

Effect of polyethylene mulching type on the growth, yield and fruits quality of *physalis pubescens*

Abstract

This investigation was carried out in a private farm located at Shebeen El-Qanatir city, El-Qaliubiya governorate, Egypt during the two successive seasons (2011/2012 and 2012/2013 A.D.) to study the response of husk tomato plants (*Physalis pubescens* L.) cv. (local variety) to polyethylene mulching black and double face (white on black). A bare soil plot of equal area was also maintained with raised beds un-mulched as a control. Seedlings were transplanted forty days after sowing into open field transplanting carried out in 60 cm apart on the row among plants. Results showed that the significant maximum value of plant height, stem diameter, number of branches per plant and leaf area were obtained from white on black mulching treatment followed in a descending order by black treatment, while bare soil treatment recorded the minimum significantly value in both seasons. Results appeared that the significant maximum value of total soluble solids, vitamin C, total sugar and total carotenoids were obtained from white on black mulching treatment followed by black treatment, while bare soil treatment recorded the minimum value in both seasons. On the other hand, no significant different for total acidity and dry matter were recorded among mulching treatments in both seasons. Results appeared that the significant maximum value of number of fruit/ plant, total yield and early yield per plot were obtained from (white on black) mulching treatment followed in a descending order by black treatment, while bare soil treatment recorded the minimum value in both seasons.

Keywords: *physalis pubescens*, growth, polyethylene mulching, yield, TSS, total sugars, vitamin C

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Introduction

Husk tomato (*Physalis pubescens* L.) is one of the most important vegetable crops in Egypt. The husk tomato belongs to the nightshade family (*solanaceae*). The genus *Physalis*, established by Linnaeus in 1753, contains about 463 species but 100 species are well known and have more fanciful names such as husk tomato, golden berry, ground cherry, strawberry tomato, Cape gooseberry and pubescent ground cherry.^{1,2} *Physalis* has been known in Egypt since the sixteen century under the name of its varieties 'Harankish', 'Halawyat' and 'El-Set El-Mestihya'. Because the fruit is covered in papery husk; giving it its name.³ Husk tomato plants produce small orange fruits similar in size and shape to a cherry tomato. It is a highly nutrition fruit; low in fat and contains no cholesterol or sodium. Husk tomato fruits provide an excellent source of the vitamin A and C, minerals (phosphorus and iron), protein, carotene, sugars and organic acids because of this they are a good choice for making health.⁴

Polyethylene is one of the most commonly used plastic materials for mulching, due to the fact that it is easy to process, has excellent chemical resistance, high durability, flexibility and is odorless as compared to other polymers. It forms a relatively impermeable vapor barrier on the soil surface, changing the pattern of heat flow and evaporation.⁵ The use of plastic mulch in agriculture has increased dramatically in the last 10 years throughout the world. This increase is due to benefits such as increase in soil temperature, reduced weed pressure, moisture conservation, reduction of certain insect pests, higher crop yields, and more efficient use of soil nutrients.⁶ Plastic mulches directly affect the microclimate around the plant by modifying the radiation budget of the surface and decreasing the soil water loss,⁷ resulting in more uniform soil moisture. The soil temperature in the

planting bed is raised, promoting faster crop development and earlier harvest.⁸ Mulching decreases the fluctuations in temperature in the first 20-30cm depth in soils and promotes root development reduces vegetative competition in the rooting zone reduces fertilizer leaching and soil compaction, and the vegetable productions are cleaner since no soil is splashed onto the plants or fruits.⁹

So the soil under plastic mulch remains loose, friable and well-aerated. Roots have access to adequate oxygen, and microbial activity is enhanced.¹⁰ There are three primary non-degradable mulch colors used commercially in the production of vegetable crops:⁹ black, clear and the group of white, white-on-black reflective mulches. Black polyethylene is the most popular because it prevents weed growth in addition to its low cost. Clear mulch provides an even warmer soil environment than black plastic mulch, but requires the use of another technique to control weeds (herbicide, soil fumigant or solarization). White, white on-black reflective mulches can result in a slight increase or even a slight decrease in soil temperature compared to bare soil, tending to minimize changes in soil temperature, because they reflect back into the plant canopy most of the incoming solar radiation.^{10,12}

Anikwe et al. concluded that black plastic mulching enhanced growth and yield of the plants in the arid lands. These results are also in line with the results reported by Khurshid et al.,¹² that mulching increased soil porosity and reduced soil compaction. Also, these results are in agreement with those of Sarkar et al.,¹³ whom concluded that mulching (especially black plastic mulch) reduced leaching of nutrients, reduced weed problems, reduced evaporation of soil water and increased water use efficiency. They also cleared that plastic mulch helped maintain optimum soil moisture and promoted excellent crop growth throughout the growing season. Moreover, Mulching

increased growth and fruit yield of tomato through modification of the crop growing environment by reducing weed infestation, soil moisture depletion and ameliorating soil temperatures¹⁴ on tomato.

Eissa, (2002) showed that strawberry plants grown in row covered with plastic mulch (black, silver and control) had significant increase in its fruit TSS as Compared with plants grown in bare soil. He added that Silver plastic mulch was superior in this regard to the other treatments. Meanwhile Ekinci et al.,¹⁵ mentioned that different mulches applications (clear and black) did not affect in total soluble solids of watermelon fruit.¹⁵ found that there were no significant differences in term of titratable acidity in melon fruits among the applications of polyethylene mulch (Clear and black). While¹⁶ illustrated that using plastic mulch color, red and red over black mulches showed the highest values of titratable acidity in strawberry fruits compared with other mulch color treatments (Black and control).⁵ reported that black mulches produced higher vitamin C content in chilli plants. Moreover,¹⁸ who deduce that covering the rows with black polyethylene mulch or red color gave the highest value of vitamin c in pepper fruits when compared with fruits of the plants, which grown with clear polyethylene mulch. While, the lowest concentration of vitamin c was obtained from plants grown in the bare soil. He also added that the improvement in fruit quality of pepper by mulching treatments may be due to its promotion effect in plant growth and metabolic process, which reflected on increasing chemical composition as vitamin C in fruits. Same finding were noticed¹⁹ showed that an increased amount of vitamin C in chilli fruit was observed in all the mulch treated plants (blue, and black) compared to control. Ekinci et al.,¹⁵ reported that total sugar content in fruit of melon significant increase in plants by the treatment with plastic mulches (black and clear) compared to control. Also¹⁶ who found that the application with polyethylene mulching (red, black and red on black) as a row covering significantly increased total sugar content in strawberry fruits. Same results were obtained by Parmar et al.,¹⁰ who reported that using polyethylene mulching (control, silver on black, yellow on black, red on black white and white on black) enhanced the total sugar content in Watermelon fruits.

Root of plants grown with white and yellow plastic mulch had significantly higher concentrations of B-carotene than did those grown with the other colors. Both the white and yellow surfaces reflected more photosynthetic light and a lower FR/R ratio than the blue, green, and red surfaces. Other spectral differences in reflection

from white and yellow apparently had less influence than PPF and FR/R ratio on accumulation of B-carotene in the carrot roots. Antonious and Kasperbauer found that when the carrot of effect grown in field plot that were covered with different panels that reflected various combinations of far-red (FR), red (R) and blue light (BL) to the growing leaves.¹⁷ found that fruit dry matter was increased due to polyethylene mulch. They deduced that the favorable effect on cucumber fruit quality owing to black and clear polyethylene mulches. s¹⁸ found that the dry matter (%) of fruits was unaffected by the polyethylene mulching on cucumber. Also¹⁵ reported that, There were no significant differences in term of dry matter in fruit of water melon among polyethylene mulches applications. Therefore, the objective of this study was conducted to compare the effect of different mulching materials on the growth, fruit yield and their quality of husk tomato grown in open field.

Materials and methods

The present study was carried out during the two successive seasons of 2011/2012 and 2012/2013 on husk tomato plant (*Physalis pubescens* L.) cv. (local variety). Plants were grown in a private farm located at Shebeen El-Qanatir city, El-Qaliubiya governorate, Egypt. The soil type is clay loam. Soil samples were taken before planting for physical and chemical analysis according to (Jackson 1973).¹⁹ Its physical and chemical analysis is shown in Table 1. Soil temperatures were measured at 10 cm depth for all treatments using soil thermometer at 2:30pm on second day after irrigation (Table 2). This experiment aimed to study the effect of polyethylene mulching on growth, yield and fruit quality of husk tomato plants. Two different colors of polyethylene mulch i.e., black and double face (white on black) of plastic films, 45micron thickness and 120cm width were used. Polyethylene mulches were installed manually, stretched tightly on soil surface after 45days from transplanting, whereas, the white side of the double face of plastic film was above the soil surface while the black side was below. A bare soil plot of equal area was also maintained with raised beds un-mulched as a control. Seeds were sown in seedbeds on July 5th in both seasons of 2011/2012 and 2012/2013. Seedlings were transplanted after 40days from sowing in the open field. Surface irrigation by furrows was applied and the others agricultural practices took place according to the recommendation of the Ministry of Agricultural. The area unit of each replicate was 15m² included three rows; each row was five meters long and one meter width. Seedlings were transplanted 80cm apart on the row.

Table 1 Physical and chemical analysis of the experimental soil during 2011/2012 and 2012/2013 seasons

Seasons	Physical properties				Chemical properties								
	Sand %	Silt %	Clay %	Texture	EC ds/m	PH	Soluble cation (meq l ⁻¹)				Soluble anion (meq l ⁻¹)		
							Na ⁺	Ca ⁺⁺	Mg ⁺	K ⁺	Hco3 ⁻	Cl ⁻	SO4
2011/2012	41.8	28.7	29.5	Clay loam	0.25	7.99	0.72	I	0.5	0.09	I	I	0.31
2012/2013	43.8	27.6	28.6	Clay loam	0.24	7.97	0.69	I	0.5	0.08	I	I	0.27

Table 2 Average degree of soil temperature (°C) at 10cm depth

Treatments	Control (No Mulch)		Black Mulch		White & Black Mulch	
Seasons/ months	First year (2011/2012)	Second year (2012/2013)	First year (2011/2012)	Second year (2012/2013)	First year (2011/2012)	Second year (2012/2013)
September	21.9	22.7	24.1	25.5	22	23.3
October	15.9	16.4	17.5	19.4	16.1	17.5
November	12.9	13.1	14.1	15.8	13.6	14.1
December	10.5	11.9	13.8	14.4	12.8	12.5
January	11.6	12.7	13.1	15.3	12.2	13.9
February	13.1	13.5	15.2	15.9	14.2	14.9
March	16.1	17.2	17.2	18.7	16.9	17.9
April	18.2	18.8	19.1	19.9	18.9	19.2
May	20.9	21.7	24.1	25.5	21	22.3

Data recorded

Vegetative characteristics

Physical parameters: After five months from transplanting the following data were determined:

- Plant height (cm) was estimated from cotyledons level to the main shoot tip using miter trip.
- Number of branches/plant was counted manually.
- Leaf area of the 5th leaf from the shoot tip (measured by Li-300 leaf area meter produced by Li-Cor, Pinclivania).
- Stem diameter (cm) was calculated by Vernier Caliper.

Chemical parameters: Total chlorophyll content was determined by the spectrophotometric method described by Hipkins et al.²⁰

Fruit characteristics Physical parameters: A random sample of 20 fruits from each plot was randomly chosen to determination of:

- Average fruit weight (g) was measured by a digital balance.
- Fruit size (cm³) was measured by measuring the water volume displaced by immersing the fruits in graduated Jar filled with water.
- Fruit diameter (cm) was estimated by Vernier Caliper.
- Fruit firmness (kg/cm²) was measured using a pressure tester (Digital force-Gauge Model FGV-0.5A to FGV-100A. shimpo instruments).

Chemical parameters:

- Total soluble solids (TSS %) was determined by hand Refractometer according to A.O.A.C. (2000).²¹
- Total titratable acidity (g citric/100 g fresh weight) was determined by titration with 0.01 N Na OH using phenolphthalein as indicator according to A.O.A.C (2000).²¹
- Vitamin C (Ascorbic acid) (mg/100 g f.w.) was estimated by titration with 2,6-dichlorophenolindophenol dye according to A.O.A.C. (2000).²¹
- Total sugars: Total sugars content in the curd were determined as

(g /100g dry weight) according to Smith et al., (1956).

- Total carotenoids (mg/100g f.w.) were determined using spectrophotometer and calculated by using wattstein formula as described in Hipkins and Baker (1986).²⁰
- Fruit dry matter (%): Fruit samples were dried in an oven at 70 °C till constant weight and the dry matter calculated according to the following formula: Dry matter (%)=Dry weight/Fresh weight * 100.

Yield parameters

- Number of fruits per plant was counted during the whole period of harvesting in three plants as a sample. Early yield per plot (Kg): Was calculated as the total fresh weight of fruits harvested from the first fourth pickings.
- Total yield per plant (kg): Was calculated as weight of all harvested fruit per plant throughout the whole season.
- Total yield per plot (Kg): Was calculated as weight of all harvested fruit per plot throughout the whole season.

Statistical analysis

All experiments were statistically analyzed in a complete randomized design with three replicates. Each replicate consisted of six plants. Obtained data were subjected to the analysis of variance procedure and means were compared by L.S.D. method at 5% level of significant according to Snedecor and Cochran (1982).²²

Results and discussion

Vegetative characteristics

Physical parameter: Data about the physical parameters of vegetative characters are register in Figure 1(A–D). The results clarified the presence significant increments on plant height, stem diameter, number of branches per plant and leaf area of husk tomato plants as a result of applications of different polyethylene types i.e., black and (white on black). The highest value was recorded with (white on black) followed by black mulching. However the lowest value of these parameters were obtained with the plants grown in bare soil (control). The same trends were obtained in both seasons

of 2011/2012 and 2012/2013. The increments in vegetative growth parameters of husk tomato plants as a result of mulch treatments may be due to that plastic mulches directly affect the microclimate around the plant by modifying the radiation budget of the surface and decreasing the soil water loss⁷ resulting in more uniform soil moisture. The soil temperature in the planting bed is raised, promoting faster crop development and earlier harvest.⁸ Mulching decreases the fluctuations in temperature in the first 20-30cm depth in soils and promotes root development, reduces vegetative competition in the rooting zone, reduces fertilizer leaching and soil compaction, and the vegetable productions are cleaner since no soil is splashed onto the plants or fruits⁹ From another point of view, the increments of husk tomato growth regarding to polyethylene mulching treatments may be due to the increase of light from reflectivity from the reflective mulch surface allows greater photosynthetic activity of the plants.²³ On the other hand, the primary purpose for using mulches is that black and (white on black) mulches will reduce light penetration to the soil. Weeds cannot generally survive under such mulch. Excess water runs off the impervious mulch. Fertilizer beneath the mulch is not lost by leaching, so that fertilizers are optimally used and not wasted. The soil under plastic mulch remains loose, friable and well-aerated. Roots have access to adequate oxygen and microbial activity is enhanced resulting in encouraged of plant growth.¹⁰ White, (white on black) reflective mulches can result in a slight increase or even a slight decrease in soil temperature compared to bare soil, tending to minimize changes in soil temperature, because they reflect back into the plant canopy most of the incoming solar radiation.^{9,11} Data also

cleared that using polyethylene type (white on black) obtained the superior effect than black type. Because of white plastic mulch usually generates cooler soil temperatures than black plastic.²⁴ Also white plastic is preferred during the summer growing season in warmer regions compared to black because it can maintain soil moisture while providing cooler temperatures.¹¹

Chemical parameter: Data presented in Figure 2 clearly revealed that total chlorophyll content in leaves of husk tomato plants significantly increased due to the applications of polyethylene mulching either black or (white on black) colors. Using (white on black) plastic as a row mulching obtained the highest value of this parameter followed by the black type. On the other side, growing husk tomato plants in bare soil (control) gave the lowest value. The favorable effect of polyethylene mulching on photosynthetic pigments may be due to the hypothesis that Chlorophyll a is an essential compound of the light reaction of photosynthesis, whereas Chlorophyll b function is as light harvesting pigment whose absorbed light energy which passed on to Chlorophyll a.²⁵ So, the plants grown on the mulch should increase Chlorophyll a to absorb the greatest amount of light which reflected in high dry matter content. Such response to a spectral balance of upward reflected light from variously colored mulch is consistent with development responses to shift wave length balance of light due to reflecting from comparing plants.²⁶ Moreover, the increment of total chlorophyll according to using (white on black) mulch may be due to that plastic mulching increase the soil microbial population and increased nitrogen absorption and consequently increased chlorophyll content of the plant leaves as mentioned by (Eissa, 2002).²⁷

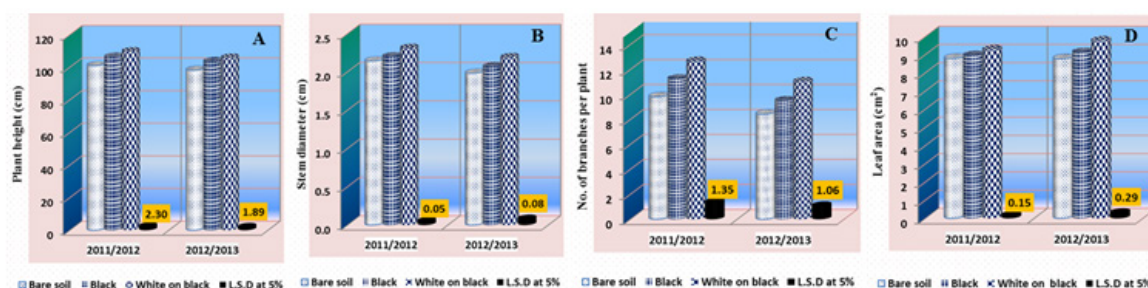


Figure 1 Effect of polyethylene mulching types on plant height (A), stem diameter (B), number of branches per plant (C) and leaf area (D) of husk tomato plant during 2011/2012 and 2012/2013 seasons.

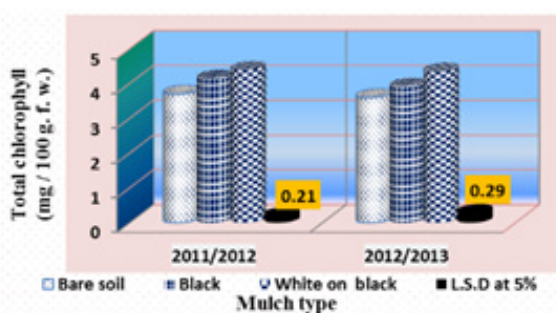


Figure 2 Effect of polyethylene mulching types on total chlorophyll of husk tomato leaves during 2011/2012 and 2012/2013 seasons.

Fruit characteristics

physical parameters: The effect of polyethylene mulching on the physical parameters of fruit characteristics is listed in Figure 3(A–D). The results indicated that average fruit weight, size, diameter and firmness of husk tomato plants significantly increased as a result of mulching rows with polyethylene. It was noticed that the grown

plants in rows covered with (white on black) gave the highest values of the previous parameters in both seasons respectively. On the other hand, the lowest average fruit weight was obtained from the plants grown in bare soil in both seasons of 2011/2012 and 2012/2013. The promotion effect of polyethylene mulch on improving physical characters of husk tomato fruits may be attributed to the enhancement effect of polyethylene treatments on vegetative growth, as well as on availability and uptake of both water and nutrients which reflected on increasing sufficient assimilation area and subsequently, increased each of fruit weight, size, diameter, and firmness.²⁸ Similar finding were reported by Manriques²⁹ who showed that mulches enhance crop production through soil water conservation and weed control. They also improve other biological, physical, and chemical properties of the soil such as bulk density, lower salinity level, oxygen diffusion rate, nutrient uptake; improve P nutrition, and elevated soil CO₂ levels. Obtained results are in agreement with those obtained by Moursi²⁸ on pepper and Kasirajan and Ngouajiang (2012).⁶

Chemical parameters: Regarding to the effect of some polyethylene types as rows mulching for husk tomato plants on fruit chemical parameters expressed as total soluble solids (TSS), total acidity, vitamin C (ascorbic acid), total sugar, total carotenoids, and dry

matter %, the results In Figures 4 and Figure 5 recorded significant increase in the previous parameters except the total acidity and dry matter % which did not affect. Also, the reflection of more light onto the tomato shoot by plastic is known to increase transpiration rate, amount of photosynthesis available to fruits and sugar: acid ratio as reported by Dorais.³⁰ Moreover, Plastic mulches concentrate carbon dioxide around the plant canopy as the planting holes acts as vents for carbon dioxide escaping from beneath the mulch. This relatively elevated carbon dioxide concentration might have accounted for the increased total soluble solids²² On the other side, the improvement in vitamin C (ascorbic acid), total sugar and total carotenoids content in husk tomato fruits according to polyethylene treatments may be due to the promotion effect in plant growth and metabolic process, which reflected on increasing chemical composition. Our results are in agreement with²⁸ on pepper.

Yield parameters: Data recorded in Figure 6(A–D) showed the effect of polyethylene mulching i.e. control (bare soil), black and (white on black) on yield and its components of husk tomato plants during the two growing seasons of 2011/2012 and 2012/2013. The results clear that both treatments of polyethylene mulching significantly raised the number of fruit per plant, early yield per plot and total yield per plant and plot compare to the control treatments (bare soil). On the

other side covering the rows with (white on black) polyethylene gave the highest early yield, while the control one obtained the lowest value in the two growing seasons of 2011-2012 and 2012-2013. The promotion effect of polyethylene mulch on the yield characters of husk tomato plants including the number of fruits per plant, early yield per plot, total yield per plant and plot may be due to low weed population, causing a reduction in competition for nutrient and partly for a better water availability due to moisture conservation by mulching.³¹ Moreover, Mulching increased growth and fruit yield of tomato through modification of the crop growing environment by reducing weed infestation, soil moisture depletion and ameliorating soil temperatures.¹⁴ On the other hand, Singh et al. reported that mulch could improve leaf photosynthetic capacity beside the role of polyethylene for enhanced root growth, as well as, absorption of each of water and nutrients and thereby, enhanced metabolic activities within plant during the period of growth and reproduction process, which possessed much shoot number per plant and width leaf area with high leaf chlorophyll content as mentioned before that induced more photosynthetic rates. This in turn built high yield of carbohydrates which gave rise to more cell division and enlargement inducing more vegetative vigorous plants, this reflect to produce more total yield as mentioned by Our results are in agreement with those results obtained with²⁸ on pepper and³² on tomato.^{33–37}

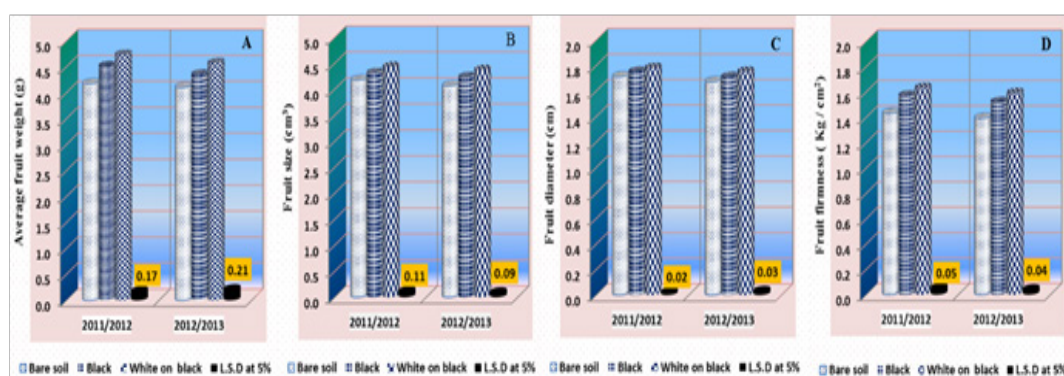


Figure 3 Effect of polyethylene mulching types on average fruit weight (A), size (B), diameter (C) and firmness (D) of husk tomato fruit during 2011/2012 and 2012/2013 seasons.

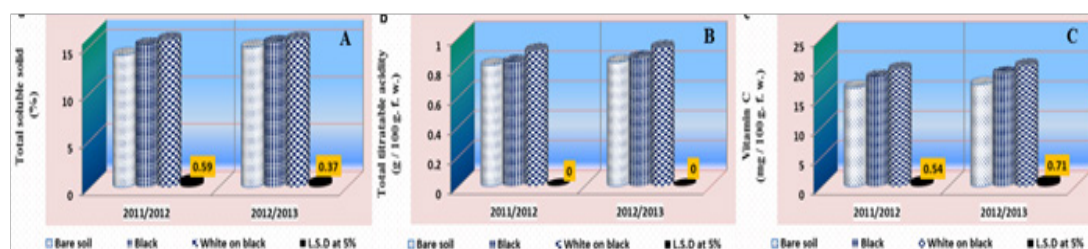


Figure 4 Effect of polyethylene mulching types on total soluble solid (T.S.) (A), total titratable acidity (B) and Vitamin C (ascorbic acid) (C) of husk tomato fruits during 2011/2012 and 2012/2013 seasons.

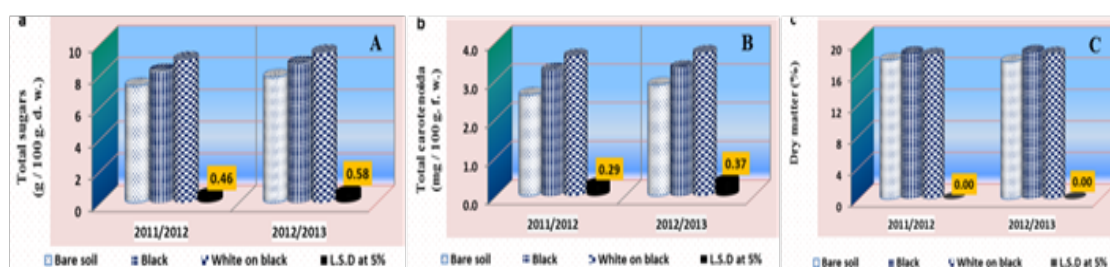


Figure 5 Effect of polyethylene mulching types on total sugars (A), carotenoids (B) and dry matter (C) of husk tomato fruits during 2011/2012 and 2012/2013 seasons.

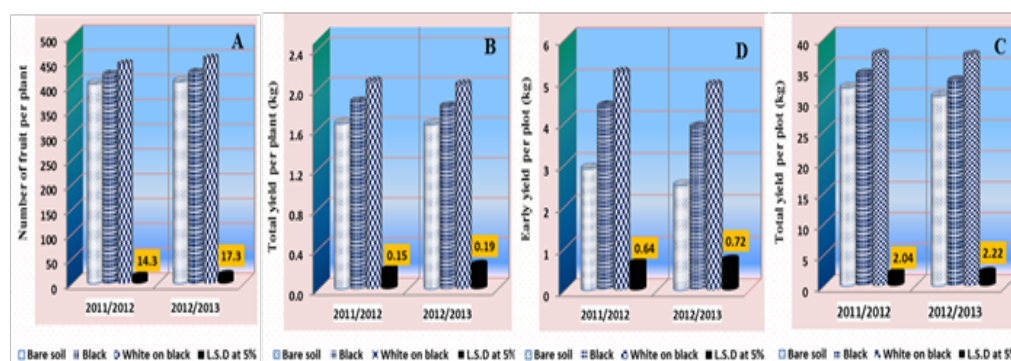


Figure 6 Effect of polyethylene mulching types on number of fruits per plant (A), total yield per plant (B), early yield per plot (C) and total yield per plot (D) of husk tomato during 2011/2012 and 2012/2013 seasons.

Recommendations

Mulching treatments increased fruit quantity and quality, early yield, and total yield. Mulching treatment of double faces (white on black) was more effective than the black mulch.

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Conflict of interest

The author declares no conflict of interest.

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