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Short Communication: Effect of mulching materials on mini-tuber production of potato from in vitro plantlets

D.A.N. MAJUMDER[1,♥], S.C. NATH[2], M.A. KABIR[3], S. MAJUMDER[1]
[1]BRAC Potato Seed Production Program, Birol, Dinajpur-5200, Bangladesh. ♥email: dilrubamajumder@yahoo.com
[2]BRAC Seed and Agro Enterprise, 75 Mohakhali, Dhaka1212, Bangladesh
[3]Department of Horticulture, Hajee Mohammad Danesh Science and Technology University, Dinajpur -5200, Bangladesh.

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Abstract. *Majumder DAN, Nath SC, Kabir MA, Majumder S. 2016. Effect of mulching materials on mini-tuber production of potato from in vitro plantlets. Nusantara Bioscience 8*: *123-127*. This paper describes the effectiveness of organic and plastic mulching for potato mini-tuber production in Bangladesh. The field experiment was carried out during the Rabi season of 2013-2014 to 2014-2015 with virus-free in vitro cultured plantlets of var. Diamant. The mulching materials of water hyacinth mulch (WHM), rice straw mulch (RSM) and black polythene mulch (BPM) were compared with no-mulching (control) to find out suitable mulching material (s) for obtaining higher tuber yield. During the whole production period morphological characters, yield characters as well as of soil temperature and soil moisture were assessed. The results showed that WHM (5.28 t/ac) and RSM (4.59 t/ac) had a positive effect on increased the proportion of tuber size above 28 mm and on increasing of tuber yields by 54.0% to 77.2% compared with control (2.98 t/ac). Higher soil temperatures were recorded with plastic mulch caused lower potato tuber yield (3.04 t/ac) while WHM and RSM decreased soil temperatures and increased the moisture percentage. The mulching of mini tubers had negative effect on tubers quality in regards to scab, green tuber, and weed biomass.

Keywords: Mini tuber, potatoes, mulching materials, soil temperature, moisture percentage, and tuber quality

INTRODUCTION

Potato (*Solanum tuberosum* L) is grown in more than 100 countries all over the world. As a staple food potato is the third most important crop after rice and wheat in Bangladesh (Haq and Matin 2006). About 90% of the total rainfall is received in monsoon (June and September) and in the reaming months (October to May) drought at different degrees occurs in almost all areas of the country. Depending on the severity of drought the estimated yield reduction in Bangladesh varies from 10 to 70% (BARC 1990). Surface mulching is one of the most cost-effective means, which may retain soil fertility and improve crop productivity (Shelton et al. 1995). Mulch could improve soil conditions especially to reduce soil water evaporation and maintain stable soil temperature (Ji and Unger 2001; Kar and Kumar 2007). Reduction of soil temperature has great importance in countries as global warming makes the conditions unfavorable for crops production (Sinkeviciene et al. 2009). For that reason, mulching becomes more important also in moderate climatic conditions. According to Boyd and Acker (2003) the fluctuation of soil moisture especially in upper soil layers, influences negative on seed germination and seed emergence, besides mulching massively reduces soil erosion (Doring et al. 2005).

Mulching influences soil moisture as well (Ramakrishna et al. 2006). Mulch maintains stable soil moisture, especially in surface soil layer. The water content directly near the soil surface plays an essential role for degradation of natural organic material by soil microbes (Hood 2001). On the other hand, a sufficient layer of mulching can inhibit weeds emergence as documented by results of some authors. They showed positive effect of mulching on weed density (Johnson et al. 2004; Sinkeviciene et al. 2009). For that reason mulching can be considered as an important weed control factor (Balalis et al. 2002; Radics and Bognar 2004) especially in systems where using herbicide is not allowed (e.g. organic farming). Except for weeds, insects and fungal diseases are the primary causes of yield loss in Bangladesh. Mulching can affect the external quality of tubers (scab of tubers, mechanical damages, greening of potato-tubers) and inner quality (chemical composition) as well (Asghari-Zakaria et al. 2009).

Thick mulch helps to retain sufficient moisture in the soil. Cut tubers should not be used in this method (Razzaque et al. 2000). In some areas of Bangladesh, farmers are practicing this technology but they are using different varieties and different mulching materials and no mulching material was standardized. Some farmers use straw as mulch, and some others use water hyacinth. They are also not aware of thickness of the mulch. For this reason, they are not getting expected yield of potato. The aim of this paper was to evaluate the effect of different mulching materials (organic and plastic mulch) on the yield and quality of tubers and on some factors like soil temperature and soil water potential influencing mini-tuber production.

Therefore, an investigation was undertaken with potato plantlets production using three mulching materials with the objective- to find out suitable mulching material (s) for obtaining higher yield in potato mini-tuber production.

MATERIALS AND METHODS

Field experiments were conducted at BRAC-Potato Seed Farm at Birol, Dinajpur, Bangladesh. The type of soil of the experimental site was acidic with high nutrient content and texture class was sandy-loam. The experiment was carried out two production season (2013-2014 and 2014-2015) during the Rabi season. Land was prepared for six times ensuring the deep plough until 8-inch depth. Virus free in vitro plantlets were planted in 3mx3m sized plot on 22 November; maintaining the planting distance from plant to plant 25cm and line to line 60cm.

Fertilizers were applied each 130-110-140-50-50-5-5 kg urea, triple super phosphate (TSP), murite of potash (MOP), zypsium, magnesium, zinc sulfate and boric acid per acre respectively. Full amount of magnesium, zypsium, zinc sulfate, boric acid and half of the urea were applied during the land preparation by broadcasting and properly mixed with soil before ploughing. The remaining fertilizer was top dressed before irrigation at around 25-30 days after planting (DAP). Before planting, shallow furrow was made by hand plough. The experimental plots were mulched with three different kinds of mulching materials black polythene sheet (BPM), rice straw (RSM) and water hyacinth (WHM) after top dressing and irrigation while no mulching materials were used in the control. Single irrigation was applied at 25-30 days after plantation. Rice straw and water hyacinth were spread manually by 6 inch thick layer at 35 days after plantation (DAP). In case of polythene mulch, 4.5m x 4.5m polythene sheet was placed on the ridge and made holes after 25cm apart. Randomized Complete Block Design (RCBD) was used with four replications. Acrobat-MZ and Imidacloprid have been used four times during the production season to prevent diseases and insects.

Mulching materials were removed at haulm pulling stage (85 DAP). Tubers were harvested manually and harvested tubers were sorted out with commercial potato sorters (grading forma). Tubers with scab, green tuber, and injured tubers were previously removed from the good tuber. Good tubers were graded into three fractions A-grade: more than 28 mm (>28mm), Mini tuber-1 (M-1): < 28 mm and Mini tuber-2 (M-2): < 15 mm.

Soil temperature was measured every day in all treatments (BPM, RSM, WHM, and Control) at the depth of 100 mm during the period from planting to haulm pulling by thermometer on the basis of maximum and minimum temperature. Soil moisture was measured in all treatments (BPM, RSM, and WHM with control) at a depth of 240 mm after 5 days interval during the period from 35 days after plantation (DAP) to haulm pulling by oven drying. Fresh soil samples were collected from field and then taken their initial weight, after that they were dried for 48 hours at 100°C temperature. The oven dried soil samples were again weighted for final weight. The weight of weed biomass in all treatments (BPM, RSM, WHM and Control) was determined before harvest (on average) when the weeds were removed.

Statistical analysis was calculated with JMP 8.0 to determine the effect of three mulching materials (BPM, RSM, and WHM) with control. The significance of results tested by one-way analysis of variance (ANOVA) and the means of the treatments were compared by the Student's *t* at significance level $P = 0.05$ (JMP software, SAS Institute, Cary NC). The pooled data of two seasons were used for statistical analysis in every parameter.

RESULTS AND DISCUSSION

Effect of mulching on growth and yield traits of potato mini tuber

Plant height, number of shoot and leaf showed significant increase with mulching over no mulching (Table 1). Considering all parameters the best results were recorded with the WHM followed by RSM and BPM. The maximum result was recorded with hyacinth mulch from the first month to haulm pulling stage. As mulch duration is an influential factor, data from these case studies suggested that 60 days of mulching duration was most favorable for potato production in the tested areas.

All growth parameters were recorded at two stages- 45 DAP and 75 DAP. Number of stems per hills at haulms cutting stage was significantly higher with mulch than the control. For the maximum number of stems per hill, the means of WHM (3.74) and RSM (3.46) treatments were significantly higher at 75 DAP than BPM (2.58) treatment, while there was no significant difference between the treatments WHM and RSM. The highest number of leaf was recorded for WHM treatment which was significantly different from the BPM treatment. Water hyacinth mulch showed taller plants (Table 1) compare with the other treatments.

Effect of different mulch was significantly different at percent of A-grade tuber number per plant, weight of tuber per plant and yield per acre. Effect of different mulching materials on the yield of potato is presented in (Table 2). Percent tuber per plant was divided into three categories; Min tuber-1 (M-1), Mini tuber-2 (M-2) and A-grade. The highest percentage of A-grade was recorded for WHM which was significantly different from other two mulching materials and no mulch material. There was no significant difference between polythene mulch and no mulch in respect of percent A-grade tuber. Wang and He (2012) reported the negative effects of plastic mulching included a lower emergence, lower potato tuber yield, and poorer tubers quality, which may be attributable to the poorer soil aeration and detrimentally high soil temperature associated with plastic mulch even the air temperature is normal.

In case of Mini tuber-1, highest number of tuber was recorded with polythene mulch, whereas lowest percentage of tuber was recorded from hyacinth mulch. There was no significant difference in percent of Mini tuber-2 among all treatments. So it was noticed that plantlets underwater

Table 1. Effect of mulching on growth parameters of potato mini-tuber production

Treatments	Plant height at 45 DAP (cm)	Plant height at 75 DAP (cm)	Number of stem/hill 45 DAP	Number of stem/hill 75 DAP	No of leaves at 45 DAP	No of leaves at 75 DAP
No Mulch	18.73 b	33.5 d	1.44 c	1.83 c	16.85 b	31.83 c
Black polythene mulch	19.27 ab	41.03 c	1.95 b	2.58 b	17.06 b	39.10 b
Rice straw mulch	20.73 ab	45.25 b	2.17 ab	3.46 a	20.40 a	42.95 ab
Water hyacinth	21.57 a	49.94 a	2.57 a	3.74 a	21.83 a	46.97a

Note: Mean separation in columns by Student's *t* at $P \leq 0.05$; Levels not connected by same letter are significantly different

Table 2. Effect of mulching on yield parameters of potato mini-tuber production

Treatments	M-1* (<28 mm diam.) (%)	M-2* (<15 mm diam.) (%)	A-grade (>28 mm diam.) (%)	Tuber weight/plant (g)	Yield/ ac (t/ac)
No Mulch	37.65 a	24. 97	37.08 c	110.46 b	2.98 b
Black polythene mulch	39.20 a	23.50	37.30 c	111.90 b	3.04 b
Rice straw mulch	30.19 b	23.39	46.45 b	200.07 a	4.59 a
Water hyacinth	24.63 b	23.28	52.13 a	204.17 a	5.28 a

Note: Mean separation in columns by Student's *t* at $P \leq 0.05$; Levels not connected by same letter are significantly different. M-1* (mini tuber-1), M-2*(mini tuber-2)

Table 3: Effect of mulching on yield quality of potato mini-tuber production (scab, green tuber, and weed biomass)

Treatments	Weed biomass (g/plot)	Percent of scab (%)	Percent of green tuber (%)
No Mulch	490.0 a	2.86 a	1.87 a
Black polythene mulch	19.7 b	1.76 b	0.70 b
Rice straw mulch	90.3 b	1.06 d	1.08 b
Water hyacinth	86.1 b	1.44 c	1.04 b

Note: Mean separation in columns by Student's *t* at $P \leq 0.05$; Levels not connected by same letter are significantly different

hyacinth mulch produced highest number of A-grade tuber and lowest number of M-1and M-2.

Petr et al. (2012) reported that grass mulch reduced the soil temperatures, soil water potential and significantly increased tuber yields even in warmer region while recorded lowest yield of tubers in treatment with black textile mulch. Second higher number of A-grade was recorded from rice straw mulch, where as there was no significant difference between BPM and Control at mean number of A-grade tuber. Higher yields showed in straw mulch by 32-35% than in no mulch which was also reported by Brust (1994).

Maximum tuber weight was recorded for WHM followed by RSM. Yield was higher with water hyacinth mulching, it was statistically same with rice straw mulch treatment and both were superior to no mulch. The maximum tuber per plant was recorded by mulching material of water hyacinth compare to other mulching materials. The reason might be behind that water hyacinth be able to retain moisture in the soil for longer period, which was ultimately increased tuber yield. The similar results were reported by Razzaque and Ali (2009)

Effect of different mulching materials on the yield of potato was studied by Razzaque and Ali (2009) and recorded maximum tuber per plant when used water hyacinth as mulching material compares with other mulching materials like polyethylene sheet and rice straw. Tuber weights were higher in water hyacinth because it can keep moisture in the soil for longer period.

Effect of mulching on quality of mini tubers (weed biomass, scab and green tuber)

The influence of different mulch treatment on weed biomass was not the same as the influence of these treatments on tuber yield. The weight of weed was statistically significantly lower on plots with BPM where control showed the highest weed biomass (Table 3). The WHM and RSM both significantly reduced the weight of weed biomass compared to C variants. Other authors also found that organic mulch such as straw mulch has consistent effect on reduction of weed biomass (Doring et al. 2005; Petr et al. 2012). Comparing the experimental sites, lowest percentage of scab was recorded on plots with RSM (1.06), where lowest percentage of green tuber had been recorded from BPM (0.70). The highest percentage scab and green tuber were recorded from the plots without mulch (Control) due to the fluctuation of soil temperature and soil moisture.

Effect of mulching on soil moisture content and soil temperature

The tendency of lower yield of tubers in treatment without mulch is shown in Table 2, Figures 1 and 3 which was related to the lowest moisture percentage on those plots. Water hyacinth and rice straw mulch could retain moisture in the soil for longer period, which can be ultimately helpful to increase the tuber yield.

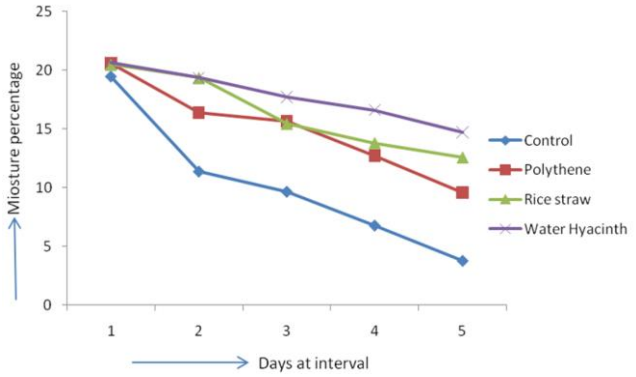

Figure 1. Average of soil moisture at 240 mm depth below surface of ridge (in the period December to February production season 2013-2014 & 2014-2015)

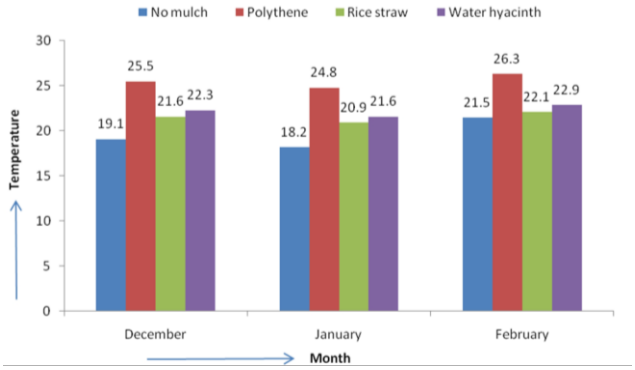

Figure 2. Average of soil temperature at 100 mm depth below surface of ridge (in the period December to February production season 2013-2014 & 2014-2015)

Figure 3. Photograph showing number of mini tubers under three mulching condition compare with no-mulch condition. A. Waterhyacinth mulch, B. Rice straw mulch, C. Black polyethylene mulch, D. No mulch

The soil temperature was recorded from December next to February which is shown in Figure 2. High temperature was observed for BPM treatment in every month might be attributed to the fact that the BPM did not allow the exchange of light and air between soil and atmospheric environment for proper growth and quality of tubers. Plastic mulch could restrain potato plant growth during the early stage, dependent on the micro-environmental air and soil temperatures. The possible negative effects of plastic mulching included a lower emergence, lower potato tuber yield, and poorer tubers quality. Weng and He (2012) also discourage the plastic mulch in their study due to its tendency of poorer soil aeration and detrimentally high soil temperature. They also suggested different drip irrigation regimes under plastic mulching conditions for lowering the soil temperature and increasing proper growth of tubers. Similarly, Petr et al. (2012) mentioned their studied results that grass mulch showed significantly higher yields than the black textile mulch with decreasing the soil temperature and soil water potential under limited rainfall conditions.

In the experiment, the mulching of water hyacinth and rice straw significantly decreased the small size potato tuber fraction (less than 15mm) but significantly increased larger sized fractions. Mulching had a positive effect on tuber yield as well. It is possible to reduce 3-4 times irrigation if organic mulch can be used.

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