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Effect of mulch on some characteristics of potato in Asadabad, Hamedan

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Abstract

In order to determine the effect of mulch on some characteristics of potato, a factorial experiment based on randomized complete block design with three replications was conducted in Asadabad, Hamedan (Iran). The experimental treatments consisted of mulch in five levels (clear mulch, white mulch, black mulch, double layer mulch and control, without mulch) and cultivar in two levels (Agria and Sante). The effect of mulch on the fresh and dry weight of weed was significant, so that the black and double layer mulches had greatest impact on reducing the fresh and dry weight of weed, respectively. As compared to control, clear mulch treatments could reduce the period of tuber formation by 6.33 days. Double layer mulches showed the highest number of stolons at 60-day after planting. In comparison to the control, mulch could reduce the days to harvest, while the clear (104.83 days), double layer (105 days), and white (105.16 days) mulches all had significant differences when compared to the control (108.16 days). Cultivar Sante and double layer mulch also had the greatest impact on early potato crop. Mulch was not, however, seen to have significant effect on yield per plant. Based on the overall results, cultivar Sante and double layer mulch are suggested for the purpose of further study in Asadabad, Hamedan.

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Introduction

Potato (*Solanum tuberosum* L.) is one of the world's major crops and the value of this food in Iran is so high that it is now considered to be the second most important staple diet after cereals among the Iranian people. Since the application of mulch has had various impacts on many vegetables, potato is also a good case to prove whether the use of mulch could actually have a positive effect on this crop. Mulch is a preventive layer covering the surface of the soil and it contains organic and inorganic materials (Jafarnia and Homayi, 2006). Commercially, plastic mulches have been used for the production of vegetables since the 1960s (Lamont, 2005). Plastic mulches are presently applied throughout the world in order to protect crops from adverse conditions caused by weather, insects, and birds. The application of plastics in agriculture has already begun in developed countries and it is now spreading to developing countries as well. Plastic was first used in cold regions, where the usage of plastic was to protect crops from the cold. In spite of such a background, however, plastic is now used in various climates, soils and seasons, because of many advantages it provides besides an increase in temperature (Kasirajan and Ngouajio, 2012). Over the past several decades, vegetable production has experienced significant developments in many parts of the world. Combined with drip irrigation, the utilization of plastic mulch has played a major role in expanding the production of some vegetables such as tomato, pepper, eggplant, watermelon, muskmelon, cucumber, and squash (Kasirajan and Ngouajio, 2012).

Depends on the type of weed, if weeds were to be not controlled at all during the entire growing season, the yield potatoes would decrease by something between 16 and 76 percent (Tripathi *et al.*, 1989). The usage of plastic cover can lead to potatoes be harvested two to three weeks earlier while its application can also improve both qualitative and quantitative properties of the product (Zayts, 1996). Mulch has also a positive effect on tuber yield of potatoes (Dvorak *et al.*, 2012). Mulch attracts more nitrogen and thus increases the growth and yield (Rupple and Makswitat., 1996). In all treatments using plastic mulches, yield potato came more than 17 tones. Despite such result, nonetheless, the highest yield (18.42 tha^{-1}) belonged to the treatment using white mulch, while the lowest yield (11.48 tha^{-1}) was that of control treatment (Masud Mahmood *et al.*, 2002). By using mulch, potato plantlets grew 8.1-11.7 earlier than the control treatment due to an increase in temperature and early seasonal moistures in the soil. The application of mulches helped the crop to mature 0.7-15 days earlier and it also contributed significantly to the plant's height, leaf area index, and dry matter, while the application of plastic mulch treatment improved the yield and efficiency of water usage in comparison to the mulch-free treatments (Zhao *et al.*, 2012). In one last study on potatoes using black and clear polyethylene mulch treatments, stem diameter, shoot dry weight, number of main stems, plant height, tuber weight per plant, yield, and the percentage of medium and large tubers were all significantly higher than those potatoes which did not benefit from any mulch treatment. Despite such impact, nevertheless, the percentage of very small tubers was considerably lower than potatoes without any mulch treatment (Farhadi and Kashi, 2003).

There are particularly lots of reports on utilization of plastic mulches in broccoli (Brown *et al.*, 1987; Csizinszky and Martin, 1988; White, 1988). Moreover, fresh market vegetables that are grown mainly on plastic mulch include bell pepper (*Capsicum annuum*), muskmelon (*Cucumis melo*), eggplant (*Solanum melongena*), slicing cucumber (*Cucumis sativus*), summer squash (*Cucurbita pepo*), tomato (*Solanum lycopersicum*), and watermelon (*Citrullus lanatus*) (Ngouajio *et al.*, 2008). The use of dark mulch helped the yield watermelon to increase by 85 percent which thereby further justifies such application of mulches economically (Kashi *et al,* 2003). The use of mulch in tomato production improves its harvest time by nine days (Diaz-Perez, 2009). In spinach, the effect of black plastic mulch treatments rather varied between the highest yield (16,410 kg per hectare) and the lowest yield (12,940 kg per hectare). Besides that, the application of clear

plastic mulches for this crop resulted in the lowest petiole length which is itself considered valuable in spinach (Mehdi Zadeh *et al.*, 2011). In another case, clear plastic mulch was installed in the seed bed of cucumber in order to increase the amount of fruits per plant and, in comparison to mulch-free treatments, the usage of polyethylene mulches, especially the clear type, led to early harvest (Farias-Larios *et al.*, 1994). One other interesting case is how plastic mulches helped to reduce weed biomass in tomatoes by 84 to 98 percent (Rajablariani *et al.*, 2012). All in all, the present study was conducted in order to find out the effects of plastic mulch on controlling weeds, early harvest, and the overall yield potatoes in the region of Asadabad, Hamedan.

Materials and methods

This research was conducted under field conditions during the cropping season of 2013-2014 in Asadabad (48°° 7′ E / 34° 47′ N, 1607 m above sea level) of Hamedan. The soil texture was sandy clay.

Experimental treatments

A factorial experiment was designed in randomized complete blocks design with three replications. The experimental treatments consisted of mulch in five levels (clear, white, black, double layer and control, without mulch) and cultivar in two levels (Agria and Sante).

Methods

Each plot was designed in 2 meters. For every plot, ridges were divided into 1.5 meter wide, while double-rows were placed in the size of 60 cm on every ridge. Plastic mulches were later placed on ridges and holes were created on mulches in certain space of each plant. In each row, the space between plants was 25cm. Potato seed tubers were planted 25 cm deep. The field of experiment was plowed very deep once in the fall. In order to carry out the research, the land was further plowed in early spring (April) and it was soon leveled through using a disk. As soon as the land was enough smoothed by furrower, ridges were designed in 1.5-meter wide. Pelleted chicken manure at the amount of 1ton per hectare and the 20-20-20 fertilizer at the amount of 500kg per hectare were distributed over the ridges through using a shovel to both blend and disperse them proportionately. Tiny furrows were placed at the middle of ridges while the strips of tapes were put inside furrows for the purpose of irrigation. Plastic mulches of different colors were laid on the ridges and the surrounding areas of the every mulch were stabilized by using the very soil of furrows. To prepare for planting potato seed tubers, holes were put on mulches according to the space between plants (25cm) and the distance created between every two rows (60cm).

Tuber seeds of cultivar Sante and Agria types were taken out of the cooling house and put under an open air one week before planting them. Two days before planting, large tubers were cut and disinfected by the Benomyl chemical of 1:1000 concentration for 2 to 3 minutes. In order to get repaired, the chopped tubers were then incubated under a temperature of +15 for two days. Potato tubers were finally planted manually during the morning and afternoon hours on April 18, 2014.

After planting, irrigation and weeding were carried out, respectively. Besides the application of pelleted chicken manure and fertilizer before planting, the 20-20-20 fertilizer in the amount of 450kg per hectare was also used during the time of growing tubers, while micronutrients such as Zn (80kg per hectare), B (50kg per hectare), and Mn (80kg per hectare) as well as the Humax fertilizer in the amount of 8litters per hectare were all injected as liquids into the water of irrigation. Other chemicals which were applied included Acetamiprid 20% SP to control Agrotis larvae, Confidor to control aphids and thrips, and Propargite to control Spider mite.

Measured characteristics

various characteristics such as the Weed fresh weight, the weed dry weight, the number of days to tuber formation, the number of stolons per plant (60 and 80 days after planting), the number of days to harvest, and total yield were all measured.

Statistical Analysis

All data were analyzed by software MS-TATC and the means were compared by Duncan's Multiple Range Test in the 1% and 5% level.

Results and Discussion

Weed fresh weight

The results of the analysis of variance (Table 1) showed that the cultivar did not have significant effect on the weed fresh weight. The effect of mulch on the weed fresh weight showed significant difference in the 1% level. The least weed fresh weight (4.120 gr/m^2) appeared in the treatment with black plastic mulch and the highest weight (67.705 gr/m^2) was seen in the control (Table 3). The interaction of cultivar and mulch on the weed fresh weight was significant at the 5% level. The least weed fresh weight (2.983 gr/m^2) was seen in the Agria and double layer mulch treatment, while the highest weight of weed fresh weight (71.317 gr/m^2) belonged to the Agria and control (Fig. 1). In this study, the black and double layer (silvery-black) plastic mulches demonstrated the least weed fresh weight as compared to control. weed fresh weight in the black, double layer, and control were 4.12, 4.82, and 67.7 gr/m^2, respectively. The results of present study correctly acknowledged the research statements made by Rajablariani *et al.* (2012), according to which black and silver-black plastic mulches could suppress the weeds whose growth had been assisted by clear, blue and, red mulches, in the same that plastic mulches could reduce 84 to 98 percent of weed biomass in tomatoes. Similar results also apply to the research conducted by Farhadi *et al.* (2006), in which mulch could restrict the progress of weeds. the results Moreover, this study proved that Schonbeck (1998) which stated that black plastic mulches could actually limit the growth of weeds, except for a few of them which found their way through the planting holes. The same also goes for the research outcomes achieved by Zhang *et al.* (1992) which reported that black plastic mulches could fully control all weeds (surprisingly 100 percent) in the corn plant. In fact, since black plastic mulches provide suitable conditions for germination (in terms of humidity and temperature), seeds of weed start to germinate. In spite of this, however, when the seedlings of weed emerge from the soil and require enough light for photosynthesis and nutrition, black mulches prevent the light and thereby cause the weeds to after a while turn yellow, get dried and eventually die out due to a limited storage of nutrition. Moreover, since the black plastic mulch absorbs the light, it turns up the temperature under the plastic and this increased temperature itself destroys the weeds For such impact, the double layer plastic, whose one side has a dark color, had the same function as the black plastic. In comparison, lots of weed appeared under the clear plastic because of a direct hit of sun coming through such plastic as well as an increase in temperature and the existence of soil moistures, particularly in surroundings 5 cm above deep.

Weed dry weight

The results of analysis of variance (Table 1) showed that effect of cultivar on weed dry weight was not significant. The effect of mulch on weed dry weight was significant at 1% level. The least weed dry weight (0.812 gr/m^2) was seen in the black mulch treatment, while the highest weed dry weight (18.188 gr/m^2) resulted from control (Table 3). The interaction effect of cultivar and mulch on the weed dry weight was significant at 5% level. The least weed dry weight (0.497 gr/m^2) came from the Agria and double-layer mulch treatment, while the highest weed dry weight (19.707 gr/m^2) belonged to the Sante and control treatment (Fig. 2). Black mulch is more effective in restricting the progress of weeds as this was clearly demonstrated by another study examining such impact on the pepper plant (Ashrafuzzaman *et al.*, 2011). The same goes on how the clear and black polyethylene mulches could actually bring under control the total growth of weeds in certain Orobanche while control could corrupt 41.25 percent of the yield tomatoes which were tested by a particular study (Hassandokht *et al.*, 2010).

Number of days to tuber formation

The results taken from the analysis of variance (Table 1) showed that the number of days to tuber formation

was significant at 5% level in which the minimum number of days (48.47 days) was seen in the Sante cultivar and the maximum (52.267 days) belonged to at 5% level. The least and most number of days to tuber formation was observed in the clear mulch (46.83 days) and control treatments (53.17 days), respectively (Table 3). The interaction effects of cultivars and mulches on the number of days for tuber formation were somehow insignificant. The results came out of the present study, therefore, acknowledged one previous observation by Ekinci and Dursan (2009), according to which the earliest time of flowering and fruiting in the melon plant came from the application of the polyethylene mulch rather than from the control treatment. As an additional observation from this study, the clear mulch, unlike the control treatment, could actually accelerate the timing for tuber formation by 6.33 days.

the Agria cultivar (Table 2). The effect of mulch on the number of days to tuber formation was significant

Table 1. Results of analysis of variance of measured characteristics of potato.

		Mean Square						
Sources of variation	**df**	**Weed resh weight**	**Weed dry weight**	**Number of days for tuber formation**	**Number of stolons per plant (60 DAP)**	**Number of stolons per plant (80 DAP)**	**Number of days to harvest**	**Total yield**
Replication	2	86.77^{ns}	3.30^{ns}	17.63^{ns}	3.7^{ns}	56.23^{*}	2.53^{ns}	6178.9^{ns}
Cultivar	1	15.50^{ns}	6.04^{ns}	108.3^{*}	13.33^{ns}	32.03^{ns}	136.1^{**}	601856.6^{**}
Mulch	4	4224.5^{**}	301.72^{**}	52.86^{*}	42.28^{**}	104.55^{**}	20.16^{*}	7368.7^{ns}
Cultivar × mulch	4	223.68^{*}	13.98^{*}	25.80^{ns}	22.58^{ns}	24.28^{ns}	26.6^{**}	27473.2^{ns}
Error	18	69.99	3.69	16.15	7.92	10.3	5.01	41378.4
Coefficient of variation	CV	28.67	28.53	7.97	19.01	23.66	2.10	24.85

ns, * and ** : non-significant and significant at 5 and 1% levels, respectively.

Table 2. Mean comparison effects of cultivar on some characteristics of potato.

	Characteristics						
Cultivar	**Weed fresh weight (gr/m²)**	**Weed dry weight (gr/m²)**	**Number of days for tuber formation**	**Number of stolons per plant (60 DAP)**	**Number of stolons per plant (80 DAP)**	**Number of days to harvest**	**Total yield (gr per plant)**
Agria	28.45 a	6.28 a	52.26 a	14.13 a	12.53 a	113.06 a	676.69 b
Sante	29.89 a	7.18 a	48.46 b	15.46 a	14.60 a	99.6 b	959.97 a

Columns with same letters are not significantly different at 5% level.

Table 3. Mean comparison effects of mulch on some characteristics of potato.

	Characteristics						
Mulch	**Weed fresh weight (gr/m²)**	**Weed dry weight (gr/m²)**	**Number of days for tuber formation**	**Number of stolons per plant (60 DAP)**	**Number of stolons per plant (80 DAP)**	**Number of days to harvest**	**Total yield (gr per plant)**
Clear mulch	29.52 c	6.04 b	46.83 c	16.33 a	19.33 a	104.83 b	853.1 a
White mulch	39.7 b	7.69 b	47.5 bc	12.66 b	10.83 b	105.16 b	844.6 a
Black mulch	4.12 d	0.81 c	51.83 abc	11.83 b	16.33 a	108.5 a	829.4 a
Double layer mulch	4.82 d	0.94 c	52.5 ab	18.33 a	12.16 b	105 b	770.3 a
Without mulch	67.7 a	18.18 a	53.16 a	14.83 ab	9.16 b	108.16 a	794.2 a

Columns with e same letters are not significantly different at 5% level.

Number of stolons per plant

Based on the results came out of the analysis of variance (Table 1), the effect of cultivar on the number of stolons per plant was not significant at the 60 and 80 days after planting. But the effect of mulch on the number of stolons per plant was rather significant at the 60 and 80 days after planting. The double layer mulch with 18.33 stolons per plant and the black mulch treatment with 11.83 stolons per plant led to the most and least number of stolons per plant at 60 days after planting, respectively, while the black mulch treatment with 19.33 and the control treatment with 9.16 stolons per plant were responsible for the most and least number of stolons per plant at the 80 days after planting, respectively (Table 3). The interaction effects of cultivars and mulches on the number of stolons per plant were significant at the 60 and 80 days after planting. The

clear and black mulches increased the number of stolons with the aging of plant in the aftermath of tuber formation, while the double layer and white mulches actually decreased the number of stolons per plant. During the 80 days after planting, mulches, unlike the control treatments, resulted in a higher number of stolons per plant. The main reason for such increase was a higher temperature under the plastic mulches which thereby led to an active metabolism in the plant, an increase in the amount of nutrition absorption by the roots, and eventually a jump in the reproductive capacity of potatoes.

Number of days to harvest

According to the results obtained from the analysis of variance (Table 1), the effect of cultivar on the number of days to harvest was significant at 1% level. The least and most number of days to harvest were seen in the Sante (99.6 days) and Agria (113.06 days) cultivars, respectively (Table 2). The effect of mulch on the number of days to harvest was significant at the 5% level. The least number of days to harvest (104.83 days) came from the clear mulch, while the most number of days to harvest (108.5 days) resulted from the application of the black mulch (Table 3). The interaction effect of cultivar and mulch on the number of days to harvest demonstrated significant difference at 1% level. The least number of days to harvest (94/66 days) came from the Sante and double layer mulch treatment, while the most number of days to harvest (115/33 days) were seen from the Agria and double layer mulch treatment (Fig. 3). Compared to the control, the clear, double layer, and white mulches left significant effects on the time of harvesting. In the present study, mulches could accelerate the time of harvesting by 3 to 4 days. The reason that fruits get ripe quicker is that mulch increases the temperature of soil and it thereby contributes to the absorption and transfer of minerals to the plant through its roots. That is how the application of the polyethylene mulches, unlike the control treatment, could accelerate the harvesting time in cucumbers by 5 to 6 says as observed by another research (Fonseca *et al.*, 2003). The results of this study also came to acknowledge some other research observations on how the plastic mulch, unlike the control treatment, could help the melon crop to get ripe quicker (Schales and Scheldrake, 1995), how the plastic mulch could accelerate the harvesting time in pumpkin (Bhatt *et al.*, 2011), and how the application of plastic mulches could bring down the number of days to harvest in cucumber for 12 days (Farias-Larios *et al.*, 1994).

Total yield

According to the results taken from the analysis of variance (Table 1), the effect of cultivar on the total yield was significant at 1% level. The highest yield was seen in the Sante cultivar with the weight of 959.97 gr per plant, while the least yield belonged to the Agria cultivar with the weight of 676.69 gr per plant (Table 2). The effect of mulch and the interaction effects of cultivar and mulch on the total yield were not significant. Although mulch did not have significant impact on the total yield, nonetheless, the clear, white and black mulches all resulted in higher yield than did the control treatment. Since most of the growth factors were higher in the mulch treatments, there was an expectation that they lead to better yield, but it turned out not to be the case. One major reason for such eventuality was an excessive temperature in the later period of growing season at the end of July, especially in the region where the present study was conducted. Such an increase in weather temperature also raised the temperature of soil and it thereby prevented the roots to absorb all the necessary mineral elements under a warmer temperature. As a consequence, the tubers under mulches did not grow enough and the total yield of the plant was not significant as compared to the control treatment. Under a more suitable climate in the region in which this study was tested, an early planting can make up for this loss and such a research outcome also approves one another observation (Wadas *et al.*, 2004), according to which in a cropping season with a warm spring the effect of mulches on the total yield of potatoes is not significant. Moreover, the plastic mulches could improve the growth and total yield of the crop as this was in agreement with another study on watermelons, in which the plants grown under

clear mulches resulted in the highest yield of marketable watermelons (Egel and Martyn, 2008).

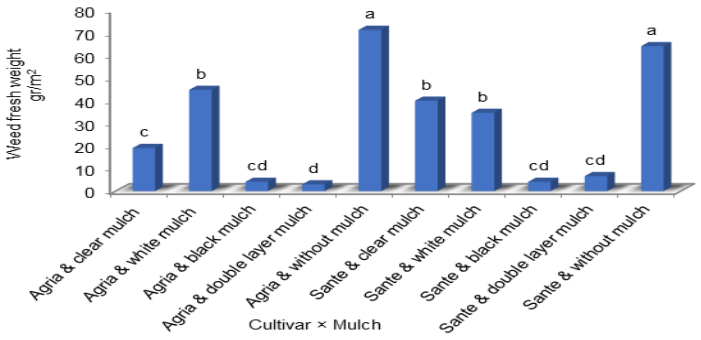

Fig. 1. Interaction of cultivar and mulch on the weed fresh weight of potato.

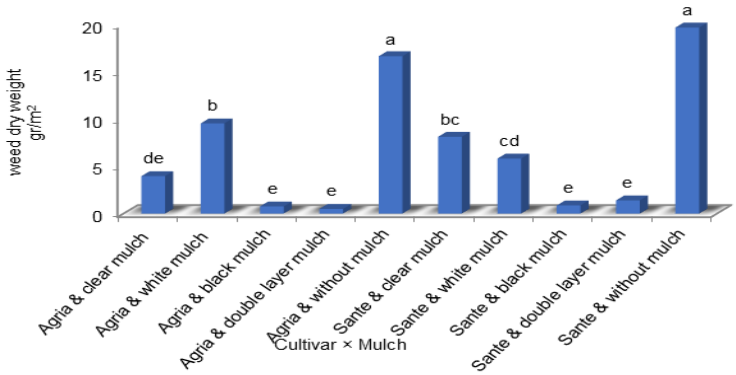

Fig. 2. Interaction of cultivar and mulch on the weed dry weight of potato.

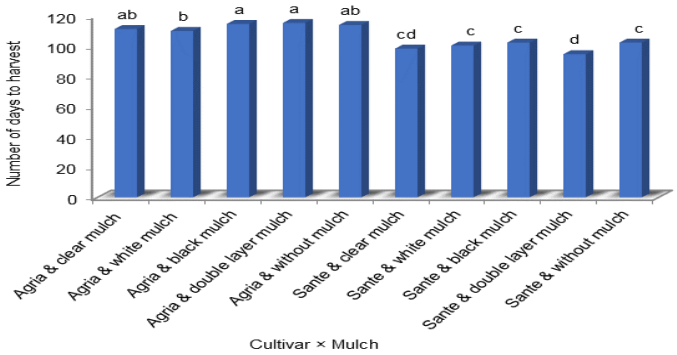

Fig. 3. Interaction of cultivar and mulch on the number of days to harvest of potato.

This is also comparable to one other study, in which the total yield of marketable watermelons planted under the clear, black, and white polyethylene mulches were 48.3, 43.2, and 38.3 tons per hectare, respectively, while such performance the control treatment was only 22.8 tons per hectare (Farias-Larias and Orozoco-santos, 1997).

Based on all observations driven from the present study, the Sante cultivar and the double layer mulch are suggested to achieve better results from cropping potatoes in the region where this study was conducted.

References

Ashrafuzzaman M, Abdul Halim M, Razi Ismail M, Shahidullahand SM, Alamgir Hossain M. 2011. Effect of Plastic Mulch on Growth and Yield of Chili (*Capsicum annuum* L.). Brazilian Archives of Biology and Technology. **54** (2), 321-330.

Bhatt L, Rana R, Uniyal S, Singh V. 2011. Effect of Mulch Materials on Vegetative Characters, Yield and Economics of Summer Squash (*Cucurbitapepo*) under Rainfed Mid-hill Condition of Uttarakhand. Journal of Vegetable Science. **38** (2), 165-168.

Brown JE, Osborn MC, Bryce HM. 1987. Effects of Planting Methods, Row Covers, and Black Plastic Mulch on Production and Economic Returns of Muskmelon Intercropped with Broccoli. Horticultural Science. **22**, 1091-1109.

Csizinszky AA, Martin FG. 1988. Relation of Hollow-stem in Broccoli (*Brassica oleracea* L. Italica Group) to N and K Rates in Plastic Mulch Culture. Horticultural Science. **23** (3), 827.

Diaz-Perez J. 2009. Root Zone Temperature Plant Growth and Yield of Broccoli as Affected by Plastic Film Mulches. Scientia Horticulture. **123**, 159-163.

Dvorak P, Tomasek J, Kuchtova P, Hamouz K, Hajslova J, Schulzova V. 2012. Effect of Mulching Materials on Potato Production in Different Soil-climatic Conditions. Romanian Agricultural Research. **29**, 201-209.

Egel DS, Martyn R. 2008. Planting Method, Plastic Mulch, and Fumigation Influence Growth, Yield, and Root Structure of Watermelon. Horticultural Science. **43** (5), 1410-1414.

Ekinci M, Dursun A. 2009. Effects of Different Mulch Materials on Plant Growth, Some Quality Parameters and Yield in Melon (*Cucumimelo* L.) Cultivars in High Altitude Environmental Condition. Pakistan Journal of Botany. **41** (4), 1891-1901.

Farhadi A, Soleimani Pour A, Nikooii A, Bagheri A. 2006. Effect of Polyethylene Mulches and Planting Method on Cucumber Crop. Seed and Plant Journal. Research Center for Agriculture and Natural Resources of Isfahan. **22** (3), 339-348. (In Persian)

Farhadi b, Kashi A. 2003. Assessing Effects of Polyethylene Mulches, Cropping Pattern, and Irrigation on Growth and Yield of Potatoes. Journal of Horticultural Science and Technology. **4**, 115-120. (In Persian)

Farias- Larios J, Guzman S, Michel AC. 1994. Effect of Plastic Mulches on the Growth and Yield of Cucumber in Tropical Region. Biological Agriculture and Horticulture. **10**, 303-306.

Farias-Larios J, Orozco-Santos M. 1997. Effect of Polyethylene Mulch Colour on Aphid Populations, Soil Temperature, Fruit Quality and Yield of Watermelon under Tropical Conditions. New Zealand Journal of Crop and Horticultural Science. **25**, 369-374.

Fonseca ICB, Klar AE, Goto R, Neves CSVJ. 2003. Colored Polyethylene Soil Covers and Grafting Effects of Cucumber Flowering and Yield. Scientia Agricola. **60** (4), 643-649.

Hassandokht MR, Mohsenifar M, Peyvast GA. 2010. Effects of Dark and Light Mulches on Quantitative and Qualitative Traits of Three Tomato Cultivars. Plant Ecophysiology. **1**, 193-197.

Jafarnia S, Homayi M. 2006. A Comprehensive Guide to the Greenhouse Cultivation of Cucumber and Tomato. Tehran, Sokhan Gostar Press. (In Persian)

Kashi A, Hossein Zadeh S, Babalar M, Lesani H. 2003. Effect of Black Polyethylene Mulch and Calcium Nitrate on Growth, Yield and Blossom End Rot on Gray Charleston Watermelons. Journal of

Science and Technology of Agriculture and Natural Resources. **26**, 1-10. (In Persian)

Kasirajan S, Ngouajio M. 2012. Polyethylene and Biodegradable Mulches for Agricultural Applications, A Review. Agronomy for Sustainable Development. **32**, 501-529.

Lamont WJ. 2005. Plastics: Modifying the Microclimate for the Production of Vegetable Crops. Hort Technology. **15**, 477-481.

Masud Mahmood M, Farooq K, Hussain A, Sher R. 2002. Effect of Mulching on Growth and Yield of Potato Crop. Asian Journal of Plant Sciences. **2**, 132-133.

Mehdi Zadeh A, Hassanpour A, Rasooli SA. 2011. Effects of Mulch on Quality and Quantity of Two Types of Local Spinach for the Purpose of Organic Production. Seventh Congress of Horticultural Science, September 5-8, 2011. University of Sanati esfahan. 1206-1210. (In Persian)

Ngouajio M, Auras R, Fernandez RT, Rubino M, Counts JW, Kijchavengkul T. 2008. Field Performance of Aliphatic-aromatic Copolyester Biodegradable Mulch Films in a Fresh Market Tomato Production System. Hort Technology. **18** (4), 605-610.

Rajablariani HR, Hassankhan F, Rafezi R. 2012. Effect of Colored Plastic Mulches on Yield of Tomato and Weed Biomass. International Journal of Environmental Science and Development. **3**, 590-593.

Ruppel S, Makswitat E. 1996. Effect of Balck Plastic Mulch on Nitrogen Balance in Cultivation of Pickle. Gartenbawissenschafl. **61** (5), 230-237.

Schales FD, Sheldrake R. 1995. Mulch Effects on Soil Condition and Muskmelon Response. American Society for Horticultural Science. **88**, 425-448.

Schonbeck MW. 1998. Weed Suppression and Labor Costs Associated with Organic, Plastic, and Paper Mulches in Small-scale Vegetable Production. Journal of Sustainable Agriculture. **13**, 13-33.

Tripathi B, Singh CM, Bhargava M. 1989. Comparative Efficacy of Herbicides in Potato under Conditions of North-Western Himalayas. Pesticides. **23**, 37-38.

Wadas W, Jablonska-Ceglarek R, Kosterna E. 2004. Effect of Plastic Covering and Nitrogen Fertilization on Yield and Quality of Early Potatoes. Folia Horticulturae. **16** (2), 41-48.

White JM. 1988. Effect of Plastic Mulch Beds, Nitrogen Fertility, and Plant-populations on Broccoli. Horticultural Science. **23**, 829.

Zayts P. 1996. Olericulture under Plastic Cover. Translated by Gholamali Peyvast, 2nd Edition. Gilan, Gilan University Press. (In Persian)

Zhang BY, Chen HG, Zhou TW. 1992. Exploration on Coloured Plastic Film Mulch for Controlled Weeds in Tomato and Maize Fields. Plant Protection. **6**, 40-41.

Zhao H, Xiong YC, Li FM, Wang RY, Qiang SC. 2012. Plastic Film Mulch for Half Growing-season Maximized WUE and Yield of Potato Via Moisture-temperature Improvement in a Semi-arid Agroecosystem. Agricultural Water Management. **104**, 68-78.