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# Effect of Plastic Color and Organic Mulching on the Yield of Tomato and Lettuce

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**ABSTRACT**

This investigation was carried out at Dokki protected cultivation experimental site, Central Laboratory for Agricultural Climate (CLAC), Agricultural Research Center (ARC), Ministry of Agriculture and Land Reclamation; to study the effect of different polyethylene colors mulch and organic mulch "rice straw" on the growth as well as yield and its quality of the two types of vegetable crops (tomato and lettuce). Lettuce crop was used as a model for leafy crops. Tomato crop was used as a model for fruity crops. Seedlings of tomato cv. Super strain B were transplanted in 1$^{st}$ of September 2015 and 2016. Lettuce seedlings cv. Iceberg was transplanted at 5$^{th}$ of October 2015 and 2016. Different plant parameters: vegetative growth parameters (number of branches/plant, plant height, number of leaves per plant, stem diameter, plant fresh weight and plant dry weight); nutrients content (nitrogen, Phosphorous, potassium) and total yield and its content from total soluble solids and ascorbic acid were measured. The soil temperature during the experiment was recorded. The experimental design was a randomized complete block design with three replications**.** Tomato: All measured parameters of tomato yield were significantly enhanced by using the green mulch and recorded the highest significant values, compared to other colors and the organic mulch during both experimental seasons. Lettuce: All measured parameters of lettuce yield were significantly enhanced by using the red mulch and recorded the highest significant values, compared to other colors and the organic mulch during both experimental seasons. In addition, using green and red mulches achieved the highest net return of tomato and lettuce crops, respectively.

## INTRODUCTION

Development of polyethylene plastic film and using it as plastic mulch which revolutionized the production and led to high value of vegetable crops. Soil mulching is considered as the backbone between components of the complete package for intensive production system of vegetable crops. Through using plastic mulch, farmers increase the efficiency of other intensive production system components such as drip irrigation. In addition, plastic mulching reflected positively on yield quantity and its quality.

Almost the obtained all advantage from soil mulching is a direct result of controlling the microclimate around the plants. Soil mulch is governing microclimate depending on the thermal properties for the particular material such as reflectivity and absorption or transmittance of the incoming solar radiation (Moursy *et al.*, 2015).

Mulch color control the radiating energy and the profile of microclimate around vegetable plant, which mean that both surface and underlying soil temperatures are determined by color of the mulch. There are three common mulch colors used commercially in the production of vegetable crops: black, clear, and white (or white-on-black). Recently, new wavelength selective mulch is produced. This type of mulch is transmitting radiation in a selective way.

Color of this new mulch can be red, blue or green (Ngouajio and Ernest, 2004). These colors allow mulches to reflect different radiation patterns into the plant canopy of the crop and affecting photosynthesis and/or plant morphogenesis, and these increase early and total yields.

The reflected different radiation patterns make colored mulches affecting the crop yield in multiple ways (Rajablariani *et al.*, 2012). For example, black plastic mulch increased number of fruit in tomato (Diaz-Perez and Batal, 2002). However, clear plastic mulch causes high strawberry yield (Johnson and Fennimore, 2005). Gough (2001) stated that tomatoes under red mulches produce earlier fruit set and more ripe fruit than plants grown in black plastic mulch.

Moreover, colored mulches affected crop yield in multiple ways, such as, it affect soil temperature, red polyethylene mulch causes the highest soil temperature followed by black and silver mulches, respectively (Gough, 2001).

Above all it mentioned advantage of polyethylene it is non-degradable, hard to remove from the field, does not break down and should never be disked into the soil (Lamont, 1993), that is not environmentally friend.

From another point of view, soil mulching using organic mulches is one of the natural methods in this concern. It can be achieved by using plant mulches and mulches from straw left after cereal grain harvest (Liebman and Davis, 2000; Kosterna, 2014). Additionally, straw mulch affected soil temperature to make it higher during the colder seasons and lower during the warmer seasons when compared with the bare soil (Moursy *et al.*, 2015).

From the previous review, it's concluded that it is very important to select the right color of plastic mulch to produce a certain vegetable crop with high yield and good quality.

Hence, the present investigation aimed to determines the effect of different available colors of soil mulch (plastic or straw) on the growth and yield performance of lettuce (leafy crop) and tomato (fruit crop) as well as the effect on soil temperature.

## MATERIALS AND METHODS

The current investigation was carried out at Dokki Protected cultivation experimental site, CLAC, ARC, Ministry of Agriculture and Land Reclamation. A net house was used; the main frame was multi-span (five spans) steel structure. White insect proof net was used to cover the net house.

### Plant materials:

Two types of vegetable crops were tested in this investigation; lettuce was used as a model for leafy crops, while, tomato was used as a model for fruity crops.

Seedlings of tomato (*Solanum lycopersicum* cv. Super strain B) were transplanted in 1$^{st}$ of September 2015 and 2016 at a spacing of 0.5 m between plants inside the same raw. Lettuce seedlings (*lactuca sativa* cv. Iceberg) were transplanted in 5$^{th}$ of October 2015 and 2016; with spaces of 30 cm between the plants. Raised beds were prepared and recommended doses of nutrients for tomato or lettuce were applied before spreading the mulches (extension bulletin no. 1294/2013).

**Treatments:**

Two types of soil mulch were tested in this investigation (for testing the colorful effect) as follow:

(a) Polyethylene mulch: five colors of 60 micron polyethylene mulch were used. Each color was considered as a separate treatment (red, transparent, green, blue and black). All treatments tested were compared to the bare soil as control.

(b) Organic mulch: "Rice straw" (6 cm thickness) was used as soil mulch for both tested crops.

Mulches were spread manually and holes of 5 cm diameter were made over the polyethylene films for transplanting zone. The soil set was irrigated using drip irrigation system in which the dripping line was placed about 10 cm from the center of the seedbed.

**Soil temperature profile:**

To determine soil temperature under each mulch treatment, measurements of maximum and minimum temperature at 10 cm soil depth were daily recorded in each plot and in bare soil (control) by using a digital thermometer Art.No.30.5000/30.5002 produced by TFA, Germany.

**Recorded data:**

For tomato plants data were recorded, after 45 and 90 days from transplanting, as following: number of branches/plant, plant height, number of leaves per plant, stem diameter, plant fresh weight and plant dry weight, total yield and average fruit weight.

For lettuce plants, data were recorded after 60 days from transplanting, as following: plant height, number of leaves, head plant fresh and dry weight and total head yield/$m^2$ as well as average head weight.

Three plants were chosen, randomly from each plot either tomato or lettuce, for chemical analysis.

1- Nitrogen%: total nitrogen was determined using Kjeldahl method according to the procedure described by FAO (2008), and data was calculated as percentage.

2- Phosphorous%: phosphorous concentration in acid digested was determined by colorimeter method (ammonium molybdate) using spectrophotometer according to FAO (2008), and the data was calculated as percentage.

3- Potassium%: potassium content was determined photometrically using Flame photometer as described by FAO (2008), and data was calculated as percentage.

4- Total soluble solids (TSS"%") was determined by hand refractometer according to A.O.A.C. (2000).

5- Ascorbic acid (Vitamin C) (mg/100 g f.w.) was estimated by titration with 2, 6-dichlorophenolindophenol dye according to A.O.A.C. (2000).

**Economic evaluation:**

The economic evaluation of net house, (540 $m^2$) production of tomato and lettuce yield was calculated by simple method as follows:

- Total return (L.E. /net house) = Total yield (Kg) x average price which was 4 L.E. for tomato on 2015/2016 and 5 L.E. in 2016/2017. The average price which arranged between 1.5 to 3.25 L.E. for lettuce on 2015/2016 and 1.75 to 3.5 L.E. in 2016/2017 (according to sorting of head size).

- Mulches cost which included to the cost of different types of mulch (organic "rice straw" and polyethylene).

- Operation cost (laborers, irrigation, fertilizer, pesticides, seedlings and etc.)

- Net income = Total return – (mulch cost + operation cost).

*Notice*:

* The polyethylene mulch was used for two years.

** Total costs (fixed and variable costs) were calculated according to study of important indicators of the agricultural statistics 2015.

**Experimental design and data analysis:**

The mulch treatments were arranged in randomized complete block design with three replications. Data were statistically analyzed using the analysis of variance method. L.S.D. tests at 5% level of probability were used to compare means of the treatments.

## RESULTS AND DISCUSSION

**Soil temperature profile:**

Data in Figures (1 and 2) showed that the starting temperature point of each growing season was the highest soil temperature during both studied seasons for tomato and lettuce plants under all tested treatments. In addition, different mulch colors increased soil temperature compared to bare soil (control) by different degrees. In addition, it was clear that the lowest soil temperature under all treatments was observed during December and January for both studied seasons.

Concerning the thermal effect of different tested color, it was clear that soil temperature under black mulch was the highest followed by the blue mulch and then by red mulch. However, the lowest soil temperature was recorded in bare soil (control) followed by rice straw then green mulch and finally transparent mulch.

Regarding the black soil mulch, during seasons of 2015/2016 and 2016/2017, it increased soil temperature by 1.2C° in average. The blue mulch increased soil temperature by 1.1C°compared to the control treatment. Moreover, the soil temperature was increased by 1C° as a result of using the red soil mulch.

Concerning transparent soil mulch thermal effect, it increased soil temperature by about 0.8C° in average during both studied seasons. Similarly, 0.76C° and 0.74C° increase in soil temperature were obtained when using green mulch and rice straw mulch, respectively, during both studied seasons.

The obtained trend of result was in agreement with Rajablariani *et al.* (2012). They indicated that mulch color significantly influenced soil temperature.

The discussed trend of differences in soil temperature under different mulch color was in harmony with Rashidi *et al.*, 2010, who explained differences in soil temperature on basis of

differences in reflection, absorption and transmission of solar energy of the colored mulch. Accordingly, it could be concluded that mulch color is significantly influenced soil temperature, which is also confirmed by Rajablariani *et al.* (2012).

Franquera and Mebsa (2016) presented another explanation to the variation of soil temperature with different colors of plastic mulch on bases of components of radiation balance, which is due to the effect of mulch on albedo, sensible heat flux, latent heat flux and soil heat flux. Moreover, some authors reported that the usage of darker colors increases soil temperature through greater heat absorbance while lighter colors reflect more solar radiation, which tends to minimize changes in soil temperature while increasing the irradiance under the plant canopy.

Similar conclusion was reported by Ham *et al.* (1993). They mentioned that differences in soil temperature, by the surface energy balanced of the plastic mulch, and its influence on crop microenvironment is determined by the optical properties of plastic.

Several studies showed different results of soil temperature with mulch color. For instance, according to Stapleton and Duncan (1994), red plastic mulch created the highest soil temperature among other colored plastic mulch. The same conclusion was reported by Franquera and Mebsa (2016). They indicated that maximum recorded soil temperature was observed with the red plastic mulch at 2pm with a temperature of 31°C. On the other hand, black plastic mulch had significantly higher soil temperature than the red plastic mulch in a study conducted by Rangarajan and Ingall (2001).

Furthermore, in another study higher soil temperature was recorded with blue mulch than other colored plastic mulch including the red (Gordon *et al.*, 2008). Dissimilarities of soil temperature within the different colored plastic mulch could be due to the differences in reflection, absorption and transmission of solar energy of the colored plastic mulch (Rashidi *et al*., 2010). This means that the color of the mulch significantly influenced the soil temperature Locasio *et al.* (2005). Furthermore, the color and type of polyethylene mulch can differentially affect soil temperature, or root zone temperature, which may generally, affects plant growth and development (Streck *et al.*, 1995).

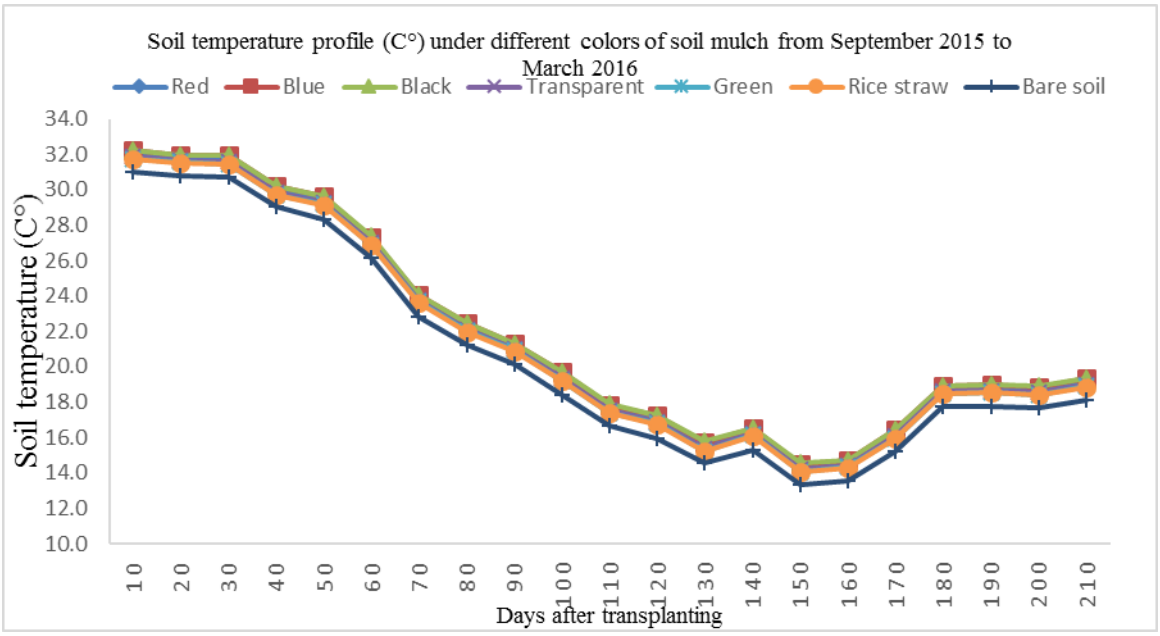


**Figure (1): Average soil temperature under different colors of soil mulch starting from first of September 2015 to the end of March 2016.**

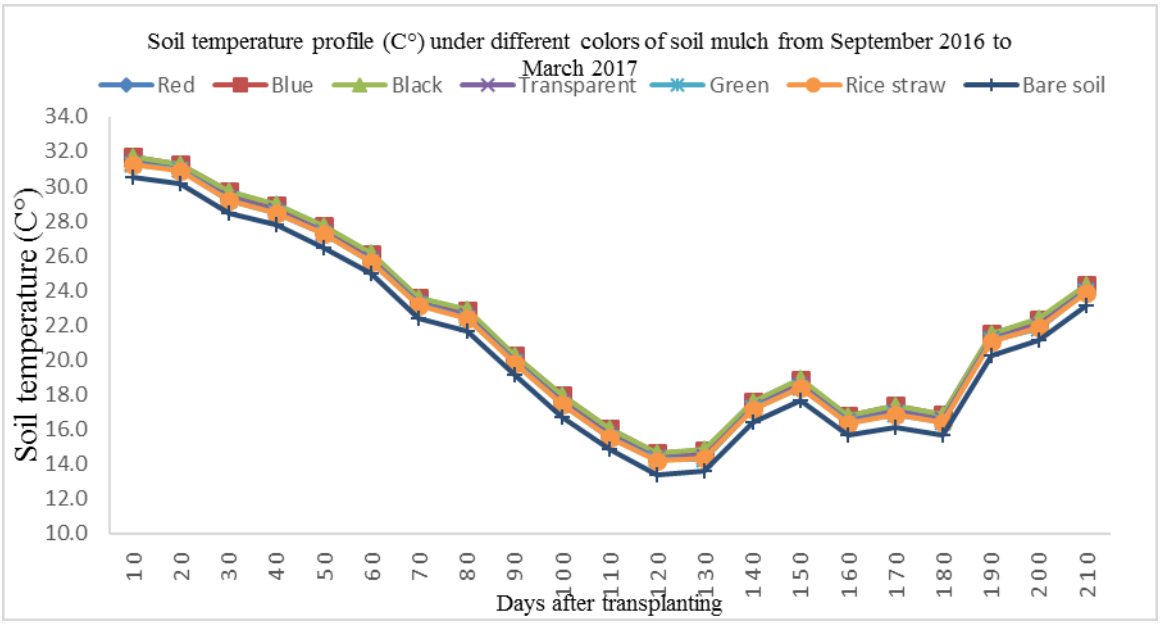


**Figure (2): Average soil temperature under different colors of soil mulch starting from first of September 2016 to the end of March 2017.**

**Effect of different colors of soil mulch on vegetative growth:**

It is concluded from data in Tables (1-a) and (1-b) that, vegetative growth characteristics of tomato plants were affected significantly by all tested colors of soil mulch. Vegetative growth

of tomato plants were significantly enhanced by using the green mulch and recorded the highest significant values of (branches number/plant, plant height, number of leaves/plant, stem diameter and plant fresh and dry weights). In addition, both red and transparent soil mulch promoted tomato vegetative growth and recorded second and third highest significant values of the previously mentioned vegetative growth characteristics. The same trend was found after 45 and 90 days from transplanting.

Posada *et al*. (2011) obtained similar results; they explained differences on plant fresh weight on basis of differences in the spectral distribution of light, which was reflected from the surface of the colored mulch. In addition, because of the reflections of different light wavelengths, different mulch colors create a specific environment that could have a considerable effect on plant growth and its development, which also affects the plants biomass.

**Table (1-a): Effect of different colors of soil mulch on tomato vegetative growth after 45 and 90 days from transplanting during season of 2015/2016.**

| Treatments | No. of branches/plant | Plant height (cm) | No. of leaves/plant | Stem diameter (cm) | Fresh weight (Kg) | Dry weight (g) |
|---|---|---|---|---|---|---|
| | After 45 days from transplanting | | | | | |
| Bare soil | 2.00 | 68.00 | 29.00 | 0.45 | 0.50 | 39.16 |
| Rice straw | 2.67 | 71.00 | 30.00 | 0.56 | 0.59 | 40.54 |
| Transparent | 5.00 | 91.17 | 44.67 | 0.82 | 0.87 | 73.52 |
| Black | 3.67 | 79.67 | 33.33 | 0.72 | 0.79 | 60.43 |
| Red | 5.67 | 95.00 | 47.00 | 0.93 | 0.92 | 92.82 |
| Blue | 4.67 | 87.97 | 42.33 | 0.75 | 0.81 | 70.02 |
| Green | 6.00 | 107.57 | 48.67 | 0.96 | 1.09 | 120.45 |
| L.S.D. at 5% | 1.21 | 13.31 | 7.02 | 0.17 | 0.10 | 3.87 |
| | After 90 days from transplanting | | | | | |
| Bare soil | 4.00 | 109.67 | 41.33 | 0.90 | 0.70 | 63.67 |
| Rice straw | 6.00 | 127.33 | 47.33 | 0.91 | 1.01 | 64.72 |
| Transparent | 7.67 | 141.97 | 57.67 | 1.02 | 1.38 | 156.92 |
| Black | 6.33 | 132.33 | 49.67 | 0.97 | 1.22 | 127.69 |
| Red | 8.33 | 146.17 | 88.33 | 1.27 | 1.46 | 159.62 |
| Blue | 6.67 | 140.67 | 55.67 | 1.00 | 1.23 | 144.57 |
| Green | 10.00 | 153.80 | 95.33 | 1.30 | 2.09 | 282.74 |
| L.S.D. at 5% | 1.33 | 10.54 | 5.58 | 0.19 | 0.18 | 7.02 |

**Table (1-b): Effect of different colors of soil mulch on tomato vegetative growth after 45 and 90 days from transplanting during season of 2016/2017.**

| Treatments | No. of branches/plant | Plant height (cm) | No. of leaves/plant | Stem diameter (cm) | Fresh weight (Kg) | Dry weight (g) |
|---|---|---|---|---|---|---|
| | After 45 days from transplanting | | | | | |
| Bare soil | 1.67 | 75.50 | 32.03 | 0.49 | 0.50 | 43.27 |
| Rice straw | 2.00 | 76.23 | 36.50 | 0.59 | 0.59 | 45.78 |
| Transparent | 4.00 | 96.83 | 50.33 | 0.89 | 0.88 | 77.83 |
| Black | 2.33 | 83.00 | 39.33 | 0.78 | 0.80 | 64.40 |
| Red | 4.67 | 104.33 | 53.00 | 1.13 | 0.92 | 96.97 |
| Blue | 3.00 | 94.33 | 48.33 | 0.80 | 0.81 | 73.57 |
| Green | 6.67 | 115.50 | 53.67 | 1.17 | 1.11 | 124.17 |
| L.S.D. at 5% | 1.10 | 14.93 | 9.62 | 0.18 | 0.11 | 3.70 |
| | After 90 days from transplanting | | | | | |
| Bare soil | 7.00 | 115.00 | 44.33 | 0.90 | 0.76 | 66.25 |
| Rice straw | 8.00 | 130.00 | 51.00 | 1.03 | 1.20 | 68.04 |
| Transparent | 9.67 | 148.67 | 63.33 | 1.20 | 1.68 | 161.69 |
| Black | 8.33 | 137.00 | 53.67 | 1.07 | 1.33 | 131.31 |
| Red | 10.33 | 154.00 | 95.67 | 1.43 | 1.70 | 165.42 |
| Blue | 8.67 | 145.33 | 61.67 | 1.10 | 1.50 | 149.42 |
| Green | 12.00 | 158.67 | 105.00 | 1.47 | 2.25 | 299.57 |
| L.S.D. at 5% | 1.04 | 12.20 | 7.09 | 0.20 | 0.16 | 7.27 |

On the contrary, tomato plants, under conditions of control treatment (bare soil), were affected significantly in a negative way to record the lowest significant values of number of branches, plant height, number of leaves, stem diameter, and plant fresh and dry weights. However, plants under rice straw soil mulching were significantly the second lowest values of tomato vegetative growth characteristics. The last mentioned trend was confirmed after 45 and 90 days from transplanting.

Moreover, in this investigation measured the parameters under blue mulch were always higher than those under black mulch. This finding was in agreement with the finding of Gordon *et al.* (2010). Blue plastic mulch produced high values of plant height and fresh weight comparable to black plastic. It is possible that the FR:R ratio and blue light reflected from the plastic mulches could have improved vegetative growth.

Concerning effect of soil mulch color on lettuce vegetative growth, data in Table (2), indicated that the highest significant values of lettuce vegetative growth was obtained under

the red soil mulching conditions followed by the blue soil mulch, while, the black mulch ranked the third in promoting lettuce vegetative growth (plant height, number of leaves and plant fresh and dry weights). On the other hand, lettuce plants cultivated without soil mulching (control) were significantly the lowest in vegetative growth, when, those cultivated under rice straw soil mulch conditions placed as second mulch treatment to reduce the lettuce vegetative growth. The mentioned trend obtained for tomato and lettuce plants were confirmed in both studied seasons, according to influence of mulching type, i. e., plastic color or rice straw and the control.

**Table (2): Effect of different colors of soil mulch on lettuce vegetative growth after 60 days from transplanting during seasons of 2015/2016 and 2016/2017.**

| Treatments | Plant height (cm) | No. of leaves | Fresh weight (g)/plant | Dry weight (g)/plant | Plant height (cm) | No. of leaves | Fresh weight (g)/plant | Dry weight (g)/plant |
|---|---|---|---|---|---|---|---|---|
| | First season | | | | Second season | | | |
| Bare soil | 12.57 | 30.90 | 231.70 | 15.17 | 12.50 | 33.60 | 242.00 | 15.73 |
| Rice straw | 13.70 | 31.57 | 263.00 | 23.97 | 13.57 | 30.60 | 273.70 | 24.93 |
| Transparent | 15.57 | 35.67 | 294.00 | 27.50 | 15.00 | 42.70 | 288.00 | 26.57 |
| Black | 17.60 | 40.73 | 350.30 | 29.60 | 17.20 | 43.97 | 360.00 | 28.00 |
| Red | 20.17 | 48.70 | 424.30 | 39.87 | 19.77 | 46.60 | 428.00 | 40.33 |
| Blue | 18.90 | 45.97 | 352.70 | 32.27 | 18.75 | 44.37 | 369.00 | 34.73 |
| Green | 15.30 | 35.67 | 276.70 | 24.60 | 14.73 | 37.40 | 281.7 | 25.60 |
| L.S.D. at 5% | 1.23 | 0.71 | 0.79 | 3.25 | 0.73 | 0.54 | 1.17 | 0.17 |

**Effect of different colors of soil mulch on chemical contents:**

Focusing on response of nutrient contents of leaves (nitrogen, phosphorus and potassium) to different mulching colors treatments, data in Table (3) showed the significant effect of tested colors of soil mulch on nutrient contents of leaves in both of tomato and lettuce plants.

Nitrogen, phosphorus and potassium recorded the highest significant values in tomato plants which cultivated under conditions of green soil mulching followed by those under conditions of red soil mulching.

On the contrary, highest significant values of nitrogen, phosphorus and potassium were found in lettuce plants cultivated under conditions of red soil mulch followed by those cultivated under green soil mulch.

However, the lowest significant values of N, P and K were detected in plants cultivated in bare soil (control) and then those cultivated with rice straw soil mulching. The same trend was found in both studied seasons for both of tomato and lettuce plants.

Dodd *et al*., 2000 reported that, temperature under the plastic mulch influenced some physiological processes such as nutrient content and water absorption, since the temperature under the polyethylene mulch could influence the temperature around the roots zone, thus this could also affect the activities within the roots such as gas exchange and activity of various enzymes thus this could also reflect on the yield.

**Table (3): Effect of different colors of soil mulch on chemical contents of leaves of tomato and lettuce plants during seasons of 2015/2016 and 2016/2017.**

| Treatments | N (%) | P (%) | K (%) | N (%) | P (%) | K (%) |
|---|---|---|---|---|---|---|
| | First season | | | Second season | | |
| | Tomato | | | | | |
| Bare soil | 2.20 | 0.24 | 2.67 | 2.23 | 0.25 | 2.73 |
| Rice straw | 2.50 | 0.34 | 2.87 | 2.52 | 0.35 | 2.91 |
| Transparent | 3.57 | 0.65 | 4.20 | 3.62 | 0.67 | 4.27 |
| Black | 2.97 | 0.54 | 3.90 | 3.20 | 0.56 | 4.17 |
| Red | 4.07 | 0.70 | 4.40 | 4.21 | 0.73 | 4.44 |
| Blue | 2.70 | 0.40 | 3.10 | 2.72 | 0.42 | 3.31 |
| Green | 5.77 | 0.74 | 4.97 | 5.75 | 0.76 | 5.23 |
| L.S.D. at 5% | 0.31 | 0.02 | 0.13 | 0.28 | 0.03 | 0.17 |
| | Lettuce | | | | | |
| Bare soil | 1.92 | 0.35 | 1.78 | 1.98 | 0.36 | 1.59 |
| Rice straw | 2.15 | 0.36 | 1.92 | 2.18 | 0.37 | 1.86 |
| Transparent | 2.64 | 0.49 | 2.37 | 2.73 | 0.44 | 2.52 |
| Black | 2.45 | 0.48 | 2.28 | 2.55 | 0.40 | 2.36 |
| Red | 2.84 | 0.54 | 2.63 | 2.95 | 0.48 | 2.65 |
| Blue | 2.34 | 0.43 | 2.16 | 2.35 | 0.39 | 2.25 |
| Green | 2.83 | 0.51 | 2.42 | 2.93 | 0.44 | 2.54 |
| L.S.D. at 5% | 0.01 | 0.01 | 0.01 | 0.03 | 0.02 | 0.04 |

**Effect of different colors of soil mulch on the yield:**

Data in Table (4) indicated that different colors of soil mulch affected significantly on crop yield of tomato and lettuce plants. The green and red soil mulches recorded the highest significant tomato and lettuce crop yield, respectively. However, the second significant

values of total yield were detected by using red and green soil mulches for tomato and lettuce; respectively.

Moreover, plants cultivated under transparent soil mulch ranked the third highest total yield for both studied crops. The lowest significant crop was obtained from plants under the rice straw soil mulch conditions followed by those cultivated under control conditions (bare soil). The mentioned trend of results was confirmed during both studied seasons.

Concerning average fruit weight of tomato, it was notable from data in Table (4) that the red soil mulch enhanced significantly the average fruit weight and recorded the highest value followed by fruits obtained from plants cultivated under red soil mulch conditions. However, average lettuce head weight significantly enhanced by the red soil mulch followed by the blue soil mulch. The same result was found during both studied seasons.

**Table (4): Effect of different colors of soil mulch on tomato and lettuce crop yields and its components during seasons of 2015/2016 and 2016/2017.**

| Treatments | Lettuce | | Tomato | |
|---|---|---|---|---|
| | Head yield ($Kg/m^2$) | Average head weight (Kg) | Fruit yield ($kg/m^2$) | Average fruit weight (g) |
| | First season | | | |
| Bare soil | 4.80 | 231.70 | 20.14 | 81.12 |
| Rice straw | 5.90 | 263.00 | 24.27 | 83.80 |
| Transparent | 9.70 | 350.30 | 29.05 | 92.50 |
| Black | 8.40 | 276.70 | 28.31 | 87.90 |
| Red | 10.80 | 424.30 | 32.35 | 121.40 |
| Blue | 7.50 | 294.00 | 25.60 | 87.06 |
| Green | 10.20 | 352.70 | 37.42 | 110.80 |
| L.S.D. at 5% | 0.71 | 0.79 | 4.36 | 3.69 |
| | Second season | | | |
| Bare soil | 5.20 | 242.00 | 19.95 | 80.97 |
| Rice straw | 6.30 | 273.70 | 23.84 | 83.40 |
| Transparent | 9.80 | 360.00 | 28.94 | 91.20 |
| Black | 8.20 | 281.7 | 27.96 | 87.20 |
| Red | 11.10 | 428.00 | 31.33 | 120.73 |
| Blue | 7.50 | 288.00 | 24.90 | 84.70 |
| Green | 10.80 | 369.00 | 36.57 | 109.60 |
| L.S.D. at 5% | 0.71 | 1.17 | 3.52 | 4.45 |

Recent investigations showed that colored polyethylene mulches, especially red color, are more favorable in enhancing both studied yield and head weight of lettuce, as well as, tomato average fruit weight (fruit quality). This result was in agreement with those of Franquera and

Mebsa, 2016; they reported that the highest yield was observed in lettuce grown with red plastic mulch. Moreover, they explained that the changes in crop yield according to the response to the different colored plastic mulch, were due in part to the range of reflected wavelengths produced by individual mulch color and small difference in the light reflected would cause a certain response from the plant. Higher yields in red plastic mulch was due to the red plastic mulch ability to produce a greater FR:R ratio which generated a positive phytochrome response within specific vegetables.

Moreover, Franquera (2015) on lettuce grown with red plastic mulch was heavier and has a longer leaves compared with lettuce grown with other colored plastic mulch.

On the other hand, Chaudry *et al.*, 2002 obtained a significant higher yield of tomato that was grown in green plastic mulch than within the red plastic mulch.

**Effect of different colors of soil mulch on total soluble solids and ascorbic acid:**

As shown in Table (5), the application of different colors of soil mulch affected significantly on total soluble solids (T.S.S. "%") and ascorbic acid content (Vitamin C. "mg/100g") in tomato fruits and lettuce heads. The green and red soil mulches recorded the highest significant fruits and heads content from T.S.S. and ascorbic acid, respectively. However, the second significant values of T.S.S. and ascorbic acid were detected by using red and green soil mulches for tomato fruit and lettuce head, respectively.

Furthermore, plants cultivated under transparent soil mulch placed the third highest fruits content from the previous parameters. The lowest significant T.S.S. and ascorbic acid were obtained from plants under the control conditions (bare soil), while, those cultivated under rice straw soil mulch conditions ranked the second lowest values. The mentioned trend of results was confirmed during both studied seasons.

On the other hand, 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 solids (Sanders *et al.*, 1989). On the other side, the improvement in ascorbic acid (vitamin C), content in 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.

**Table (5): Effect of different colors of soil mulch on T.S.S and ascorbic acid content in fruits of tomato and heads of lettuce plants in 2015/2016 and 2016/2017 seasons.**

| Treatments | T. S. S. (%) | Ascorbic acid content (mg/100g) | T. S. S. (%) | Ascorbic acid content (mg/100g) |
|---|---|---|---|---|
| | First season | | Second season | |
| | Tomato | | | |
| Bare soil | 4.33 | 24.28 | 4.20 | 23.80 |
| Rice straw | 4.83 | 25.30 | 4.69 | 24.79 |
| Transparent | 6.00 | 26.93 | 5.82 | 26.39 |
| Black | 6.00 | 26.64 | 5.82 | 26.10 |
| Red | 6.17 | 28.58 | 5.98 | 28.01 |
| Blue | 5.13 | 25.65 | 4.98 | 25.14 |
| Green | 6.59 | 28.88 | 6.39 | 28.30 |
| L.S.D. at 5% | 0.32 | 0.06 | 0.31 | 0.06 |
| Bare soil | Lettuce | | | |
| Rice straw | 4.32 | 22.38 | 4.15 | 22.04 |
| Transparent | 4.60 | 23.62 | 4.41 | 23.26 |
| Black | 5.04 | 25.20 | 4.84 | 24.82 |
| Red | 4.80 | 24.79 | 4.61 | 24.42 |
| Blue | 5.81 | 25.79 | 5.58 | 25.40 |
| Green | 4.75 | 24.58 | 4.56 | 24.21 |
| Bare soil | 5.17 | 25.55 | 4.97 | 25.17 |
| L.S.D. at 5% | 0.20 | 0.21 | 0.19 | 0.20 |

In addition, this means that the color of the mulch had influence the total soluble solids content of the lettuce (Franquera, 2015). Posada *et. al.* (2011) reported that the total soluble solids which measured showed significant variations among the different colored plastic mulch. Those grown with red mulch had higher total soluble solids compared with the other colored mulch. Red and Far red light is captured by phytochrome (Kasperbauer *et. al.*, 2001) which triggers a series of chemical modifications including sweetness of fruits. This may be the reason for the higher values of total soluble solids in lettuce grown within the red plastic mulch. These phytochrome regulated enzymes could also be related to the improved sweetness of the plants which could explain the improved sweetness and higher total soluble solids or bix found in lettuce grown with red plastic mulch.

Another factor which could affect the brix levels or total soluble solids in vegetables is the environmental conditions such as temperature. Exposure of various environmental conditions such as temperature could influence the amount of soluble solids (mostly sugars) in marketable leaves, fruits, tubers and roots of vegetables. This environmental factor interacts to set a rate of sugar production affecting the sweetness of the vegetables and fruits

(Kleinhenz and Bumgarner, 2012). This may explain also the reason for the significant differences on the amount of total soluble solids of lettuce grown within the different colored plastic mulch since the color of the mulch could modify the plant microenvironment affecting its growth and development (Tarara, 2000; Kasperbauer *et. al.*, 1987).

**Economic evaluation:**

Data in Tables (6 and 7) showed the economic evaluation of the different combinations between the colors of soil mulch on tomato and lettuce for the net house (NH) area (540 $m^2$). Obviously, data stated that using of green and red mulches achieved the highest net income yield of net house (tomato and lettuce crops, respectively) in both tested seasons. On the contrary, using of different kind of polyethylene mulch occurred save money during 2015/2016 and 2016/2017 seasons because the yield price was greatest than the total cost of production. So, it is recommended to using the treatment of green and red plastic mulch with tomato and lettuce crops, respectively, to get the highest economical return.

**Table (6): Economic evaluation of using the colors of soil mulch on tomato yield during seasons of 2015/2016 and 2016/2017 of net house production.**

| Treatments | Yield (Kg/NH) | Yield price (L.E./NH) | Total cost (L.E.) | Net income (L.E.) |
|---|---|---|---|---|
| | First season | | | |
| Bare soil | 6042 | 24168 | 2000 | 22168 |
| Rice straw | 7281 | 29124 | 3080 | 26044 |
| Transparent | 8715 | 34860 | 4700 | 30160 |
| Black | 8493 | 33972 | 4700 | 29272 |
| Red | 9705 | 38820 | 5000 | 33820 |
| Blue | 7680 | 30720 | 5000 | 25720 |
| Green | 11226 | 44904 | 5000 | 39904 |
| | Second season | | | |
| Bare soil | 5985 | 29925 | 2500 | 27425 |
| Rice straw | 7152 | 35760 | 3580 | 32180 |
| Transparent | 8682 | 43410 | 5200 | 38210 |
| Black | 8388 | 41940 | 5200 | 36740 |
| Red | 9399 | 46995 | 5500 | 41495 |
| Blue | 7470 | 37350 | 5500 | 31850 |
| Green | 10971 | 54855 | 5500 | 49355 |

**Table (7): Economic evaluation of using the colors of soil mulch on lettuce crop during seasons of 2015/2016 and 2016/2017 of net house production.**

| Treatments | No. lettuce heads/Nh | Yield price (L.E./NH) | Total cost (L.E.) | Net income (L.E.) |
|---|---|---|---|---|
| | First season | | | |
| Bare soil | 1800 | 2700 | 1000 | 1700 |
| Rice straw | 1800 | 3600 | 1540 | 2060 |
| Transparent | 1800 | 4950 | 2350 | 2600 |
| Black | 1800 | 4500 | 2350 | 2150 |
| Red | 1800 | 5850 | 2500 | 3350 |
| Blue | 1800 | 4500 | 2500 | 2000 |
| Green | 1800 | 5400 | 2500 | 2900 |
| | Second season | | | |
| Bare soil | 1800 | 3150 | 1250 | 1900 |
| Rice straw | 1800 | 4050 | 1790 | 2260 |
| Transparent | 1800 | 5400 | 2600 | 2800 |
| Black | 1800 | 4950 | 2600 | 2350 |
| Red | 1800 | 6300 | 2750 | 3550 |
| Blue | 1800 | 4950 | 2750 | 2200 |
| Green | 1800 | 5850 | 2750 | 3100 |

## CONCLUSION

Black mulch was more suitable to increase soil temperature and followed by the blue mulch and then by red mulch. Vegetative growth characteristics of tomato plants (number of branches/plant, plant height, number of leaves per plant, stem diameter, plant fresh and dry weights) were enhanced by using the green mulch. In addition, red mulch leaded to increase lettuce vegetative growth (plant height, number of leaves/head and plant fresh and dry weights plant). The green (for tomato) and red (for lettuce) soil mulches gave the highest yield. Moreover, red mulch enhanced average tomato fruit weight and average lettuce head weight. The favorable effect of green and red soil mulches on plant growth and yield of tomato and lettuce, respectively, due to increasing N, P and K percent as well as total soluble solids and ascorbic acid content.

Based on the finding of this study, it is recommended that using green mulch in tomato and red mulch in lettuce were adequate for maximum growth parameters compared by other mulches.

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