants were harvested to record the yield and yield contributing characters of potato. Tuber yield was harvested from randomly pre-selected central areas (about 9 m^{-2}) of each plot and converted into tons per hectare (t ha^{-1}). Mean data was analyzed statistically and was carried out to analysis of variance (ANOVA) using the MSTAT-C.

RESULTS AND DISCUSSION

Effect of potato plant character under different mulch materials

The results revealed that days to start emergence, the percent emergence at 30 DAP, plant height (cm), number of stem $hill^{-1}$ and Tuber yield kg $plot^{-1}$ as well as Tuber yield t ha^{-1} at 90 DAP varied significantly but days to 80% emergence and foliage coverage percentage (%) at 60 DAP, did not varied significantly (Table 1). In case of days to start emergence the treatment black polythene mulch emerged earlier than control and the other mulch materials which was significantly different. The control treatment (no mulch) taken the maximum days (16.67) to emerge and it was statistically similar to the others treatment that was followed by the water hyacinth (12.67), sawdust(13), white polyethene (13.33), rice straw mulch (13.67). In case of percent emergence at 30 DAP the maximum emergence (95.56) was recorded at white polythene mulch which was similar to black polythene (95) and rice straw (94.45) and followed by sawdust (91.67) and water hyacinth (91.11) which were significantly different from control (86.67) which is similar to sawdust and was significantly differed from control (86.67). In case of plant height the tallest plant was found in water hyacinth (74.6cm) and same to the black polythene mulch (73.63cm) and the shortest plant was recorded in control (68.83cm) treatment. In case of days to 80% emergence no significant effect was found in six treatments and in case of % foliage coverage gave the same result too at 60 DAP.

Table1
Soil physical properties influenced by the mulch materials during 2014-15 at Munshigonj.

Treatments	Soil P^H	Soil moisture (%)	Soil temperature (^oC)
Rice Straw	5.57	35	35.5
Water hyacinth	6.3	63.33	30.93
Saw dust	5.7	50.33	35.83
Black polythene	6.03	40.33	40.9
White polythene	5.47	44	36.17
Control (No mulch)	5.93	33	35.17

Table 2
Weed biomass and dry matter % of potato influenced by the different mulch materials during 2014-15 at Munshigonj.

Treatments	Fresh Weight of weed biomass (Kg/plot)	Dry matter percent at 90 DAP
Rice Straw	0.78c	18.66ab
Water hyacinth	0.19d	17.27b
Saw dust	0.26d	19.24a
Black polythene	0.14d	19.10a
White polythene	1.98a	19.68a
Control (No mulch)	1.16b	18.42ab
CV (%)	15.75	3.99
Level of significance	**	*

** Significant at P≤ 0.01, *NS=Not significant; same letters within column are non significant

Yield performance of potato under different mulch materials

Due to maximum water retention in the soil and minimum growth of weeds the soil ensures the maximum nutrient uptake by the plants. In case of yield kg plot^{-1} at 90 DAP the highest yield (34.21 kg) was found in the black polythene mulch condition which was significantly varied from other mulch materials. The lowest yield per plot was found in followed by next highest yield (23.82 kg) was found in the straw mulch condition that was statistically similar with the white polythene mulch (23.80 t ha^{-1}) condition. Tuber yield t ha^{-1} the black polythene gave the maximum yield 38 t ha^{-1} which was statistically different from all other treatments, the lowest yield (28.49 t ha^{-1}) recorded in the control condition.

Soil physical properties and dry matter production of potato influenced by the mulch materials

Soil physical properties influenced by the mulch materials during 2014-15 presented in table 2. Soil P^H did not varied significantly, but in case of soil moisture the highest soil moisture was recorded in water hyacinth and lowest was in control condition which was significantly varied with each other. In case of soil temperature the maximum temperature was recorded in black polythene mulch which was significantly different from water hyacinth and others. In case of dry matter, all the treatments significantly influenced the highest dry matter (19.68%) was found in white polythene mulch which was similar to the saw dust (19.24%) and black polythene mulch (19.10%) and the lowest (17.27%) was in water hyacinth mulch. In case of weed biomass the highest (1.98 kg plot^{-1}) was recorded in white polythene mulch and lowest in black polyethene mulch (0.14kg) per plot.

Effect of tuber grading under different mulch materials

Tuber grading influenced by different mulch materials during 2014-15 presented in Table 3. The highest number of tuber size was found in water hyacinth mulch at the >55 mm size of tuber and the heaviest (30.84) tuber was found in same mulch materials at same size. Mulching with plastic film on the potato improved tuber yields and water use efficiency, with increased economic benefits. Mulching can be the addition of inorganic or organic material such as straw, cover crop residue or live plant to the soil surface to provide one or several ecosystem services such as enriching or protecting the soil, preventing pest establishment or enhancing crop yield. Due to maximum water retention in the soil and minimum growth of weeds the soils ensure the maximum nutrient uptake by the plants. The highest tuber yield (38 t ha^{-1}) was found in black polythene mulch which was statistically different from all other treatments, the lowest yield (28.49 t ha^{-1}) was recorded in the control condition.

Table 3
Plant characters of influenced by the mulch materials during 2013-14 at Munshigong.

Treatments	Days to start emergence (Days)	Days to 80 % emergence (Days)	% of emergence at 30 DAP	Plant height (cm) at 60 DAP	Number of stem /hill at 60 DAP	Foliage coverage at 60 DAP (%)	Tuber Yield (kg/plot) at 90 DAP	Tuber Yield (t/ha) at 90 DAP
Rice Straw	13.67	27	94.45	72.33	4.8	90	30.98	34.41
Water hyacinth	12.67	27.67	91.11	74.6	4.33	86.67	30.81	34.24
Saw dust	13	24.33	91.67	72.97	4.3	86.67	30.44	33.82
Black polythene	12.33	24.67	95	73.63	5.3	88.33	34.21	38
White polythene	13.33	25	95.56	69.43	4.43	90	31.33	34.29
Control	16.67	25.33	86.67	68.83	3.73	91.67	25.64	28.49
CV (%)	4.96	6.32	3.14	2.56	8.51	5.10	4.72	4.98
Level of significance	**	ns	*	*	*	ns	**	*

** Significant at P≤ 0.01, *NS=Not significant

Table 4
Effect of different mulch materials on Tuber grading.

Variety	% of Grading by Number			% of Grading by Weight		
	<28mm	28-55mm	>55 mm	<28mm	28-55mm	>55mm
Rice Straw	24.5	70.07	4.377bc	4.02	76.99	20.43b
Water hyacinth	23.97	72.74	8.273a	3.97	65.17	30.84a
Saw dust	19.1	75.94	4.905bc	2.75	80.96	16.25b
Black polythene	18.74	74.22	7.023ab	2.5	73.86	22.96ab
White polythene	22.45	72.65	4.877bc	4.14	78	17.85b
Control (No mulch)	22.8	73.61	3.773c	4.59	79.91	15.48b
CV (%)	24.16	7.35	25.02	7.68	6.90	28.32
Level of significance	NS	NS	**	NS	NS	**

** Significant at P≤ 0.01, *NS=Not significant; same letters within column are non significant

The mulching treatment increased tuber yields of potato, with significantly higher tuber yields for full mulching than no mulching at Munsigonj. These could be attributed to the higher temperature and humidity under mulched during the early development. As a result, mulching led to the higher emergence rate and strong seedling, accordingly increased the stems and branches per plant, leading to more number of tubers in tuber initiation. Furthermore the extended period of tuber initiation could have also promoted the tuber bulking. Consequently, the number and weight of tuber in mulching were highest, especially mulched condition. The mulching practice affects crop growth and development in various ways. It decreases the amount of water loss due to evaporation (Wang et al., 2008; Li et al., 2013) enhances soil water infiltration (Gan et al., 2013),

distributes soil moisture again and therefore relieves water stress to some degree (Chakraborty et al., 2008). Owing to many advantages, mulching improves crops yields both in quantity or quality (Wang et al., 2008), and increases water use efficiency (Wang et al., 2008; Ferdous et al., 2017b).

In our study, the mulching increased the humidity and temperature in topsoil, consequently advanced the germination and emergence of seedling when compared to plots without mulch. It is obvious that the mulching played an important part in ameliorating plant growth, particularly during early growing stages, in this area.

In case of weed biomass the highest (1.98 kg plot^{-1}) was recorded in white polythene mulch and lowest in black polyethene mulch (0.14 kg plot^{-1}). Weeds are still the number one production constraint for many crop producers (Turner et al., 2007). Cover crop mulch that remains on the soil surface can be used to add soil organic matter (Dabney et al., 2001), prevent soil erosion, increase soil water retention, improve soil health (Wang et al., 2011), and suppress arthropod and weed pests as well as diseases (Ferdous et al., 2017b ; Gonzalez-Martin et al., 2014). This organic matter increase crop yield (Ferdous et al. 2011a,b; Ferdous et al. 2014; Sarker et al. 2010; Rahman et al. 2011; Anowar et al. 2012). Organic mulch associated with no-till farming is well-known for its soil health benefits (Doran, 2002).

CONCLUSION

By considering different plant characters and yield contributing characters the mulch material black polythene may be the most useful mulch for potato cultivation. Mulches contribute to weed management in organic crops by reducing weed seed germination, blocking weed growth, and favoring the crop by conserving soil moisture and sometimes by moderating soil temperature. Mulching in the form of cover crops and practicing reduce tillage have some ecological advantages over conventional land preparation tasks such as plowing and disking the entire field as they are generally less disrupted to the soil environment.

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