ISSN 1110-0419

Annals Of Agric. Sc., Moshtohor,
Vol. 43(4): 1471-1496, (2005).

STUDIES ON PHOTOMORPHOGENESIS IN SOME ECONOMICAL PLANTS.
I – VEGETATIVE GROWTH OF TOMATO AND SWEET PEPPER PLANTS AS AFFECTED BY RED AND FAR-RED LIGHT REFLECTED FROM COLORED PLASTIC MULCHES.

BY

El-Desouky, S.A. ; Abd El-Dayem, H.M.; Wanas, A.L. and Mady, M.A.
Dep. of Agric. Botany, Fac. of Agric. at Moshtohor, Benha Univ., Egypt

ABSTRACT

In this study, the red and red over black mulch colors reflected more amount of red and far-red light on growing plants comparing with either other colors or bare soil, i.e., unmulched one. So, the effect of this reflection on growth of tomato cv. Super Strain B and sweet pepper cv. Baladi was studied during 2001 and 2002 seasons. In this concern, significant increase was existed in many growth aspects as stem length and diameter, number of formed branches and leaves/plant, fresh and dry weight of both stems and leaves, total leaf area/plant and specific leaf weight as well with all applied colors of plastic mulch at 45 and 60 days after transplanting during the two seasons. The red followed by red over black mulch colors were more effective in this respect compared with other mulch colors. Also, these two treatments increased the number of branches/plant more than two times of the control value in tomato and more than three or four times of the control value in sweet pepper at 60 days after transplanting. Besides, they increased the absolute growth rate of shoots to reach more than three times of the control values in both tomato and sweet pepper.

In addition, N, P and K content as well as total crude protein were increased in leaves of both tomato and sweet pepper with all applied mulch colors compared with those of control.

Moreover, different applied mulch colors increased photosynthetic pigments,, total soluble sugars and total carbohydrates in leaves of tomato and sweet pepper with the superiority of red and red over black mulch colors.

Therefore, it could be recommended the applying of red mulch color for reflecting more red and far-red light on growing plants. Thus, increasing their absorption by plants, hence, this positively affected all physiological processes within growing plants.

INTRODUCTION

Because photosynthetic organisms are dependent on photosynthetically active radiation (PAR) as their source of energy; plant growth and development are intimately tied to changes in the light environment (Alba *et al.*, 2000).

The direction of incident light entices shoots and roots to respond photo-tropically; light intensity and wavelength composition are important factors in determining the speed of cell growth, pigment accumulation and plastid differentiation (Von-Arnim and Deng, 1996).

In general, roughly 1.3 KW m^{-2} of radiant energy from the sun reaches Earth, but only about 5% of this energy can be converted into carbohydrates by a photosynthesizing leaf. The reason that this percentage is so low is that a major fraction of the incident light is of a wavelength either too short or too long to be absorbed by the photosynthetic pigments. In addition, much of the absorbed light energy is lost as heat, and a much smaller amount is lost as fluorescence. About 85 to 90% of the photo-synthetically active radiation (PAR) is absorbed by the leaf; the remainder is either reflected at the leaf surface or is transmitted through the leaf. Because, chlorophyll absorbs very strongly in the blue and the red regions of the spectrum, the transmitted and reflected light are enriched in green, yielding the green color of vegetation (Terashima and Hikosaka, 1995). Therefore, reporting that light plays a major signaling role in plant development is not surprising. A plant's ability to maximize its photosynthetic productivity depending on its capacity to sense, evaluate and respond to light quality, quantity and direction (Briggs and Olney, 2001).

Applying water through trickle-irrigation tubes located below the plastic mulch can provide enough water for optima growth and avoid nutrient leaching by excessive rainfall. The most widely used color of plastic mulch is black (Sweeney *et al.*, 1987; Bhella, 1988 and Lamont, 1993).

In this respect, Kasperbauer (1992) hypothesized that changing mulch color could keep those benefits while also reflecting a yield enhancing morphogenic light signal to the growing plants. Since, plant growth, development and productivity are dependent on both the quantity and wavelength distribution (color) of light. Hence, the quantity and interception of photosynthetically active radiation (PAR) have been studied for many years (Hesketh and Baker, 1967; Casal *et al.*, 1986 and Bruggink and Heuvelink, 1987), but the role of photomorphogenic light as a regulator of photosynthate allocation in growing plants under field conditions is a recent discovery (Kasperbauer and Hunt, 1998; Coffey *et al.*, 1999 and Kasperbauer, 2000).

In the field, the amount of FR (and the FR/R ratio) received by a growing plant is influenced by FR reflected either from nearly green plants (Kasperbauer, 1992; Thomas and Vince-Prue, 1997 and Oyaert *et al.*, 1999) or from the soil (or mulch) surface (Taber *et al.*, 1999; Waterer, 2000 and Greer and Dole, 2003).

Experimentally, Shinomura *et al.* (2000) and Runkle and Heins (2001) stated that, adding far red light (FR, 700 to 800 nm) to red light (R, 600 to 700 nm) to extend the day or interrupt the night for many plants promotes extension growth. Also, blue light (B, 400 to 500 nm) independently inhibits extension growth (Runkle and Heins, 2001).

Also, Csizinszky *et al.* (1995) reported that tomato growth and its yield were inconsistent with mulch colors during the three seasons of their study.

In general, since there is no report in Egypt on the effect of various colored mulch covers that create a specific microenvironment for tomato and sweet pepper plants. So, changes in the microenvironment in case of different colors, compared to bare soil (unmulched), include changes in the quantity and quality of light reflected from the mulch surface back to tomato and sweet pepper leaves (canopies), are of interest to be considered.

Thereby, present study in this part aimed to quantify vegetative growth of tomato and sweet pepper plants. That included evaluation of different growth aspects and dry matter distribution during the first sixty days of tomato and sweet peppers ages in case of different used colored-mulches.

MATERIALS AND METHODS

Two field experiments were conducted at the Experimental Farm Station of the Faculty of Agriculture, Moshtohor, Benha University during the two growing successive seasons of 2001 and 2002.

Two economical crops, i.e. tomato (*Lycopersicon esculentum*, Mill., cv. Super Strain B) and sweet pepper (*Capsicum annuum*, L., cv. Baladi), those known to be largely cultivated in Egypt in warm seasons, were taken as a botanical material in this study. Seeds of these two crops were secured from Vegetable Research Department, Agricultural Research Center, Ministry of Agriculture, Giza.

These experiments were performed to study the effect of some new promising treatments, polyethylene mulch surface colors, on some vegetative growth characteristics and dry matter distribution of both tomato and sweet pepper plants compared to bare soil (unmulched).

The trickle irrigation system was used before covering the soil surface with black, red, red over black and blue plastic mulches as well as bare soil (control).

Since the lateral lines used are line source tubing made with 16 mm diameter polyethylene hose. The applied emitter rates were 2.5 and 3 liter / hr. The trickle irrigation lines were laid on the surface of the experimental rows.

Polyethylene surface color was considered the main factor in this study. Polyethylene mulch sheets were of 1.20 m wide and 150 µ. thick. The black, red and blue colors of mulch were used in this study.

Five-week-old tomato and sweet pepper seedlings (i.e., at 20th and 15th of February for 2001 and 2002 seasons, respectively) were transplanted to the experimental plots.

The mulch treatments (black, red, red over black, blue polyethylene mulch colors and the bare soil as control) were arranged in a randomized complete-block design with three blocks (replicates). Each block had five plots (30m length and 3 m width). Each plot had three rows (30m length and 80 cm width) as a replicate for tomato and pepper as well. There are three rows of bare soil (unmulched) between each two treatments (Fig. 1) to provide complete separation of different colors.

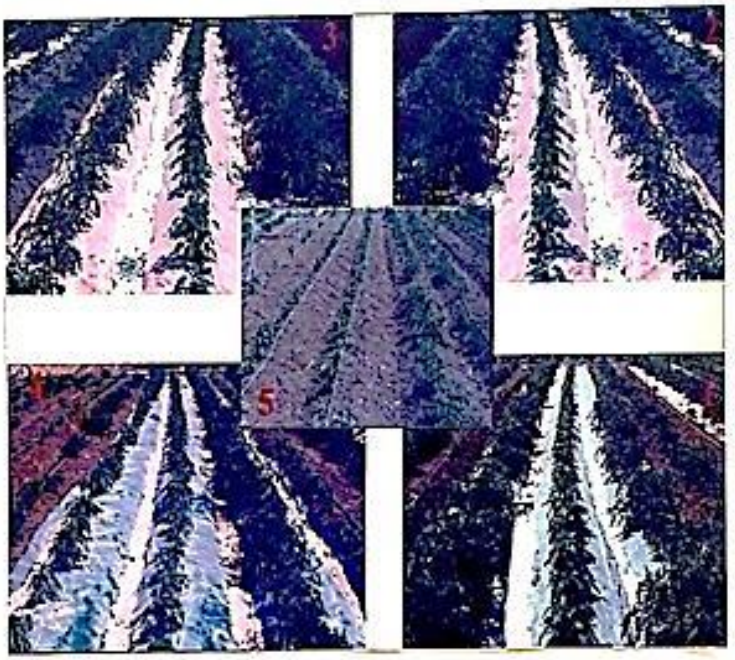

Fig. (1): Indicates the three rows of bare soil between each two treatments

In the two assigned seasons all agricultural practices of growing tomato and sweet pepper plants including equal amount of fertilizers were followed as recommended for the two species in case of trickle irrigation system (Cook *et al.*, 1982). Irrigation was for one hour two times weekly for different mulch color treatments. But it was for 2 hours three times weekly for the bare soil. The fertilizer was applied weekly through the trickle irrigation system for 12 weeks starting 10 days after transplanting. That means that bare soil was consumed amount of water exceeded that consumed in trickle irrigation by three times more during the tomato and pepper life cycles. That was very necessary to prevent permanent wilting and to reach the normal growth of tomato and sweet pepper cultivated in bare soil (control).

Light reflection:

Light reflection was measured for each color of polyethylene mulch treatments at mid-day of April and May the 14th for 2001 and 2002 seasons, respectively using an Exotech model 100 Ax field hand radiometer. Light reflection measurements included each of green-orange-yellow (500-600 nm), Red light, R (600-700 nm), Far-red light, FR (700-800 nm) and the invisible near infra-red, NIR (800-1100). Then the R photon ratio according to Decoteau *et al.* (1989) and (1990) using the equation of R photon ratio = FR / R ratio was calculated (Tables; 1 and 2).

Table (1): Average of the visible and invisible light reflected from polyethylene mulch surface color at mid-day of April the 14th during 2001 and 2002 seasons (calculated as %) under experimental conditions.

Wave length (nm) / Treatment	Visible light (%)								Invisible (Light %)	
	Green-orange-yellow 500-600		Red (R) 600-700		Far-red (FR) 700-800		*FR/R ratio		Near infra-red (NIR) 800-1100	
	Season		Season		Season		Season		Season	
	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002
Black	9.40	11.60	14.18	13.20	9.78	12.05	0.690	0.913	13.72	15.93
Red	26.01	22.56	43.52	44.54	50.12	51.45	1.152	1.155	48.04	49.02
Red + Black	13.23	17.56	49.85	54.28	54.52	56.57	1.094	1.042	46.81	53.43
Blue	18.18	12.04	11.98	14.18	13.70	19.04	1.144	1.343	45.83	46.08
Bare soil	5.39	10.03	11.25	18.63	11.08	18.31	0.985	0.983	13.73	18.63

Table (2): Average of the visible and invisible light reflected from polyethylene mulch surface color at mid-day of May the 14th during 2001 and 2002 seasons (calculated as %) under experimental conditions.

Wave length (nm) / Treatment	Visible light (%)								Invisible (Light %)	
	Green-orange-yellow 500-600		Red (R) 600-700		Far-red (FR) 700-800		*FR/R ratio		Near infra-red (NIR) 800-1100	
	Season		Season		Season		Season		Season	
	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002
Black	15.31	14.84	13.04	14.70	10.55	13.30	0.809	0.905	10.78	13.47
Red	25.00	28.75	46.58	49.72	49.87	52.67	1.071	1.059	45.61	45.61
Red + Black	25.09	23.13	51.43	59.88	55.90	62.05	1.087	1.036	44.50	55.98
Blue	19.38	18.13	15.32	15.74	18.35	19.04	1.198	1.210	49.07	50.79
Bare soil	13.75	11.75	16.91	15.60	14.97	12.42	0.885	0.796	23.22	19.49

Also, reflection from the mulch color treatment without cultivation was determined only during the first season (Table, 3).

Table (3): Reflection of the visible and invisible light from polyethylene mulch surface color at mid-day of April the 14th during 2001 season (calculated as %) without cultivation.

Wave length (nm) / Treatment	Visible light (%)				Invisible (Light %)
	Green-orange-yellow 500-600	Red (R) 600-700	Far-red (FR) 700-800	*FR/R ratio	Near infra-red (NIR) 800-1100
New Black	2.76	2.54	2.12	0.835	2.55
New Red	23.26	51.35	44.34	0.864	63.73
New Red + Black	17.77	41.03	39.52	0.963	40.20
New Blue	5.64	3.33	9.64	2.895	48.04

* FR/R ratio greatly differed from color to another, is considered the more significant result of applying this system

Sampling and collecting data:

I-Growth characteristics:

Different vegetative growth characteristics of tomato and sweet pepper plants at 45 and 60 days after transplanting were measured and/or calculated. Nine plants from each treatment were randomly taken for the following measurements, stem length (cm), stem diameter (cm) at the first internode, number of both leaves and branches/plant, leaves and stems fresh weights (g)/plant and total leaf area (cm^2)/plant using the disk method according to Dericux *et al.* (1973).

Samples of each treatment were taken for growth measurements, then, dried in oven at 70 °C for 48 hours till weight stability, the dry weight of stems (main stem + branches) and leaves/plant were estimated.

Also, the percentages of dry matter distribution in different shoot organs were calculated as well as specific leaf weight and also crop growth rate of stems, leaves and shoots using the following equations:

Specific leaf weight (SLW) according to Hall *et al.* (1993).

$$SLW = \frac{\text{Dry weight of leaves (mg)/plant}}{\text{Leaf area (cm}^2\text{)/plant}}$$

Absolute growth rate (AGR) is defined as the increase of plant material per unit of time, according to Radford (1967).

$$AGR = \frac{W_2 - W_1}{T_2 - T_1}$$

Where W_1, W_2 = dry weight at 45 and 60 days after transplanting, respectively.
T_1, T_2 = time at 45 and 60 days after transplanting, respectively.

II - Chemical constituents in the leaves :

Samples of both tomato and sweet pepper leaves were taken at 45 and 60 days after transplanting in both seasons to determine photosynthetic pigments (Inskeep and Bloom, 1985), Total carbohydrates (Dubois *et al.*, 1956), total and reducing sugars (Thomas and Dutcher, 1924), total nitrogen (Horneck and Miller, 1998), phosphorus (Sandell, 1950) and Potassium (Horneck and Hanson, 1998). Crude protein was calculated using the following equation:

Crude protein = Total nitrogen X 6.25 (A.O.A.C., 1990)

III – Statistical Analysis :

Data of vegetative growth characteristics were statistically analyzed and the means were compared using the least significant difference test (L.S.D.) at 5% and 1% levels according to Snedecor and Cochran (1980).

RESULTS AND DISCUSSION

Growth behavior at 45 and 60 days after transplanting :

I- At 45 days:-

I.1-Vegetative characteristics:

I.1.1-Stem parameters:

As shown in Table (4), different estimated characteristics of stem (i.e. length, diameter, fresh weight and number of branches/plant) in both tomato and pepper plants were increased to reach the highest level of significance (1%) with all applied mulch surface colors. The exception was only insignificant increase that existed in stem length of tomato with blue mulch during 2001 season and in number of branches/plant of both tomato and sweet pepper with black mulch during the two assigned seasons.

Also, it could be noticed that stem diameter showed its highest significant increase with red + black mulch treatment. Meanwhile, stem length, stems fresh weight showed their maximum increase in case of red mulch.

Regarding, the number of branches/plant in tomato, each of red and red over black mulch surface colors increased this number more than two times of the control value. Meanwhile in sweet pepper, this number reached more than five times of the control value with red and red over black mulches in the two seasons. In this respect increasing of formed branches on a growing plant could be reversed upon many other characters such as number of leaves, leaf area, leaves dry weight, flowering and yielded fruits.

I.1.2-Leaves parameters:

Data in Table (4) clearly indicate that number of leaves, leaf area / plant and the leaves fresh weight of tomato and pepper plants were increased to reach the high level of significance with different mulch surface colors applied during 2001 and 2002 seasons.

Table (4): Effect of polyethylene mulch color on some vegetative characteristics of tomato (*Lycopersicon esculentum*, Mill.) and sweet pepper (*Capsicum annuum*, L.) plants at 45 days after transplanting during 2001 and 2002 seasons

Character / Treatment		Stem length (cm)		Stem diameter (cm)		*Stems fresh weight (g)/plant		No. of branches/plant		No. of leaves /plant		Leaf area /plant (cm^2)		Leaves fresh weight (g) /plant		Shoot fresh weight (g) /plant	
		Seasons		Seasons		Seasons		Seasons		Seasons		Seasons		Seasons		Seasons	
		2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002
Tomato																	
Control		20.83	18.63	0.73	0.60	6.60	10.52	3.00	4.00	8.33	6.67	456.87	319.31	25.06	20.61	31.66	31.16
Black		36.20	31.83	0.93	0.87	13.12	18.32	4.00	5.33	12.00	8.67	971.96	800.38	53.25	48.44	66.37	66.76
Red		32.33	29.67	1.13	0.97	24.87	29.13	7.67	8.67	18.67	15.33	1251.51	1085.59	75.42	69.0	99.59	98.13
Red + black		31.50	28.53	1.10	1.00	23.08	32.33	8.00	10.00	15.67	12.00	1428.70	1093.37	65.97	56.51	89.05	88.84
Blue		24.80	20.33	0.97	0.90	21.32	24.83	6.67	8.67	15.00	10.47	1246.87	1078.62	62.29	53.34	83.61	78.17
L.S.D.	0.05	4.51	2.27	0.14	0.25	2.99	4.08	1.52	1.67	2.13	2.24	351.48	69.75	6.29	5.81	8.27	7.22
	0.01	6.56	3.29	0.21	0.36	4.35	5.93	2.21	2.42	3.10	3.26	220.04	101.33	9.14	8.44	12.02	10.48
Sweet pepper																	
Control		17.67	14.90	0.43	0.47	2.59	2.52	1.00	1.00	19.33	13.00	82.50	70.39	5.57	4.69	8.16	7.19
Black		22.63	16.77	0.57	0.53	3.77	3.67	1.33	1.67	24.00	21.67	827.93	148.02	7.48	10.14	13.25	13.81
Red		21.27	19.50	0.73	0.67	5.78	8.81	5.67	7.67	47.33	41.00	222.18	234.95	17.13	17.54	22.95	26.35
Red + black		22.80	19.03	0.63	0.60	5.23	6.51	5.67	7.00	41.33	38.00	179.34	194.37	13.64	16.03	18.87	22.54
Blue		20.37	17.77	0.63	0.63	4.81	6.14	4.00	5.33	36.67	36.33	173.31	159.95	14.55	15.13	19.36	21.27
L.S.D.	0.05	2.36	1.43	0.10	0.15	1.48	2.67	1.77	2.05	5.59	4.44	50.17	56.30	4.98	3.33	6.11	4.84
	0.01	3.43	2.08	0.13	0.21	2.14	3.88	2.57	2.98	8.12	6.46	72.88	81.79	7.23	4.83	8.87	7.03

*Stems are including each of main stem and branches.

It could be also noticed that the red and red + black gave the highest leaf number and the red was preceding in this respect, since increase in leaf number reached more than two times of control values in the two assigned seasons.

Total leaf area / plant and leaves fresh weight in tomato and sweet pepper, behaved as the same as the above mentioned parameters. Since, all applied mulch colors showed high significant increase but its maximum was also obtained with the red then red + black treatments, respectively. Increment of leaf area may be reflected upon the efficiency of photosynthesis by accumulating more assimilates and high rates of their translocation specially toward the formed fruits.

In addition, increment of shoots fresh weight could be a base for increasing each of leaf area, number of both leaves and branches and the photosynthetic efficiency, thereby, more dry matter production and their allocation to fruits are being expected.

I.2-Dry matter distribution:

Table (5) indicates the effect of different applied mulch surface colors on dry matter production and distribution in stems (branches + main stem) and leaves of tomato and sweet pepper plants at 45 days after transplanting. Data clearly indicated that different mulch colors, i.e. black, red, red over black and blue increased dry weight of stems in tomato and pepper plants at this early stage of growth. Increases reached the high level of significance. Yet in tomato, the red color gave the highest value during 2001 season but red + black showed its maximum during 2002 season, these two treatments exceeded stems dry weight more than three times when compared with the control value. That could be more evident when related to the control values, since the 100 percentage of control rose to 339.19 and 326.72% with red mulch during first season and with red + black during second season, respectively. Meanwhile, in sweet pepper, the red mulch gave the highest values of stems dry weight in both seasons, since the percentage of this parameter reached to 245.00 and 338.24% of the control value during 2001 and 2002 seasons, respectively.

As for leaves dry weight, data in Table (5) evidently confirmed the stimulatory and significantly effects of applied mulch colors upon dry matter production and accumulation in leaves of tomato and pepper plants. Also, red color was more pronounced in this respect. Since, increases reached to nearly three times during first season and reached to nearly five times in second season comparing with control values in both tomato and sweet pepper. Therefore, total dry weight of shoots also behaved as the same as that of stems and leaves with different mulch colors and also with priority of the red mulch. Besides, dry matter distribution was high significantly affected. Since, more dry matter being distributed into leaves but that also confirm the high efficiency of photosynthesis process in plants grown up the applied mulch colors that was also, with the priority of red one in this respect.

Table (5) : Effect of polyethylene mulch surface color on dry matter distribution in different shoot organs of tomato (*Lycopersicon esculentum*, Mill) and sweet pepper (*Capsicum annuum*, L.) plants at 45 days after transplanting during 2001 and 2002 seasons

Character / Treatment		*Stem dry weight (g)/plant		*Stem dry weight %relative to the control		Leaves dry weight (g)/plant		Leaves dry weight %relative to the control		shoot dry weight (g)/plant		%distribution of dry matter in different shoot organs: *Stems		%distribution of dry matter in different shoot organs: Leaves		Specific leaf weight (S.L.W) (mg/cm²)	
		Seasons		Seasons		Seasons		Seasons		Seasons		Seasons		Seasons		Seasons	
		2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002
Tomato																	
Control		0.74	1.16	100.00	100.00	4.13	2.30	100.00	100.00	4.87	3.47	15.20	33.42	84.80	66.58	9.04	7.44
Black		1.26	2.15	170.27	185.34	9.55	8.48	231.23	367.10	10.81	10.63	11.66	20.23	88.34	79.77	9.84	9.63
Red		2.51	3.19	339.19	275.00	13.60	12.43	329.30	494.81	16.11	14.62	15.58	21.79	84.42	78.21	10.06	10.53
Red + black		2.42	3.79	327.03	326.72	12.43	10.67	300.97	461.90	14.85	14.46	16.32	26.29	83.68	73.71	8.70	9.76
Blue		2.14	2.52	289.19	217.28	10.98	9.08	265.86	393.07	13.12	11.60	16.36	21.72	83.64	87.28	8.81	8.45
L.S.D.	0.05	0.53	0.47	—	—	1.09	1.44	—	—	1.82	1.46	3.89	3.89	3.89	3.88	0.75	1.27
	0.01	0.78	0.68	—	—	1.59	2.09	—	—	1.62	2.13	5.65	5.65	5.65	5.64	1.09	1.85
Sweet pepper																	
Control		0.40	0.34	100.00	100.00	0.81	0.42	100.00	100.00	1.21	0.76	33.25	44.93	66.75	55.07	9.82	5.97
Black		0.59	0.47	147.50	138.24	1.29	0.95	159.26	226.19	1.88	1.42	30.59	33.44	69.75	66.56	10.08	6.42
Red		0.98	1.15	245.00	338.24	2.31	2.46	285.19	585.71	3.29	3.61	29.87	31.80	70.13	68.20	10.40	10.13
Red + black		0.82	0.83	205.00	244.12	2.07	2.19	255.56	521.43	2.89	3.02	28.62	27.74	71.38	72.26	11.56	11.27
Blue		0.91	0.94	227.50	276.47	1.92	1.44	237.04	342.86	2.83	2.38	32.16	37.01	67.84	62.99	11.08	8.47
L.S.D.	0.05	0.22	0.25	—	—	0.41	0.58	—	—	0.60	0.70	6.57	10.56	6.59	9.58	1.34	2.66
	0.01	0.32	0.37	—	—	0.60	0.84	—	—	0.85	1.02	9.55	15.38	8.56	14.37	1.94	3.80

*Stems are including each of main stem and branches.

Moreover, the calculated data of specific leaf weight could support the above mentioned data about the vigorous growth of tomato and pepper plants grown above the assigned mulch colors specially in red one.

In general, data in Table (5) not only being a direct results for that vigorous growth obtained in Table (4) but also could be considered an indicator for expectable high yield of fruits.

These results are in agreement with those obtained by Kasperbauer and Karlen (1994). They reported that the leaf/stem and shoot/root photosynthate allocation patterns in response to FR/R ratio (which was influenced by FR reflected from nearby plants) in field-grown seedlings was evident. The phytochrome system within the seedlings functioned as a sensor of competition (the FR/R ratio) and initiated physiological events that influenced prioritization in the allocation of new photo-assimilates to the various components of the growing plant. For example, a seedling in the higher population density received more reflected FR and a higher FR/R ratio. The adaptive response was to allocate more of the new photosynthates for development of longer stems and longer leaves, both of which increased the probability that the plant would have some photosynthetic area above competing plants. When a greater fraction of new photosynthates was allocated to elongating stems, less remained for new root growth, and *vice versa*. Thus, the leaf/stem and shoot/root biomass ratios were altered in seedlings according to the FR/R ratio, which could be modified by FR reflection from other green plants or by the FR/R ratio in upwardly reflected light over different colored surfaces. It could be concluded that it is important to be aware of these adaptive growth responses to light spectral consequences of plant spacing and soil surface color (including presence of any crop residues and mulches that might alter the FR/R ratio in reflected light), and to then use the information in development or modification of plant soil water light management systems.

I.3-Photosynthetic pigments:

As shown in Table (6) photosynthetic pigments (chlorophyll a & b and carotenoids) concentrations in leaves of tomato and pepper plants were increased with different used mulch colors during 2001 and 2002 seasons. Red + black treatment was more efficient in this respect followed by the red one. The exception was only that slight reduction of chlorophyll (b) with the blue mulch treatment during 2001 season in tomato and both seasons in pepper.

These results are of great interest, because they are lightly considered direct reason for the more dry matter production and distribution in shoots of tomato and pepper plants grown above applied mulch colors (Table, 5). Also, of interest to note that, this stimulatory effect of mulch colors upon photosynthetic pigments creation was started at this early stage of growth i.e. at 45 days after planting.

II-At 60 days:

II.1- Vegetative characteristics:

II.1.1-Stem parameters :

Stem length of tomato and pepper plants was significantly increased with various applied mulch colors during the two seasons compared with the control plants (Table, 7). Moreover, it was found that red mulch ranked the first in

this respect. The only exception was that insignificant increase in this parameter with black mulch in pepper plants during the two seasons.

As for stem diameter, its high significant increase existed with most of applied mulch colors. Here, it is of interest to note that increasing of stem diameter was accompanied with increasing stem lengh which means that mulch colors led to vigorous growth and more healthy tomato and pepper plants.

With regard to the fresh weight of stems, it was significantly increased during the two seasons with different applied mulch colors except with black mulch in case of sweet pepper, since the increase did not reach the level of significance (at 5%) in both seasons.

Regarding, the number of branches formed on tomato and pepper plants at 60 days after transplanting, it was significantly increased with most of the applied mulch colors. Again, the red + black and red mulches were more pronounced in this respect.

Such results clearly could be interpreted by those alterations are being created in the hormonal profile. Since, cytokinins level was increased on the account of auxin which might be in favor of increasing the number of formed branches and increasing transverse growth on the account of longitudinal one (El-Desouky, *et al.*, 2005b).

Table (6): Effect of polyethylene mulch surface color on photosynthetic pigments concentrations (calculated as mg/g fresh weight) of tomato *(Lycopersicon esculentum,* Mill.) and sweet pepper (*Capsicum annuum,* L.) plants at 45 days after transplanting during 2001 and 2002 seasons

Character / Treatment	Chlorophyll (a)		Chlorophyll (b)		Chlorophyll (a+b)		Carotenoids	
	Seasons		Seasons		Seasons		Seasons	
	2001	2002	2001	2002	2001	2002	2001	2002
Tomato								
Control	0.41	0.61	0.38	0.46	0.79	1.07	0.20	0.48
Black	0.47	0.67	0.39	0.52	0.86	1.19	0.22	0.50
Red	0.57	0.82	0.45	0.63	1.02	1.45	0.31	0.58
Red + black	0.62	0.85	0.50	0.68	1.12	1.53	0.32	0.63
Blue	0.50	0.66	0.34	0.54	0.84	1.20	0.22	0.49
Sweet pepper								
Control	0.60	0.50	0.34	0.40	0.94	0.90	0.30	0.32
Black	0.63	0.55	0.36	0.39	0.99	0.94	0.33	0.37
Red	0.73	0.61	0.49	0.49	1.22	1.10	0.43	0.49
Red + black	0.75	0.71	0.56	0.57	1.31	1.28	0.50	0.55
Blue	0.64	0.56	0.33	0.42	0.97	0.98	0.32	0.31

Table (7): Effect of polyethylene mulch surface color on some vegetative characteristics of tomato (*Lycopersicon esculentum*, Mill.) and sweet pepper (*Capsicum annuum*, L.) plants at 60 days after transplanting during 2001 and 2002 seasons.

Character / Treatment		Stem length (cm)		Stem diameter (cm)		*Stems fresh weight (g /plant)		No. of branches/plant		No. of leaves /plant		Leaf area /plant (cm^2)		Leaves fresh weight (g /plant)		Shoot fresh weight (g /plant)	
		Seasons		Seasons		Seasons		Seasons		Seasons		Seasons		Seasons		Seasons	
		2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002
Tomato																	
Control		28.83	30.93	1.03	0.97	30.22	27.91	8.33	7.00	18.33	12.67	1877.18	760.87	85.27	70.57	115.49	98.48
Black		45.27	51.93	1.27	1.13	44.15	55.97	12.63	12.00	32.67	26.67	1795.08	1894.07	155.79	147.73	199.94	203.70
Red		50.87	52.13	1.30	1.37	54.77	68.30	17.33	20.67	37.33	37.43	2842.57	3684.11	192.58	196.39	247.35	260.69
Red + black		47.10	49.97	1.47	1.30	84.61	80.51	19.00	18.33	48.33	40.33	4551.99	3609.59	286.92	243.94	371.53	324.45
Blue		43.53	48.77	1.23	1.27	41.41	46.95	10.33	11.00	30.00	29.33	2151.98	1961.52	137.26	135.32	178.67	182.27
L.S.D.	0.05	4.90	4.24	0.18	0.16	10.09	11.14	2.16	3.38	6.58	5.04	814.15	1171.04	28.81	27.23	92.95	93.79
	0.01	7.12	6.16	0.26	0.24	14.65	15.90	3.14	4.91	9.56	7.32	1182.65	1701.07	42.85	39.21	135.03	136.25
Sweet pepper																	
Control		21.60	19.30	1.03	0.70	23.42	10.25	11.33	6.67	48.33	42.33	245.25	225.57	20.34	17.48	45.76	27.69
Black		22.00	20.93	1.20	0.80	26.52	14.56	17.00	12.67	56.33	43.33	371.15	390.35	35.53	27.04	63.05	41.60
Red		25.17	22.00	1.27	1.15	42.51	36.81	30.33	27.33	116.00	96.00	998.58	915.03	68.21	54.11	110.72	90.92
Red + black		21.67	23.83	1.40	1.25	60.27	38.27	34.00	30.67	116.14	114.33	1333.15	1348.72	93.27	71.73	153.54	110.00
Blue		24.83	20.67	1.33	1.07	38.96	26.03	17.33	17.00	91.33	90.33	679.15	678.37	52.52	54.94	91.48	71.97
L.S.D.	0.05	4.66	5.67	0.25	0.08	16.03	4.60	5.94	3.43	12.50	10.79	155.91	193.43	16.43	14.35	25.65	15.76
	0.01	6.76	8.24	0.36	0.12	23.28	6.69	8.63	4.98	18.16	15.67	226.47	280.97	23.86	20.84	37.26	22.90

*Stems are including each of main stem and branches.

II.1.2-Leaves characteristics :

As shown in Table (7) the number of leaves formed on tomato and pepper plants at 60 days after transplanting was high significantly increased with different used mulch colors during the two seasons compared with the control plants. Exception was only that insignificant increase existed with black mulch in case of pepper plants in the two seasons. These results are of great interest because their reversion upon the final photosynthesis area, thereby the net assimilates that could be mainly directed to the developing fruits.

With regard to the leaf area in both tomato and pepper plants, it could also be noticed that its high significant increase was obtained with each of red + black and red mulches in the two seasons, but the increase reached to 5% level of significance only with blue mulch in case of tomato plants. Meanwhile, insignificant increase in this area was only existed with black mulch in each of tomato and pepper plants during the two seasons. These results could also be considered as a complete reflection of increasing of each of branches and leaves number.

While, high significant increases were dominantly existed in leaves fresh weight of both tomato and pepper with various colors of used mulch surface. It could be noticed that red + black gave highest values followed by red, blue and black mulches.

In general, shoots fresh weight of tomato was increased with various colors but reached the two levels of significance with red + black (in the two seasons) and with red color (in second season), while reached the level of 5% significance with red and black colors in first and second season, respectively, yet the rest showed only insignificant increase. Meanwhile, in case of sweet pepper, the increase in this parameter reached to the high level of significant (1%) with different used colors of mulch surface except with black one, since the increase did not reach 5% level of significance.

In addition, increment of shoots fresh weight either at 45 or 60 days could be a base for increasing each of leaf area, number of both leaves and branches and the photosynthetic efficiency, thereby more dry matter production and their allocation to fruits are being expected.

The obtained results were in harmony with those obtained by Decoteau *et al.* (1990) on pepper plants Chakraborty and Sadhu (1994) on tomato plants. In this respect Kasperbauer and Hunt (1998) reported that light reflected from the surface of plastic mulch can have a photo-regulatory role in growth of young tomato (*Lycopersicon esculentum*, Mill.) plants.

II.2- Dry matter distribution :

As shown in Table (8) different applied mulch colors significantly in most cases affected dry matter distribution, i.e. partitioning and allocation.

Table (8): Effect of polyethylene mulch surface color on dray matter distribution in different organ shoot of tomato (*Lycopersicon esculentum*, Mill.) and sweet pepper (*Capsicum annuum*, L.) plants at 60 days after transplanting during 2001 and 2002 seasons

Character / Treatment		*Stems dry weight (g)/plant				Leaves dry weight (g)/plant				Shoot dry weight (g)/plant		%distribution of dry matter in different shoot organs				Specific leaf weight (S.L.W.) (mg/cm²)	
				%relative to the control				%relative to the control				*Stems		Leaves			
		Seasons		Seasons		Seasons		Seasons		Seasons		Seasons		Seasons		Seasons	
		2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002
Tomato																	
Control		4.52	2.91	100.00	100.00	11.79	8.74	100.00	100.00	16.31	11.65	27.71	24.98	72.29	75.02	10.95	13.49
Black		8.37	9.91	185.18	340.55	25.78	32.61	218.67	373.11	34.08	42.52	24.56	23.31	75.44	76.69	14.32	14.22
Red		10.17	13.44	225.00	461.86	33.61	41.75	285.16	477.69	43.79	55.19	23.22	24.35	76.78	75.65	11.83	11.33
Red + black		13.49	12.17	298.45	418.21	47.77	39.37	405.17	450.46	61.26	51.54	22.02	23.61	77.98	76.39	10.49	10.91
Blue		7.39	7.67	163.50	263.57	23.31	24.50	197.71	280.32	30.70	32.17	24.07	23.84	75.93	76.16	10.83	14.23
L.S.D.	0.05	1.83	2.55	—	—	5.49	11.04	—	—	6.91	12.21	5.66	5.33	5.60	7.52	2.11	3.11
	0.01	2.65	3.71	—	—	7.97	16.03	—	—	10.04	17.73	8.19	7.74	8.14	10.93	3.06	4.52
Sweet pepper																	
Control		4.21	1.54	100.00	100.00	3.06	2.64	100.00	100.00	7.27	4.18	57.91	36.84	42.09	63.16	12.48	11.70
Black		5.81	2.13	138.03	138.31	4.87	4.46	159.15	168.18	10.68	6.57	54.40	32.42	45.60	67.58	13.12	18.37
Red		7.34	5.12	174.35	332.47	12.34	9.64	403.27	365.15	19.68	14.76	37.30	34.69	62.70	65.31	12.36	10.20
Red + black		9.62	5.38	228.5	349.35	16.83	14.03	550.00	531.44	26.45	19.41	36.37	27.72	63.63	72.28	12.62	10.40
Blue		5.86	4.85	139.19	314.94	8.45	7.38	276.14	279.55	14.31	12.23	40.95	39.67	59.05	60.33	12.44	10.88
L.S.D.	0.05	3.03	1.16	—	—	3.06	3.11	—	—	6.37	3.23	12.31	10.90	12.58	10.92	2.13	3.09
	0.01	4.40	1.68	—	—	4.44	4.52	—	—	9.83	4.76	18.32	15.85	18.23	15.87	3.09	4.49

* Stems are including each of main stem and branches

In this respect, stems (main stem + branches) dry weight of both tomato and sweet pepper showed its high significant increase with different colors of applied mulches during the two seasons. The exception was only that insignificant increase with the blue mulch color during 2001 season and with black mulch in the two seasons in case of pepper plants. These values reached more than three times and more than four times especially in 2002 season with the red and the red + black color mulches in both tomato and pepper plants.

As for leaves dry weight of tomato and sweet pepper, it is more evident also that different mulch colors increased it to reach the high level of significance. The only exception was that increase at 5% level with blue mulch in tomato during 2002 season and the insignificant increase with black mulch in sweet pepper during both seasons. Here, of interest to note that more dry matter being accumulated in leaves that is not only necessary for vigorous growth of grown plants but also could be in favor of developed formed fruits. So, high yielded fruits being more expected.

In addition, total dry weight of shoots as well as their relation to control made the obtained results also more evident.

Moreover, of great interest also those results obtained about dry matter distribution in stems and leaves, since increases in leaves mostly on the account of that being accumulated or directed to stems. That, because values in leaves exhibited insignificant increase but insignificant reduction was dominantly existed in case of stems, that was true only at 60 days of plant old not at 45 days of old. Those differences in dry matter accumulation existed in the first sample could be attributed mainly to variations of assimilates translocation rates and individual allocation of assimilates during this early stage of growth.

On the other hand, the specific leaf weight showed reduction in the common rate of increase that existed in other parameters. That could be also of interest, because it means that more dry matter being accumulated from the same leaf area when compared between that of different treatments and that of control one.

In this respect, other studies also reported similar positive effects of the mulch colors on the improvement of tomato vegetative growth (Adams, 1997 and Fortnum *et al.*, 1997) and strawberry vegetative characteristics (Wang et *al.*, 1998 and Kasperbauer, 2000).

II.3 - Photosynthetic pigments:

Data in Table (9) clearly indicate that different used colors of applied mulches increased each of chlorophyll a, b and carotenoids concentration in leaves of tomato and sweet pepper at 60 days from transplantation during the two assigned seasons compared with the control values.

Also, it could be noticed that maximum increase of all these pigments existed in case of red + black mulch color followed by the red one meanwhile the black one ranked the last in this respect.

Table (9): Effect of polyethylene mulch surface color on photosynthetic pigments concentration (calculated as mg/g fresh weight) of tomato (*Lycopersicon esculentum*, Mill.) and sweet pepper (*Capsicum annuum*, L.) plants at 60 days after transplanting during 2001 and 2002 seasons.

Character / Treatment	Chlorophyll (a)		Chlorophyll (b)		Chlorophyll (a+b)		Carotenoids	
	Seasons		Seasons		Seasons		Seasons	
	2001	2002	2001	2002	2001	2002	2001	2002
Tomato								
Control	0.60	0.68	0.45	0.51	1.05	1.19	0.35	0.45
Black	0.60	0.72	0.45	0.56	1.05	1.28	0.36	0.41
Red	0.71	0.80	0.55	0.60	1.26	1.40	0.44	0.46
Red + black	0.86	0.84	0.73	0.72	1.59	1.56	0.51	0.58
Blue	0.63	0.76	0.45	0.57	1.08	1.33	0.36	0.44
Sweet pepper								
Control	0.55	0.55	0.36	0.33	0.91	0.88	0.34	0.31
Black	0.59	0.57	0.42	0.40	1.01	0.97	0.37	0.39
Red	0.75	0.71	0.55	0.51	1.30	1.22	0.48	0.41
Red + black	0.84	0.79	0.64	0.53	1.48	1.32	0.52	0.44
Blue	0.72	0.65	0.47	0.45	1.19	1.10	0.35	0.35

In addition, of interest also to relate the stimulation of photosynthetic pigments creation with that of dry matter produced in each of stems and leaves that existed at 45 and 60 days of plant age.

In this respect, Bradburne *et al.* (1989) reported that the effect of FR/R ratio on soybean and tobacco seedlings was not only allocation of photosynthates among leaves, stems and roots but also on the development of photosynthetic apparatus, chlorophyll concentration and photosynthetic efficiency. also, Oguchi *et al.* (2003) hypothesized that the increase in the photosynthetic capacity in a high light condition was due to: (1) increased activity of Rubisco; (2) increased concentration of Rubisco in chloroplasts; (3) increased number of chloroplasts; (4) increased volume of chloroplasts; or (5) a combination of some of them.

III-Effect of mulch surface colors on absolute growth rate:

Here, it could be noticed that, absolute growth rate of each of stems and leaves was increased to reach the highest level of significant (1%) in most cases with different used mulch colors compared with control values (Table, 10). However, insignificant increase with blue mulch in tomato and with black one in sweet pepper during the two seasons was recorded. Also, it could be noticed that red + black ranked the first followed by red mulch in both tomato and pepper plants.

Therefore, the absolute growth rate of total shoots also behaved as the same as in leaves with different mulch colors and also the red + black treatment gave the highest values, meanwhile the red treatment ranked the second during the two seasons.

Table (11): Effect of polyethylene mulch surface color on absolute growth rate of tomato (*Lycopersicon esculentum*, Mill) and sweet pepper (*Capsicum annuum*, L.) plants from 45 to 60 days after transplanting during 2001 and 2002 seasons

Character / Treatment		Absolute growth rate (AGR)											
		Stems				Leaves				shoots			
		g/day		%relative to the control		g/day		%relative to the control		g/day		%relative to the control	
		Seasons		Seasons		Seasons		Seasons		Seasons		Seasons	
		2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002
Tomato													
Control		0.25	0.12	100.00	100.00	0.51	0.43	100.00	100.00	0.76	0.55	100.00	100.00
Black		0.47	0.52	188.00	433.33	1.08	1.61	211.76	374.42	1.55	2.13	203.95	387.27
Red		0.51	0.68	204.00	566.67	1.34	2.02	262.75	469.77	1.85	2.70	243.42	490.91
Red + black		0.74	0.56	296.00	466.67	2.36	1.91	462.75	444.19	3.09	2.47	406.58	449.09
Blue		0.35	0.34	140.00	283.33	0.82	1.03	160.78	239.53	1.13	1.37	153.94	249.09
L.S.D.	0.05	0.18	0.18	—	—	0.43	0.77	—	—	0.50	0.86	—	—
	0.01	0.16	0.27	—	—	0.63	1.12	—	—	0.72	1.25	—	—
Sweet pepper													
Control		0.25	0.08	100.00	100.00	0.15	0.58	100.00	100.00	0.40	0.23	100.00	100.00
Black		0.35	0.11	140.00	137.50	0.24	0.33	160.00	153.33	0.58	0.34	145.00	147.83
Red		0.42	0.27	168.00	337.50	0.63	0.48	466.67	320.00	1.09	0.74	272.50	321.74
Red + black		0.59	0.30	236.00	375.00	0.98	0.79	653.33	526.67	1.75	1.09	437.50	473.91
Blue		0.33	0.16	132.00	225.00	0.45	0.40	3.0000	266.67	0.77	0.66	192.50	286.96
L.S.D.	0.05	0.21	0.09	—	—	0.19	0.20	—	—	0.35	0.22	—	—
	0.01	0.31	0.14	—	—	0.27	0.29	—	—	0.51	0.31	—	—

A photo-regulatory role for upwardly reflected light on tomato plant development in plastic mulch culture has been established (Decoteau *et al.*, 1988). Morphological development of young tomato plants was altered by subtle changes in the wavelength composition of light reflected from various painted colors of polyethylene surfaces (Decoteau *et al.*, 1986). Differences in tomato plant development can be induced in controlled environments by exposure to red (R) and far-red (FR) light, implicating phyto -chrome as the sensing mechanism (Decoteau *et al.*, 1988 and Tucker, 1975). Tomato plants treated with FR light at the end of the day grew taller and had fewer branches than tomato plants treated with R light. Even subtle changes in the FR: R ratio can have a major influence on plant growth (Kasperbauer, 1988 and Kasperbauer *et al.*, 1964). Because tomato plant growth is responsive to subtle changes in the plant light environment alternative colors of mulch that selectively reflect desired wavelengths of light into the plant canopy may have potential for improving tomato yields under field conditions.

IV-Chemical composition:

IV.1- Minerals and crude protein concentrations:

With regard to the mineral concentrations, data in Table (11) clearly indicate that different used mulch colors increased N, P and K concentrations in leaves of tomato and sweet pepper plants at 45 and 60 days after transplanting during 2001 & 2002 seasons compared with control values. Also, it could be noticed that the highest increase of any of these elements obtained with red mulch alone or that used as red over black treatment.

As for protein concentration, it could be noticed that it behaved as the same as in case of elements, since the three used color mulches increased this content during two assigned seasons. So, protein concentration in leaves of tomato and pepper plants grown above different applied mulch surface colors was higher when compared with the control ones.

IV.2-Sugars and carbohydrates concentrations at 45 and 60 days after transplanting:

As shown in Table (12), total carbohydrates and total soluble sugars (reducing and non reducing) in leaves of tomato and pepper plants were increased with different used mulch colors during 2001 and 2002 seasons at the two times of determination, i.e. at 45 &60 days after transplanting, compared with the control values.

Again, red mulch color when used above black mulch gave the highest contents of both total carbohydrates and soluble sugars during the two seasons followed by red then blue mulch, while the black mulch ranked the last. That was true at the two times of determination during the two assigned seasons.

In this respect, high total carbohydrates is a direct result for high rates of photosynthesis with great efficiency. That was preceded with large photosynthetic area (Tables 6 & 9) and high content of photosynthetic pigments (Tables 8 & 11) as well under the treatments of various mulch colors but it reached its maximum with red one.

Table (11): Effect of polyethylene mulch color on minerals and crude protein concentrations of tomato (*Lycopersicon esculentum*, Mill) and sweet pepper (*Capsicum annuum*, L.) leaves at 45 days and 60 days after transplanting during 2001 and 2002 seasons

Character	45 days								60 days							
	N mg/g dry weight		P mg/g dry weight		K mg/g dry weight		Crude protein mg/g dry weight		N mg/g dry weight		P mg/g dry weight		K mg/g dry weight		Crude protein mg/g dry weight	
	Seasons		Seasons		Seasons		Seasons		Seasons		Seasons		Seasons		Seasons	
Treatment	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002
Tomato																
Control	38.34	39.86	4.18	4.34	37.08	39.44	239.62	249.12	40.34	42.80	4.54	4.42	43.24	44.28	252.13	267.50
Black	41.64	46.86	4.50	5.02	42.34	43.42	260.25	292.87	47.42	48.14	5.18	5.46	45.61	47.28	296.38	300.88
Red	50.35	51.67	5.48	5.64	46.82	45.81	314.68	322.94	51.77	52.86	6.04	6.20	48.23	49.44	323.56	330.38
Red + black	48.32	51.24	5.72	5.28	46.03	45.23	302.00	320.25	49.34	50.78	5.78	6.12	47.82	48.63	308.38	317.38
Blue	40.81	44.68	4.69	4.78	39.67	41.85	255.06	279.25	45.73	47.82	4.96	5.34	45.16	45.86	285.81	298.87
Sweet pepper																
Control	30.24	31.08	3.32	3.27	40.85	41.65	189.00	194.25	31.84	32.86	4.56	4.40	41.84	42.18	199.00	205.38
Black	33.46	38.32	3.42	4.80	42.97	43.25	209.13	239.50	39.42	38.68	4.94	4.66	43.82	44.65	264.38	241.50
Red	42.48	43.38	4.98	5.16	45.15	45.72	265.50	271.13	44.61	43.68	5.32	5.60	45.25	46.22	279.00	273.00
Red + black	40.42	42.36	4.84	5.40	45.09	45.61	252.63	264.75	43.88	44.26	5.22	5.46	45.83	46.70	274.25	276.63
Blue	38.46	32.56	4.08	4.28	42.49	43.09	240.38	202.25	35.46	37.24	4.72	4.98	42.89	43.20	221.63	232.75

Table (82): Effect of polyethylene mulch color on sugars and carbohydrates concentrations in tomato (*Lycopersicon esculentum*, Mill.) and sweet pepper (*Capsicum annuum*, L.) leaves at 45 and 60 days after transplanting during 2001 and 2002 seasons

Character / Treatment	45 days								60 days							
	Total carbohydrates mg/g dry weight		Reducing sugars mg/g fresh weight		Non Reducing sugars mg/g fresh weight		Total sugars mg/g fresh weight		Total carbohydrates mg/g dry weight		Reducing sugars mg/g fresh weight		Non Reducing sugars mg/g fresh weight		Total sugars mg/g fresh weight	
	Seasons		Seasons		Seasons		Seasons		Seasons		Seasons		Seasons		Seasons	
	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002
Tomato																
Control	416.88	403.59	13.59	15.60	6.67	8.78	20.28	24.38	425.34	420.50	11.70	14.53	6.72	8.17	18.42	22.70
Black	422.92	418.09	17.95	18.24	8.45	8.88	26.40	27.12	439.84	447.09	19.54	18.20	8.78	8.54	28.32	26.74
Red	502.67	495.42	23.89	22.62	10.73	14.62	34.62	37.24	506.29	501.13	25.32	22.94	11.38	10.88	36.70	33.82
Red + black	509.92	505.09	24.62	25.32	11.68	13.84	36.30	39.16	507.50	508.72	26.80	24.72	13.38	13.64	40.18	38.36
Blue	468.84	456.75	20.57	21.24	9.68	10.48	30.25	31.72	473.67	478.50	18.92	22.54	13.70	12.08	32.62	34.62
Sweet pepper																
Control	441.04	422.92	15.37	14.28	6.45	6.42	21.82	20.70	465.28	447.09	16.50	17.24	7.42	7.41	23.92	24.65
Black	513.54	507.50	16.47	18.35	8.23	8.03	24.70	26.42	519.59	529.25	18.87	20.08	7.93	8.64	26.80	28.72
Red	582.42	599.34	22.85	25.15	9.59	11.07	32.44	36.22	589.67	600.54	24.85	25.89	10.62	11.65	34.77	37.54
Red + black	606.59	623.50	26.33	27.17	10.79	12.23	37.12	39.40	601.75	609.00	26.75	27.50	11.77	12.38	38.52	39.88
Blue	543.75	577.59	21.03	22.66	9.25	9.52	30.28	32.18	555.84	549.79	20.16	21.40	9.28	9.97	29.44	31.25

So, red mulch being reflected more red and far-red light (Tables 1, 2, 3 and 4) to again penetrate the photosynthetic area of growing tomato and sweet pepper plants that is related with the alteration of R/FR ratio. Alterations of R/FR ratio has been recommended to increase photo-assimilate accumulation in and translocation out, of the photosynthetic leaves (Kasperbauer 1988, 1992 and 2000), Kasperbauer and Hunt (1998) and Runkle and Heins (2001).

REFERENCES

A.O.A.C. (1990): Official Methods of Analysis. 15th ed., Association of Official Analytical Chemists, Inc., USA.

Adams, S. (1997): Colored mulch starves nematodes. Agr. Res. Was., 45: 10-18.

Alba, R.; Cordonnier-Pratt, M. and Pratt, L.H. (2000): Fruit-localized phytochromes regulate lycopene accumulation independently of ethylene production in tomato. Plant Physiol., 123: 363-370.

Bhella H.S. (1988): Tomato response to trickle irrigation and black polyethylene mulch. J. Amer. Soc. Hort. Sci., 113: 543-546.

Bradburne, J.A.; Kasperbauer, M.J. and Mathis, J.N. (1989): Reflected far-red light effects on chlorophyll and light- harvesting chlorophyll protein (LHC-II) contents under field conditions. Plant Physiol., 91:800-803.

Briggs, W.R. and Olney, M.A. (2001): Photoreceptors in plant photomorphogenesis to date. Five phytochromes, two crypto-chromes, one phototropin and one superchrome. Plant Physiol., 125: 85-88.

Bruggink, G.T. and Heuvelink, E. (1987): Influence of light on the growth of young tomato, cucumber and sweet pepper plants in the greenhouse: Effects on relative growth rate, net assimilation rate and leaf area ratio. Scientia Hort., 31: 161-174.

Casal, J.J.; Sanchez, R.A. and Deregibus, V.A. (1986): Effects of plant density on tillering: The involvement of the R/FR and the proportion of radiation intercepted per plant. Exp. Environ. Bot., 26: 365-371.

Chakraborty, R.C. and Sadhu, M.K. (1994): Effect of mulch type and colour on growth and yield of tomato *(Lycopersicon esculentum)*. Indian J. Agric. Sci., 64 (9): 608-612.

Coffey, D.I.; Buschermohle, M.J.; Wills, J.B.; Burns, R.T.; Yoder, R.E.; Honea, G.S. and Summerlin, J.R. (1999): Soil temperature and moisture conditions and performance of tomatoes grown on colored plastic mulches. Natl. Agr. Plastic Conger. Proc., 28: 54.

Cook, W.P.; griffin, R.P. and Drye, C.E. (1982): Commercial pepper, tomato and eggplant production. Clemson Univ. Coop. Ext. Serv. Hort. Lflt. 35.

Csizinszky, A.A.; Schuster, D.J. and Kring, J.B. (1995): Color mulches influence yield and insect pest populations in tomatoes. J. Amer. Soc. Hort. Sci., 120 (5): 778-784.

Decoteau, D.R.; Daniels, D.D.; Kasperbauer, M.J. and Hunt, P.G. (1986): Colored plastic mulches and tomato morphogenesis. Proc. Natl. Agr. Plastic Congr., 19: 240-248.

Decoteau, D.R.; Kasperbauer, M.J. and Hunt, P.G. (1989): Mulch surface color affects yield of fresh-market tomatoes. J. Amer. Soc. Hort. Sci., 114 (2): 216-219.

Decoteau, D.R.; Kasperbauer, M.J. and Hunt, P.G. (1990): Bell pepper plant development over mulches if diverse colors. Hort. Sci., 25 (4) : 460-462.

Decoteau, D.R.; Kasperbauer, M.J.; Daniels, D.D. and Hunt, P.G. (1988): Plastic mulch color effects on reflected light and tomato plant growth. Scienta Hort., 34: 169-175.

Derieux, M.; Kerrest, R.and Montalanty, Y.(1973): Etude de la sulface foliaive et de lactivite photosynthetique chez kulkues hybrids de mais.Ann. Amelior Plants, 23:95-107.

Dubois, M.; Gilles, K.A.; Hamilton, J.K.; Rebens, P.A. and Smith, F. (1956): Colorimetric method for determination sugars and related substances. Anal. Chem. Soc., 46:1662-1669.

El-Desouky, S. A.; Abd El-Dayem, H.M.; Wanas,, A.L. and Mady, M.A. (2005b): Studies on photomorphogenesis in some economical plants. II- Endogenous phytohormones and leaf anatomy in tomato and sweet pepper plants as affected by red and far-red light reflected from colored plastic mulches. Ann. Agric. of Moshtohor 43(4): 1497-1519.

Fortnum, B.A.; Decoteau, D.R. and Kasperbaner, M.J. (1997): Colored mulches affect yield of fresh-market tomato infected with *Meloidogyne incognita*. Journal of Nematology, 29 (4): 538-546.

Greer, L. and Dole, J.M. (2003): Aluminum foil, aluminum-painted, plastic and degradable mulches increase yields and decrease insect-vectored viral diseases of vegetables. Hort. Technol., 13 (2): 276-284.

Hall, D.O.; Scurlock, J. M.O.; Bolhar-Nordenkampl, H.R.; Leegood, R.C. and Long S.P. (1993): Photosynthesis and production in a changing Environment. A field and laboratory manual. 3-Growth analysis. London. Glasgow New York. Tokyo. Melbourne. Madras., pp. 39.

Hesketh, J. and Baker, D. (1967): Light and carbon assimilation by plant communities. Crop Sci., 7: 285-325.

Horneck, D.A. and Hanson, D. (1998): Determination of potassium and sodium by Flare-Emission Spectrophotometry. In Handbook of Reference Methods for Plant Analysis. pp. 153-155.

Horneck, D.A. and Miller, R.O. (1998): Determination of total nitrogen in plant tissue. In Handbook of Reference Methods for Plant Analysis.pp. 75-83.

Inskeep, W.P. and Bloom, P.R. (1985): Extraction coefficients of chlorophyll a and b in NN- dimethylformade and 80% acetone. Plant physiol., 77:483-485.

Kasperbauer, M.J. (1988): Phytochrome involvement in regulation of the photosynthetic apparatus and plant adaptation. Plant Physiol. Biochem., 26 (4): 519-524.

Kasperbauer, M.J. (1992): Phytochrome regulation of morphogenesis in green plants: From the Beltsville spectrograph to colored mulch in the field. Photochem. Photobiol., 56: 823-832.

Kasperbauer, M.J. (2000): Strawberry yield over red versus black plastic mulch. Crop Sci., 40: 171-174.

Kasperbauer, M.J. and Hunt, P.G. (1998): Far-red light affects photosynthate allocation and yield of tomato over red mulch. Crop Sci., 38: 970-974.

Kasperbauer, M.J. and Karlen, D.L. (1994): Plant spacing and reflected far-red light effects on phytochrome- regulated photosynthate allocation in corn seedlings. Crop Sci., 34:1564-1569.

Kasperbauer, M.J.; Borthwick, H.A. and Hendricks, S.B. (1964): Reversion of phytochrome 730 (Pfr) to P660 (Pr) in *Chenopodium rubrum* L. Bot. Gaz., 125: 75-90.

Lamont, W.J. (1993): Plastic mulches for the production of vegetable crops. Hort Technol., 3: 35-39.

Oguchi, R.; Hikosaka, K. and Hirose, T. (2003): Does the photosynthetic light-acclimation need change in leaf anatomy. Plant Cell Environ., 26: 505-512.

Oyaert, E.; Volckaert, E. and Debergh, P.C. (1999): Growth of chrysanthemum under coloured plastic films with different light qualities and quantities. Scientia Hort., 79: 195-205.

Radford, P.J. (1967): Growth analysis formulae - their use and abuse. Crop Sci., 7:171-176.

Runkle, E.S. and Heins, R.D. (2001): Specific functions of red, far-red and blue light in flowering and stem extension of long-day plants. J. Amer. Soc. Hort. Sci., 126 (3): 275-282.

Sandell, R. (1950): Colorimetric determination of traces of metal. 2nd ed. Interscience pub., Inc. New York.

Shinomura, T.; Uchida, K. and Furuya, M. (2000): Elementary processes of photoperception by phytochrome A for high- irradiance response of hypocotyls elongation in Arabidopsis. Plant Physiol., 122: 147-156.

Snedecor, G.W. and Cochran, W.G. (1980): Statistical methods. 7th ed. Iowa state Univ. Press. Ames Iowa, USA.

Sweeney, D.W.; Graetz, D.A.; Botteher, A.B.; Locascio, S.J. and Campbell, K.L. (1987): Tomato yield and nitrogen recovery as influenced by irrigation methods, nitrogen source and mulch. Hort. Sci., 22: 27-29.

Taber, H.; Lawson, V. and Smith, B. (1999): Colored plastic mulches affect early tomato yield. Natl. Agr. Plastics Congr. Proc, 28: 61.

Terashima, I. and Hikosaka, K. (1995): Comparative ecophysiology of leaf and canopy photosynthesis. Plant Cell Environ., 18: 1111-1128.

Thomas, B. and Vince-Prue, D. (1997): Photoperiodism in plants. 2nd ed., Academic Press, London.

Thomas, W. and Dutcher, R.A. (1924): The colorimetric determination of carbohydrates methods. J. Amer. Chem. Soc, 46: 1662-1669.

Tucker, D.J. (1975): Far-red light as a suppressor of side shoot growth in tomato. Plant Sci. Lett., 5: 127-130.

Von-Arnim, A.V. and Deng, X.W. (1996): Light control of seedling development. Ann. Rev. Plant Physiol. Plant Mol. Biol., 47: 215-243.

Wang, S.Y.; Galletta, G.J.; Camp, M.J. and Kasperbauer, M.J. (1998): Mulch types affect fruit quality and composition of two strawberry genotypes. Hort. Sci., 33 (4): 636-640.

Waterer, D.R. (2000): Effect of soil mulches and herbicides on production economics of warm season vegetable crops in a cool climate. Hort. Technol., 10: 154-159.

دراسات على التشكل الضوئى الظاهرى فى بعض النباتات الاقتصادية
١- النمو الخضرى لنباتات الطماطم والفلفل الحلو تحت تأثير الضوء الاحمر والاحمر البعيد المنعكس من الأغطية البلاستيكية الملونة .

سعيد على الدسوقى ، حسنى محمد عبد الدايم ، أحمد لطفى ونس ، محمد أحمد ماضى
قسم النبات الزراعى – كلية الزراعة بمشتهر – جامعة بنها– مصر

أوضحت هذه الدراسة أن اللون الاحمر لأغطية التربة البلاستيكية سواء عند استخدامه بمفرده أو فوق الأغطية السوداء يعكس كمية اكبر من الضوء الاحمر والاحمر البعيد مقارنة بالالوان الأخرى المستخدمة من الأغطية البلاستيكية أو التربة غير المغطاة. ولذلك تم دراسة تأثير هذا الانعكاس على نمو نباتات كل من الطماطم صنف سوبر سترين بى والفلفل الحلو صنف بلدى خلال موسمي ٢٠٠١ ، ٢٠٠٢. حيث حدثت زيادة معنوية فى العديد من قياسات النمو مثل طول وقطر الساق ، عدد الأوراق والأفرع المتكونة/نبات ، الأوزان الطازجة والجافة لكل من الساق والأوراق، مساحة الأوراق الكلية/نبات وكذلك الوزن النوعى للأوراق وذلك مع كل الألوان المستخدمة من الأغطية البلاستيكية بعد ٤٥ و ٦٠ يوم من الشتل خلال موسمى الدراسة. علاوة على ذلك ، كانت الأغطية البلاستيكية الحمراء تليها الأغطية الحمراء فوق السوداء هى الأكثر تأثيراً فى هذا الشأن مقارنة بالألوان الأخرى من الأغطية البلاستيكية. كذلك أدت هاتين المعاملتين إلى زيادة عدد الأفرع/نبات إلى أكثر من ضعف قيمتها فى معاملة المقارنة بالنسبة للطماطم وأكثر من ٣ أو ٤ مرات قدر قيمتها فى نباتات المقارنة للفلفل الحلو خاصة بعد ٦٠ يوم من الشتل . علاوة على ذلك فان الأغطية البلاستيكية الحمراء و الحمراء فوق السوداء أدت إلى زيادة معدل النمو المطلق للمجموع الخضري فى كل من الطماطم و الفلفل ليصل إلى أكثر من ٣ مرات قدر قيمته فى نباتات المقارنة خاصة فى موسم ٢٠٠٢.

بالإضافة إلى ذلك ، زاد تركيز بعض العناصر المعدنية مثل النيتروجين ، الفوسفور والبوتاسيوم ، وكذلك البروتين الخام فى أوراق كل من الطماطم والفلفل بعد ٤٥ و ٦٠ يوم من الشتل مع كل الألوان المستخدمة من الأغطية البلاستيكية مقارنة بنباتات الكنترول.

علاوة على ذلك ، فإن الألوان المختلفة من الأغطية البلاستيكية أدت إلى زيادة تركيز صبغات التمثيل الضوئى والسكريات الذائبة الكلية وايضا

الكربوهيدرات الكلية فى أوراق كل من الطماطم والفلفل الحلو مع تفوق الأغطية الحمراء فوق السوداء فى هذا الشأن.

وبناءً على ما تقدم يمكن التوصية باستخدام اللون الاحمر من الأغطية البلاستيكية للتربة لزيادة كمية الضوء الأحمر والأحمر البعيد المنعكسة على النباتات المنزرعة ومن ثم زيادة الكمية الممتصة منهما بواسطة النبات وهذا من شانه أن يؤثر ايجابيا على كل العمليات الفسيولوجية التى تتم داخل النبات.