

Effects of Different Mulching Materials on Plant Growth, Fruit Yield and Quality of Two Cultivars of Watermelon (*Citrullus lanatus* Thunb.)

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Abstract

The study was conducted to investigate plant growth, fruit yield and quality attributes of two cultivars of watermelon as affected by mulching materials during the winter seasons of 2014 and 2015 in the field of Department of Horticulture and Agricultural Biotechnology, Yezin Agricultural University. The treatments were laid out in two-factor factorial arrangement in randomized complete block design with four replications. The first factor was mulching materials: rice straw, black polyethylene, silver polyethylene and clear polyethylene and without mulch was control. The second factor was cultivars: namely 855 and Padamya. The data on main vine length (cm), number of nodes on main vine and number of branches per plant were weekly recorded. Soil moisture content (%) and weed infestation (g) were also measured. At harvest time, single fruit weight (kg), total fruit yield (ton ha⁻¹), skin and pulp firmness (kg cm⁻²), Brix %, juice content (%) and total titratable acidity (TTA %) and color values of L*, a*, b* were also analyzed. All mulching materials showed significantly higher single fruit weight and total fruit yield than control. The plants without mulch (control) showed the lowest values in single fruit weight and total fruit yield. All mulching materials not only maintained the maximum soil moisture but also suppressed weed infestation. There was an interaction between mulching materials and cultivars on single fruit weight, total fruit yield and also the fruit quality attributes of juice content and color values of L*, a* and b*. According to the results, mulching practice is efficient for watermelon production and silver polyethylene mulch is the best among them. There were no significant differences in the main growth parameters of single fruit weight and total fruit yield between two cultivars. Moreover, the quality attributes of Brix %, juice content and TTA % of cultivar 855 did not differ from cultivar Padamya. Therefore, cultivar Padamya may be a potential cultivar for local consumption and for export in future along with the cultivar 855.

Keywords: mulching materials, watermelon, growth parameters, yield, fruit quality attributes

Introduction

Watermelon (*Citrullus lanatus* Thunb.) is the most widely grown cucurbitaceous crop in the world. In Myanmar, the area under watermelon was over 15,262 hectares and total production was about 183,514 tons with the average fruit yield of 12.02 tons per hectare (DOA 2013). It is also a commercial vegetable and popular dessert fruit in Myanmar. It is a good source of water, vitamin C, vitamin A, other vitamins and minerals.

The factors affecting growth, yield and quality of watermelon are the genetic characteristics of the cultivar, growing environment, pest and disease management and cultural practices. Mulching is a

cultural practice of placing organic or inorganic materials on the soil around plants to provide a more favorable environment for growth and production (Osiru and Hahn 1994). Mulching is a beneficial practice for crop production and it has many advantages. Mulches can conserve soil moisture, soil temperature, soil fertility, control weed and prevent the plants from direct soil contact (Parmar et al. 2013). Moreover, it can increase soil organic matter content and plant nutrients when organic mulch is used.

There are two types of mulch: namely organic and inorganic mulch. Organic mulches like rice straw, hay, grass clippings, leaves and compost tend to return nutrients to the soil through decomposition

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and improve the water-holding capacity of the soil and organic matter. It can also provide an ideal environment for earthworms and effective soil microorganisms (Dickerson 2000). Inorganic mulches like plastic films and polyethylene can provide many advantages for the growers. They can increase crop yield, early maturity with high quality produces and can also control insect and weed (Lament 1993).

Although mulching is widely used for watermelon production in developed countries, in Myanmar, its production was usually done in open fields without mulching. The market demand of watermelon becomes higher day by day since people gradually come to know its nutritive values. And thus growers are trying now to increase the production of watermelon by using mulching materials to meet the market demands. However, there is little academic information on watermelon production by the use of different mulching materials in Myanmar. Therefore, the present study was carried out with the following objective; to investigate plant growth, fruit yield and quality attributes of two cultivars of watermelon as affected by different mulching materials

Materials and Methods

The field experiments were conducted at the Department of Horticulture and Agricultural Biotechnology, Yezin Agricultural University, Nay Pyi Taw. The experiments were carried out in winter seasons of 2014 and 2015. The treatments were laid out in two-factor factorial arrangement in randomized complete block design with four replications. The first factor was mulching materials: rice straw, black polyethylene, silver polyethylene and clear polyethylene mulch and without mulch was used as a control. The second factor was cultivars: namely 855 and Padamya.

The experimental area was 48 m × 40 m and each plot size was 12 m × 4 m. The experimental field was thoroughly prepared with double row sowing practice. The raised beds were 990 cm in length, 90 cm in width and 20 cm in height. There were 10 plants per plot and 400 plants in the whole experiment. The 12-day-old seedlings were transplanted to the field with the plant spacing of 90 cm and plot spacing of 540 cm for tendril running. T h e

fertilizers were applied at the rate of 250 kg Urea, 100 kg T-Super and 100 kg Muriate of Potash per hectare according to Parmar et al. 2013. Full dose of T-Super, farmyard manure (5 ton ha⁻¹) and lime (500 kg ha⁻¹) were applied as a basal. Urea and Muriate of Potash were split four times, one basal and three side dressings, which were applied at 30 days after sowing (DAS), 45 DAS and 60 DAS. Foliar fertilizers were weekly sprayed starting from 45 DAS. Various insecticides and fungicides were weekly applied at the recommended rates. Care and management for plants followed farmer practices and conventional methods.

Ten sample plants were selected from each treatment to collect data. The crop growth parameters of main vine length (cm), number of nodes on main vine and number of branches per plant were weekly recorded. Soil moisture content (%) at the time of harvest and weed infestation (g) at 45 and 60 DAS were also measured. At harvest time, single fruit weight (kg), total fruit yield (ton ha⁻¹), skin and pulp firmness (kg cm⁻²), Brix %, juice content (%), total titratable acidity (TTA %) and pulp color values of (L*,a*,b*) were also determined. All the collected data were statistically analyzed by using Statistix 8.0 program and treatment means were compared using least significant difference (LSD) test at 5% level.

Results and Discussion

Growth Parameters

Main vine length (cm)

Effects of different mulching materials on main vine length of two cultivars of watermelon are described in table 1. The main vine length of watermelon was highly significantly different among the mulching materials between two cultivars. The main vine length of cultivar 855 was longer than that of cultivar Padamya. Among the mulching materials, the plants treated with silver polyethylene mulch gave the longest main vine length of 329.18 cm. All mulched plants were significantly longer in main vine length than control. The plants without mulch resulted in the shortest main vine length of 261.24 cm.

These results are similar to the findings of Par-

mar et al. (2013), who reported that silver coating on black plastic mulch increased main vine length among different mulching materials. Moreover, Maughan and Drost (2016) also stated that silver reflective plastics mulches are very effective in reducing aphid and thrips populations.

As all treated plants showed longer main vine length than control, it may be due to the fact that mulches can more or less conserve soil moisture near root zone and can minimize the soil surface evaporation losses.

Number of branches per plant

Effects of different mulching materials on number of branches per plant of two cultivars of watermelon are mentioned in table 1. The number of branches per plant was significantly different among the mulching materials between two cultivars. Among the mulching materials, the plants treated with silver polyethylene mulch showed the highest number of branches per plant (38.52). The lowest number of branches per plant (17.47) was observed in control followed by clear polyethylene mulch (25.23). There was no significant difference in number of branches per plant of rice straw (28.84) and black polyethylene (31.82) mulched plants. The number of branches per plant for cultivar 855 was significantly more than that of cultivar Padamya.

These results are similar to the findings of Parmar et al. (2013). They reported that silver plastic mulch produced more number of branches per plant compared to control. It may be due to the fact that the plants treated with silver polyethylene mulch can maintain soil moisture, which can result in favorable microclimate condition for more branches per plant.

Number of nodes on main vine

Table 1 shows the effects of different mulching materials on number of nodes on main vine of two cultivars of watermelon. The number of nodes on main vine was highly significantly different among the mulching materials between two cultivars. Among the treatments, the plants treated with silver polyethylene mulch showed the highest number of nodes on main vine (37.29) followed by clear poly-

ethylene mulch (35.92). The lowest number of nodes on main vine was observed in control (32.92). The cultivar 855 resulted in higher number of nodes on main vine than cultivar Padamya.

The result of this study was similar to the finding of Parmar et al. (2013), who reported that plants treated with silver plastic mulch increased number of nodes per vine among the mulching materials. It can be assumed that the plants with mulching materials resulted in higher number of nodes on main vine due to favorable soil moisture for node development while the plants without mulch cannot maintain soil moisture, which is a constraint for node development.

Single fruit weight (kg)

Effects of different mulching materials on single fruit weight of two cultivars of watermelon are described in table 1. Single fruit weight of watermelon was significantly influenced by the mulching materials. Among the mulching materials, silver polyethylene mulched plants were recorded to have the highest single fruit weight (6.45 kg) followed by clear polyethylene mulched ones (5.97 kg). The lowest single fruit weight was observed in control (3.80 kg). There was no significant difference in single fruit weight of cultivars 855 and Padamya.

Similar results have been reported by Ansary and Roy (2005). They stated that all mulching treatments, especially the silver polyethylene mulches, significantly increased the average fruit weight. Soil moisture and temperature are the important factors for crop growth and development. In this study, silver polyethylene mulch resulted in higher single fruit weight. It may be due to high soil moisture content under mulch that results in favorable microclimate conditions for fruit development. Moreover, it can be assumed that silver polyethylene mulch has insect repellent action and it can suppress insects and pests infestation which can enhance fruit development.

Total fruit yield (tons ha⁻¹)

Effects of different mulching materials on total fruit yield of two cultivars of watermelon are presented in table 1. The total fruit yield of watermelon was significantly influenced by mulching materials. The plants mulched with silver polyethylene gave

Table 1. Combined analysis of effects of different mulching materials on crop growth parameters of two cultivars of watermelon

Treatments	Main vine length (cm)	Number of Branches per plant	Number of nodes on main vine	Single fruit weight (kg)	Total fruit yield (tons ha ⁻¹)	Soil Moisture (%)	Weed infestation (g)
Mulching							
Control	261.24 c	17.47 d	32.92 c	3.80 c	13.64 c	16.68 d	270.94 a
Straw	302.06 b	28.84 bc	34.71 bc	5.38 b	19.30 b	19.68 c	88.19 b
Black	304.58 b	31.82 b	34.33 bc	5.36 b	19.01 b	33.26 a	68.69 b
Silver	329.18 a	38.52 a	37.29 a	6.45 a	23.20 a	34.07 a	61.06 b
Clear	304.14 b	25.23 c	35.92 ab	5.97 ab	21.20 ab	31.21 b	89.38 b
LSD _{0.05}	22.87	6.42	2	0.88	3.2	1.91	36.25
Cultivar							
855	311.21 a	30.27 a	36.17 a	5.36	19.04	26.77	112.62
Padamya	289.27 b	26.49 b	33.90 b	5.44	19.51	27.19	116.18
LSD _{0.05}	13.3	2.88	0.96	0.51	1.86	1.07	19.34
Pr>F							
Mulching	<0.001**	<0.001**	<0.001**	<0.001**	<0.001**	<0.001**	<0.001**
Cultivar	0.002**	0.012*	0.001**	0.746	0.609	0.431	0.713
Mulching x Cultivar	0.633	0.001**	0.099	0.003**	0.005**	0.001**	0.001**
CV %	28.23	34.74	12.37	28.86	29.65	9.91	62.65

Means in the same column followed by the same letters are not significantly different at $P \leq 0.05$.

* = significant at 5% level

** = significant at 1% level

significantly highest total fruit yield (23.20 ton ha⁻¹) followed by clear polyethylene mulched plants (21.20 ton ha⁻¹). However, the plants without mulch produced the lowest total fruit yield (13.64 ton ha⁻¹). There was no significant difference in total fruit yield of the cultivar 855 and Padamya.

This result agreed with that of Dean et al. (2004). They stated that the total fruit yield was significantly higher in mulched plants especially in silver polyethylene mulch. Maughan and Drost (2016) also stated that silver reflective plastic mulches are very effective in reducing aphids and thrips populations. The microclimate condition around the plant would be greatly influenced by mulches and that can provide favorable temperature and moisture for crop growth and yield. In this study, all mulches especially silver polyethylene mulch produced larger fruit and higher total fruit yield than control. It can be assumed that the application of mulch on soil surface can support the favorable microclimate condition (i.e. soil moisture and soil temperature) for fruit development to attain higher total fruit yield. Moreover, silver polyethylene mulch has insect repellent action and it can

also suppress weed growth resulted more fruit development and total fruit yield.

Soil moisture content (%)

Effects of different mulching materials on soil moisture content of two cultivars of watermelon are shown in table 1. There were highly significant differences in soil moisture content among the mulching materials. The soil moisture contents were significantly lowest (16.68 %) in treatments without mulch (control) followed by rice straw mulch (19.68 %). Soil moisture contents were significantly highest in the treatments with silver and black polyethylene mulches.

The treatments with polyethylene mulches significantly maintained soil moisture contents than did others (rice straw and without mulch). These results are similar to the findings of Maged (2006), who stated that different types of mulches maintained soil moisture by reducing evaporation from soil surface compared to bare soil. It may be assumed that polyethylene mulches can improve soil moisture by decreasing moisture losses from soil because they completely covered around the

root environment. That fact is favorable for plant growth due to effective use of water. The plants treated with no mulch and rice straw mulch cannot maintain soil moisture because they did not completely cover around the root zone and thus there were more moisture losses and not enough moisture for plant growth and development.

Weed infestation (g)

Effects of different mulching materials on weed infestation of two cultivars of watermelon are demonstrated in table 1. The weed infestations were significantly different between mulched and unmulched plants. The weed infestation of control plants were significantly more than the mulched plants. However, there were no significant differences in weed infestation among the mulching materials of inorganic mulch (polyethylene) and organic mulch (rice straw).

According to the results, the plants treated with different mulching materials significantly suppressed the weed growth. Similar results were found by Hatami et al. (2012). They stated that polyethylene mulch had a significant effect on weed infestation. It can be assumed that the plants without

mulch showed the highest weed infestation due to favorable condition for weed germination and weed growth. Moreover, inorganic mulches especially polyethylene can block light entering through the mulch, which can suppress weed growth and reduce weed competition. It may be due to the fact that the growth of weeds could be retarded in the absence of light under the polyethylene mulches.

Fruit Quality Attributes

Fruit skin and pulp firmness (kg cm^{-2})

Effects of different mulching materials on skin and pulp firmness of two cultivars of watermelon are shown in table 2. There were highly significant differences in skin and pulp firmness among the mulching materials. The highest skin and pulp firmness (3.86 and 0.47 kg cm^{-2}) were observed in the fruits treated with rice straw mulch. However, there were no significant differences in skin and pulp firmness in other treatments. The skin firmness was also significantly affected by different cultivars while pulp firmness was not.

Table 2. Combined analysis of effects of different mulching materials on quality attributes of two cultivars of watermelon

Treatments	Skin Firmness (kg cm^{-2})	Pulp Firmness (kg cm^{-2})	Brix %	Juice content %	TTA %	Color development		
						L*	a*	b*
Mulching								
Control	3.55 b	0.41 bc	8.54 b	68.65 b	0.12 c	39.86	35.32 a	15.94 b
Straw	3.86 a	0.47 a	8.83 b	69.34 b	0.14 a	39.80	33.80 bc	16.40 ab
Black	3.66 b	0.38 c	9.50 a	72.92 a	0.12 c	40.22	32.93 c	16.41 ab
Silver	3.62 b	0.43 ab	9.50 a	74.41 a	0.13 b	39.26	34.24 ab	17.13 a
Clear	3.57 b	0.43 ab	9.07 ab	69.04 b	0.13 b	39.98	32.85 c	16.80 a
LSD _{0.05}	0.12	0.05	0.63	3.08	0.006	1.20	1.15	1.13
Cultivar								
855	3.73 a	0.43	9.00	70.99	0.13	41.46 a	34.67 a	17.16 a
Padamya	3.58 b	0.42	9.17	70.75	0.12	38.19 b	32.99 b	15.92 b
LSD _{0.05}	0.08	0.03	0.41	1.90	0.004	0.76	0.78	0.58
Pr>F								
Mulching	<0.001**	0.005**	0.013*	<0.001**	0.001**	0.570	0.001**	0.042*
Cultivar	0.001**	0.572	0.394	0.809	0.20	0.001**	0.001**	0.001**
Mulching x Cultivar	0.003**	0.028*	0.667	0.001**	0.001**	0.001**	0.001**	0.001**
CV %	6.18	16.89	16.83	6.01	3.36	2.21	1.80	2.82

Means in the same column followed by the same letters are not significantly different at P^a 0.05.

The skin and pulp firmness of rice straw were highest among the mulching materials. According to Tindall et al. (1991), straw mulch can delay crop growth than plastic mulch due to soil cooling effect. Therefore, it can be assumed that the firmness of skin and pulp may be partly due to soil cooling effect and partly due to less soil moisture content in this study.

Total soluble solid (TSS or Brix %)

Effects of different mulching materials on total soluble solid (TSS or Brix %) of two cultivars of watermelon are expressed in table 2. The Brix % of watermelon was significantly different among the mulching materials. The highest and the same value of Brix % (9.50) was observed in the fruits treated with black and silver polyethylene mulches followed by clear polyethylene mulched plants (9.07). The lowest Brix % (8.54) was observed in control fruits followed by rice straw mulch (8.83). There was no significant difference in Brix % of fruits between two cultivars.

According to the findings of Ansary and Roy (2005), the maximum total soluble solid were observed in the fruits treated with silver polyethylene mulch while the minimum sugar content was observed in control. In this study, all polyethylene mulched fruits, especially black and silver polyethylene mulched ones, were sweeter than those of other treatments. It can be assumed that polyethylene mulches can absorb and maintain high temperature, which might improve sugar level or Brix % of watermelon.

Juice content (%)

Effects of different mulching materials on juice content (%) of two cultivars of watermelon are shown in table 2. The juice content of watermelon was significantly influenced by mulching materials but there was no significant difference in the two cultivars of watermelon. Among the mulching materials, the fruits treated with silver polyethylene mulch showed the highest juice content (74.41 %) followed by black polyethylene mulch (72.92 %). Other treatments did not significantly differ from each other.

According to the findings of Moreno et al. (2009), there was no significant difference in the

juice content of tomato among the mulching treatments. However, in this study, silver and black polyethylene mulched fruits resulted in the highest juice content. It can be assumed that the plants mulched with polyethylene may have higher soil temperature and soil moisture, which can enhance plant growth and fruit development with high juice content.

Total titratable acidity (TTA %)

Effects of different mulching materials on total titratable acidity (TTA %) of two cultivars of watermelon are described in table 2. The TTA % was highly significantly different among the mulching materials. The fruits treated with rice straw mulch showed the highest TTA % (0.14) while the lowest and the same TTA % of (0.12) was observed in black polyethylene mulch and control. However, no significant differences of TTA % were observed between two cultivars.

In this study, the fruits treated with black polyethylene mulch showed the lowest TTA % with the highest Brix %. It can be assumed that the decrease in TTA % of fruits may be due to conversion of the malic acid to sugar level and lycopene biosynthesis resulted in becoming less TTA % (Rathore et al. 2007).

Color values (L*, a*, b*)

Effects of different mulching materials on pulp color values of L*, a* and b* of watermelon are shown in table 2. Customers always determine fruit quality by color. Therefore, color is one of the most important quality attributes of fruit. The value of L* (lightness) was not significantly different among the mulching materials. However, significant differences in the values of a* (redness) and b* (yellowness) were observed among the mulching materials between two cultivars. The highest a* value was observed in the fruits treated with no mulch (35.32) followed by silver polyethylene mulch (34.24). The lower a* values occurred in mulching materials of clear (32.85) and black (32.93) polyethylene mulches. The highest b* value (17.13) was observed in the fruits treated with silver polyethylene mulch followed by clear polyethylene one (16.80). The lowest b* value occurred in the fruits without mulch (15.94). The color values of a*

and b* of cultivar 855 were significantly higher than those of the cultivar Padamya.

The pulp color in watermelon was not affected by different mulching materials. But the significant differences in redness and yellowness (a* and b* values) in the pulp of watermelon were observed to be affected by different mulching materials and cultivars. It might be due to the fact that the red color intensity of watermelon was attributed to the increased synthesis of lycopene and deep red fleshed watermelon has a high concentration of lycopene (Perkins-Veazie and Collins 2004). Lycopene is the major pigment in the red variety of watermelon (Lewinsohn et al. 2005).

Conclusion

This study revealed that all growth parameters of main vine length, number of branches per plant, number of nodes on main vine, single fruit weight and total fruit yield were significantly influenced by different mulching materials. Moreover, all of the mulching materials not only maintained the maximum soil moisture but also suppressed weed infestation. The fruit quality attributes of skin and pulp firmness, Brix %, juice content, total titratable acidity, color values of a* and b* were significantly different among the mulching materials.

All mulching materials showed significantly higher single fruit weight and total fruit yield than control. The plants without mulch (control) were observed to be the lowest in single fruit weight and total fruit yield. The plants treated with silver polyethylene mulch resulted in the highest value in main vine length, number of nodes on main vine, number of branches per plant, single fruit weight and total fruit yield. Moreover, their fruit quality attributes of Brix %, juice content and color values of a* and b* were higher than those of others. There were interactions between mulching materials and cultivars on single fruit weight, total fruit yield and also quality attributes of juice content and color values of L*, a* and b*.

According to the results, mulching practice is efficient for watermelon production and silver polyethylene mulch is the best among them. There were no significant differences in the main growth parameters of single fruit weight and total fruit yield

between two cultivars. Moreover, the quality attributes of Brix %, juice content and TTA % of cultivar 855 did not differ from cultivar Padamya. Therefore, cultivar Padamya may be a potential cultivar for local consumption and for export in future along with the cultivar 855.

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