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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.

BY

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ABSTRACT

After 60 days from transplanting in 2002 season, design samples and specimens were taken from tomato (cv. Super Strain B) and sweet pepper (cv. Baladi) plants to investigate the endogenous phytohormones level in their shoots and the anatomical features of their leaves as affected by their growth above different applied mulch surface colors (i.e. red, red over black, blue, black mulches) as well as bare soil (unmulched) as control. A reduction in total level of endogenous growth promoters (gibberellins + auxins + cytokinins) in tomato and sweet pepper shoots was occurred with most applied mulch surface colors. This reduction, in case of tomato, was mainly due to reduction in levels of both endogenous gibberellins and auxins, but in sweet pepper, it was only due to a reduction in endogenous auxin level. Meanwhile, endogenous cytokinins level was increased in tomato and sweet pepper shoots with all used colors of plastic mulch. The red over black mulch treatment was more effective in this concern.

Besides, the reduction in total level of growth promoters was accompanied with more obvious reduction in the endogenous level of the growth inhibitor abscisic acid that, in turn, led to an increase of growth promoters: growth inhibitor ratio. Hence, the obtained vigorous growth of both tomato and sweet pepper plants was mainly attributed to this obvious decrease in the endogenous level of the growth inhibitor. In addition, auxin: cytokinins ratio was decreased with all applied mulch colors in both tomato and pepper shoots.

On the other hand, increases were existed in many anatomical features of tomato and sweet pepper leaves as thickness of lamina, mesophyll tissue, xylem and phloem tissues, dimensions of vascular bundle, and number of xylem vessels / bundle with all applied mulch colors. Also, red mulch applied alone or over black was more pronounced in this respect.

Furthermore, the most important effects of mulch color treatments were those upon stem anatomy above and below the first fruiting node of sweet pepper. Since, obvious increase in stem diameter and thickness of both conductive tissues

(phloem and xylem) was obtained with all applied mulch colors, especially with the red mulch applied alone or over black mulch. Besides, the alterations in endogenous phytohormones level and ratios which could be in favor of increasing number of formed branches and floral primordia as well as increasing of sink organs (fruits) ability to accumulate and storage more assimilates.

INTRODUCTION

Plants use light as a source of information about their environments as well as a source of energy for photosynthesis. Plants sense both the quantity (fluence) and quality (wavelength) of light and respond in many ways, ranging from germination and de-etiolation of seedlings to flowering. But, for most of the physiological responses and various other aspects of plant photomorphogenesis, phytochrome has been implicated to transmit the message of light and remains the most investigated photoreceptor system (Terzaghi and Cashmore, 1995; Grover *et al.*, 1999 and Kevei and Nagy, 2003).

The photon ratio of FR relative to R sets the photoequilibrum between the R-absorbing and FR absorbing forms of phytochrome (Rajapakse *et al.*, 1999 and Kubota *et al.*, 2000), which function as a regulator of photosynthate allocation and adaptive plant development including alteration each of hormonal profile and anatomical print (Britz and Sager, 1990; Smith, 1992; Aphalo and Ballare, 1995 and Ballare *et al.*, 1995). 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; Marler *et al.*, 1994; 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 and flowering. Also, blue light (B, 400 to 500 nm) independently inhibits extension growth (Runkle and Heins, 2001).

Furthermore, the relationship between endogenous hormones and light in the regulation of plant growth is complex. For example, cytokinins have many effects upon different processes involved in photomorphogensis. Here, Hammerton *et al.* (1998) stated that plants grown at the highest irradiance had in their stems, leaves, petioles and roots significantly higher levels of cytokinins than plants grown at the lowest irradiance.

In general, since there is no report in Egypt on the effect of various color 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 research of this study aimed to quantify and evaluate the effect of the created specific microenvironment by using color mulches on the endogenous levels of auxins, gibberellins, cytokinins and abscisic acid as well as their effect upon the internal structure of tomato and sweet pepper leaves.

In addition, pioneer findings were obtained regarding each of plenty of formed branches and fruits on the same node; histologically was declared.

MATERIALS AND METHODS

During 2001 and 2002 seasons, two field experiments were carried out at the experimental Farm Station, Faculty of Agriculture at Moshtohor, Benha University, Egypt. Seeds of tomato (*Lycopersicon esculentum*, Mill., cv. Super Strain B) and sweet pepper (*Capsicum annuum*, L., cv. Baladi) were secured from Vegetable Research Department, Agricultural Research Center, Ministry of Agriculture, Giza. The mulch treatments (black, red , red over black and blue polyethylene mulch colors) and bare soil (as control) were arranged in a randomized complete – block design with three blocks (replicates). The trickle irrigation system was used before covering the soil surface with the applied mulches. (El- Desouky *et al.*, 2005a). Five-week-old seedlings of both tomato and sweet pepper were transplanted to the experimental plots at 20th and 15th of February for 2001 and 2002 seasons, respectively.

According to the wide differences in the morphological characters due to treatments in the first season studied before (El-Desouky *et al.*, 2005 a); endogenous phytohormones levels in the shoots and anatomical features in the leaves of both tomato and sweet pepper were studied only during the second season.

1- Endogenous phytohormones:

Endogenous phytohormones were determined quantitatively in tomato and sweet pepper shoots at 60 days after transplanting during 2002 season. The method of Koshioka *et al.* (1983) was used for the HPLC "High-performance liquid chromatography" determination of auxin (IAA), gibberellic acid (GA3) and abscisic acid (ABA). Cytokinins were determined by the UPLC according to Nicander *et al.* (1993).

Extraction procedure:

For hormonal extraction, 10 g of the shoot fresh weight were cut to small pieces and macerated, extracted twice with 96% methanol then twice with 40% methanol, each for 24 hours (Shindy and Smith, 1975). The methanolic extract was filtered and evaporated in a rotary evaporator at 40°C to an aqueous solution. The solution was adjusted to pH 8.6 and extracted 4 times with 100 ml ethyl acetate. The alkaline ethyl acetate solution were mixed together and purified with anhydrous sodium sulphate (one tea spoon / 100 ml). The ethyl acetate fraction was filtered and evaporated to dryness, the residue dissolved in 4 ml absolute methanol. This extraction was used for the determination of cytokinin, according to Nicander *et al.* (1993).

The aqueous solution was acidified to pH 2.6-2.8 and extracted as described above, this extraction was used for the determination of gibberellic acid (GA_3), indole-3-acetic acid (IAA) and abscisic acid (ABA) by HPLC according to the method described by (Koshioka *et al.*, 1983).

The identification of phytohormones was accomplished by comparing the peaks retention times with the retention times of authentic substances. The quantity of individual plant hormones was determined by comparing the peak area produced by a known weight of the plant material with the standard curves of the authentic substances which expressed the relation between the different concentrations and their peak areas.

All results for endogenous phytohormones were calculated as µg/g fresh weight.

II- Anatomical studies:

Regarding the internal structure of mulched and unmulched tomato and sweet pepper plants, a comparative studies on leaves of treated plants compared with those of the control were microscopically examined.

For tomato, specimens of leaves (1cm^2) were taken from plants aged 60 days after transplanting from the terminal leaflet of the 3rd leaf below the apical bud. Similarly, specimens of sweet pepper leaves (1 cm^2) were taken from plants aged 60 days after transplanting from the middle of certain leaf lays directly below the first formed fruit. In addition, specimens were taken from the main stems directly ½ cm below the first node that assigned with the formation of the first fruit as well as from branches formed above the mentioned node at ½ cm above this node.

These vegetative specimens were then killed and fixed for at least 48 hours in FAA (10 ml formalin: 5ml glacial acetic acid: 85 ml ethyl alcohol 70%), washed in 50% ethyl alcohol, dehydrated in a series of ethyl alcohols 70, 90, 95 and 100% infiltrated in xylene, embedded in paraffin wax with a melting point 60-63°C Sass, (1950), sectioned at 20 µ using a rotary microtome, double stained with fast green and safranin (Johanson, 1940), cleared in xylene and mounted in Canada blsam. The prepared sections were microscopically examined. Counts and measurements (µ) were taken using a micrometer eye piece. Averages of readings from 4 slids / treatment were calculated.

RESULTS AND DISCUSSION

I- Endogenous phytohormones:

Effect of mulch colors on phytohormones profile in tomato and sweet pepper. shoots at 60 days after transplanting:

Data in Table (1) clearly indicate that different used mulch colors decreased the level of endogenous gibberellins (GAs) in tomato shoots at 60 days after transplanting. Exception was only that obvious increase (644.08 µg/g f. w.) recorded with red + black treatment. Similarly, a reduction in gibberellins level ranged -35.35, -36.20 and -47.02% of the control value for black, red and blue mulch treatments, respectively.

Table (1): Effect of polyethylene mulch surface color on endogenous phytohormones of tomato (*Lycopersicon esculentum*, Mill.) and sweet pepper (*Capsicum annuum*, L.) shoots at 60 days after transplanting during 2002 season.

Character / Treatment	Promoters								Inhibitors	
	Gibberellins (GA_3)		Auxins (IAA)		Cytokinins		Total		Abscisic acid (ABA)	
	µg/g fresh weight	% relative to the control	µg/g fresh weight	% relative to the control	µg/g fresh weight	% relative to the control	µg/g fresh weight	% relative to the control	µg/g fresh weight	% relative to the control
Tomato										
Control	295.113	100.00	8.590	100.00	4.888	100.00	308.59	100.00	1.604	100.00
Black	190.781	64.65	2.548	29.66	4.810	84.08	197.44	58.15	0.337	21.01
Red	188.293	63.80	3.178	37.00	10.725	219.42	202.20	65.52	0.775	48.32
Red + Black	644.080	218.25	27.726	322.77	12.987	265.69	684.79	211.91	0.121	7.54
Blue	156.362	52.98	7.831	91.16	5.931	121.34	170.12	55.13	0.128	7.98
Sweet pepper										
Control	21.249	100.00	434.779	100.00	12.169	100.00	457.20	100.00	1.715	100.00
Black	109.173	513.78	74.661	17.17	170.883	1404.25	354.72	77.59	0.334	19.48
Red	80.717	379.91	42.530	9.78	187.638	1541.93	310.90	68.00	0.658	38.37
Red + Black	122.419	576.12	149.418	34.37	201.451	1566.44	473.29	103.52	0.042	2.45
Blue	16.927	79.66	143.617	33.03	185.883	1527.51	346.43	75.77	0.575	33.53

It is obvious that black, red and red + black mulches increased endogenous gibberellins level in sweet pepper shoots by 413.78, 279.91 and 476.12% more than the control, respectively.

The level of auxins (IAA), in tomato shoots behaved as the same as gibberellins, since only the treatment of red + black increased its level, yet its decrease existed with the rest of treatments. Also, it could be noticed that the highest reduction in auxin level that reached to 70.34% less than the control existed with the black color. However, a reduction in the endogenous auxins in sweet pepper was resulted in case of various colors of used mulches. The highest reduction (90.22% less than the control) reached by the red mulch.

Data in Table (1) also clearly show that red, red + black and blue colors increased cytokinins level in tomato shoots and red + black one was more pronounced in this respect. Meanwhile, black mulch decreased this level by 15.92%, less than the control value.

In sweet pepper, cytokinins was dominantly increased with various color mulches and reached to its maximum (1555.4%, more than the control) with the red + black treatment. That means that cytokinins level in shoots of sweet pepper grown over red + black mulch increased with more than fivteen times of the control value and with red mulch by more than fourteen times.

In general, total phytohormones those promote growth aspects, i.e. growth promoters (auxins, gibberellins and cytokinins) only increased in case of red + black treatment by 111.91 and 3.52% more than the control values in both tomato and sweet pepper, respectively.

On the other hand, in tomato shoots, the growth inhibitor; abscisic acid was decreased with various colors of the applied mulches. Reduction values of abscisic acid were 78.99, 51.68, 92.46 and 92.02% less than the control value with black, red, red + black and blue mulches, respectively. Also, despite that reduction in the total of growth promoters, but reduction in the growth inhibitor abscisic acid was more obvious. So, improvement in different growth aspects of tomato plant under color mulches could be mainly attributed to that reduction in the level of the growth inhibitor; abscisic acid or even to those alteration of hormone profile under the color mulch treatment.

In sweet pepper, the level of abscisic acid was decreased with various colors of used mulches. The highest reduction 97.55% less than the control value existed with red + black treatment. Here, reduction of abscisic acid could also related with the positive characteristics of yielded fruits.

As shown in Table (2) cytokinins fractions (i.e. zeatin, kinetin and benzyl adenine) were variously affected with different colors of used mulches. In tomato, zeatin only was increased with red and red + black mulch colors), while kinetin was increased with black, red and red + black mulches, yet, benzyl adenine was increased with each of red, red + black and blue mulches.

Table (2): Effect of polyethylene mulch surface color on endogenous cytokinins (i.e. cytokinin fractions) in tomato (*Lycopersicon esculentum*, Mill.) and sweet pepper shoots (*Capsicum annuum*, L.) during 2002 season.

Character / Treatment	Zeatin		Kinetin		Benzyladenine		Total cytokinin	
	µg/g fresh weight	% relative to the control	µg/g fresh weight	% relative to the control	µg/g fresh weight	% relative to the control	µg/g fresh weight	% relative to the control
Tomato								
Control	0.67118	100.00	0.27255	100.00	3.944	100.00	4.888	100.00
Black	0.56911	84.79	0.80753	296.29	2.733	69.30	4.110	84.08
Red	1.52013	226.50	1.35512	497.24	8.120	205.88	10.725	219.42
Red + Black	1.28162	190.95	1.44963	531.88	10.256	260.04	12.987	265.69
Blue	0.57603	85.82	0.22980	84.31	5.125	129.94	5.931	121.34
Sweet pepper								
Control	0.26968	100.00	0.64032	100.00	11.359	100.00	12.169	100.00
Black	0.65005	241.04	1.61511	252.23	168.618	1497.29	170.883	1404.25
Red	0.69617	258.15	1.00930	170.70	185.932	1651.41	187.638	1541.93
Red + Black	0.84645	313.87	1.71320	267.52	199.738	1774.03	201.451	1729.40
Blue	0.75673	213.86	1.29360	202.02	184.031	1634.52	185.883	1527.52

In sweet pepper, an increase of different estimated cytokinin fractions i.e. zeatin, kinetin and benzyl adenine was dominantly existed with various colors of used mulches. Red + black mulch was more effective in this respect.

These results being of great interest because the activity of these fractions are greatly varied upon different characteristics of vegetative and reproductive growth of tomato and pepper plants. Also, a certain level of any of these fractions accompanied with any of these alterations existed in either other promoters (IAA & GA_3) or even the common inhibitor (abscisic acid) could be reversed upon growth or reproductive traits into stimulation or inhibition of some or all of them.

Data in Table (3) indicated that the proportions of total promoters to the inhibitor abscisic acid was increased with various used color mulches, meanwhile the proportion of auxin to cytokinins was dominantly decreased, yet auxin + cytokinins / gibberellin was only decreased with black mulch but increased with the rest of used colors.

These data has a great influence upon different vegetative and reproductive characteristics of tomato and sweet pepper plants. For example, increasing cytokinins level on the account of auxin might be in favor of increasing the number of formed branches and increasing transverse growth on the account of longitudinal one as well as increasing of sink organs (fruits) ability to accumulate and storage more assimilates.

Light and phytohormones control many aspects of plant development. Depending on the species considered and the experimental conditions, all kinds of interactions (additive, synergistic and antagonistic) have been observed. For example, the expression of many plastidic genes is induced by both light and cytokinins (Bracale *et al.*, 1988 and Cohen *et al.*, 1988); cell elongation is induced by auxins and gibberellins, meanwhile ABA and light have antagonistic effects on chlorophyll a, b binding protein gene transcription (Weatherwax *et al.*, 1996). Moreover, Bellamine *et al.* (1993) reported that increase in auxin (IAA) sensitivity during photoperiodic induction of flowering could be related to the IAA requirement in floral induction. Also, Kraepiel and Miginiac (1997) and Shinkle *et al.* (1998) suggested that IAA is involved in the light regulation of plant development. In addition, light may regulate both the content and /or the sensitivity to active gibberellins GAs (Hedden and Kamiya, 1997 and Kamiya and Garcia-Martinez, 1999) to control of stem elongation. However, consistitutes a photomorphogenic process different to that induced by phytochrome-mediated R/FR or end of day FR treatments also the photoreceptors involved and very likely the molecular mechanisms of control of stem elongation (Gawronska *et al.*, 1995 and Weller *et al.*, 1995). Furthermore, Martinez-Garcia *et al.* (2000) concluded that the modulation of epicotyl elongation in light-grown cowpea induced by light quality (R: FR) is mainly the result of phytochrome control of GA1 content.

Hammerton *et al.* (1998) showed that the levels of cytokinin nucleotides in young bean plants are about three-fold greater in plants grown at a high irradiance than in those grown at a low irradiance. This increase in cytokinin levels is associated with the increase, in general, in plant biomass, presumably its

photosynthetic potential and may be interpreted with regard to such factors as assimilate partitioning, as well as cytokinin transport and turnover.

II- Anatomical study:

II.1. Effect of mulch colors on tomato and sweet pepper leaves anatomy:

II.1.1.Leaf blade anatomy:

As for blade thickness in tomato leaf, it was increased with various mulch colors used (Table, 4 and Fig., 1). Increases reached its maximum, i.e. 337.50 micron with red + black treatment. That represent 164.47% of the control treatment. In other meaning, red + black treatment gave 64.47% increase of blade thickness more than control one. Also, values of increase more than control one were 46.93, 38.60 and 36.40% with red, black and blue mulches, respectively. In sweet pepper, blade thickness was only decreased with the black mulch, whereas, other colors i.e. red and blue increased it (Table, 4 and Fig., 1). Here, it could be mentioned that, blue mulch gave the highest thickness of sweet pepper leaf blade followed by red and lowest increase existed with the red + black mulch, whereas it completely reversed in tomato plants. From the other hand, the only case of reduction was that of black mulch with value of 5.87% less than the control, yet values of increase were 40.05, 23.72 and 7.65 more than the control with blue, red and red + black, respectively.

With regard to the thickness of each of upper and lower epidermis in tomato leaf blade, were also increased with different mulch colors. Red + black treatment showed highest value followed by red, blue and black mulches in descending order. The exception was only that reduction in lower epidermis thickness existed with black treatment. Also, it could be noticed that increases in upper epidermis was higher than that of the lower one.

On the other hand, in sweet pepper leaf, upper epidermis was decreased, whereas lower one was increased. That was true with all used of color mulches. Also, the highest increase (18%) in the lower or decrease (21.60%) in the upper epidermis were obtained with the blue mulch and the red one, respectively.

As regards mesophyll tissue in tomato leaf blade, its thickness was increased with all mulch colors used. Here, mesophyll thickness was 168.30 micron but increased to reach 286.20, 25420, 240.30 and 236.70 micron with red + black, red, black and blue mulches, respectively. So, increases more than control were 70.05, 51.34, 42.78 and 40.64 in the same order.

It is interesting to note that mesophyll tissue increase belongs to that increase of each of palisade and spongy tissue thickness (Table, 4). Since, the two components were increased with color mulch treatments but reached their maximum as other traits with red + black treatment.

For pepper leaf blade, it could be noticed that its thickness only decreased with black mulch, yet it was increased with the rest of used colors and reached its maximum with the blue one (+44.96% more than the control value). In addition, the increase of mesophyll tissue belongs to increase of each of palisade and spongy tissues. That was true for all used colors except for the blue

one. That is because spongy tissue was decreased so, increase of mesophyll came from only that obvious increase (202.50%) of palisade tissue.

Generally, in tomato, of great interest to note that red + black (followed by red alone) treatment gave the highest thickness of palisade and spongy tissues. Meanwhile, when obtained data related to the mesophyll values; blue mulch being the more effective one for increasing spongy tissue as it gave + 55.13% but was the less effective one for increasing palisade tissue as gave + 44.87%. In this respect, red mulch gave the highest value of palisade tissue and the lowest value of spongy one when data related to the mesophyll values. Thereby, red color gave obvious increase of chloroplasts riched-palisade tissue.

While, in sweet pepper, results could be interpreted on the basis that pepper plants were cultivated earlier in which day length still shorter than the normal ones, So, grown pepper plants exhibited to some extend some anatoimical modification to be received more light including reduction in the thickness of upper epidermis (meanwhile lower was increased) and increase of palisade tissue (meanwhile, spongy was decreased). These anatomical alterations enabled leaves to receive rapidly and with efficiency more light.

In general, different existed variations in blade anatomy (especially, obvious increase of mesophyll thickness) could be a result of increasing the endogenous cytokinins level under mulch treatment. Since, cytokinins known to increase extension growth of different plant organs (Cohen *et al.*, 1988 and Jang *et al.*, 1997).

II. 1.2. Medvein anatomy:

As for the midrib of tomato and pepper leaves, Table (5) and Fig. (2&3) showed that its thickness was increased with various applied colors, but in tomato reached its maximum with the red mulch alone or even when used above the black one followed by black and the blue ones. So, red mulch alone gave 151.96% when related to the control, with 51.96% of increase. Meanwhile, for pepper, its thickness was increased with various mulch colors. Increases value were +3.47, +17.41, +27.67 and +32.59% with black, red, red + black and blue mulches, respectively. So, the blue mulch gave the highest value of midrib thickness.

With regard to the vascular bundle, in case of tomato, it was noticed that its length and width were increased with all colors of applied mulches. But length showed its maximum with red + black mulch treatment and the same for width with red one. So, red + black gave 47.35% and the red gave 52.8 1 more than control for length and width respectively. Here, also it was noticed that lowest increase in length (+9.52%) existed with black mulch but for width (+4.38%) with the blue one. Except the reduction existed in phloem tissue thickness (-23.73%) with the black mulch, the rest of colors treatments increased the thickness of both phloem and xylem tissues (i.e the two component of vascular bundle. In addition, it was found that red mulch gave the highest value of phloem tissue thickness and the highest diameter of xylem vessel in xylem tissue as well. Meanwhile, the red black mulch gave highest value of xylem tissue thickness and in the number of xylem vessels (Table, 5).

ble (3): Endogenous phytohormones (promoters and inhibitors) proportions in tomato (*Lycopersicon esculentum*, Mill.) and sweet pepper (*Capsicum annuum*, L.) shoots at 60 days after transplanting during 2002 season.

Character / Treatment	Promoters / Inhibitors		Promoters: Inhibitors	IAA/ Cytokinins		IAA: Cytokinins	IAA + Cytokinins / GA$_3$		IAA + Cytokinins: GA$_3$
	µg/g fresh weight	% relative to the control		µg/g fresh weight	% relative to the control		µg/g fresh weight	% relative to the control	
Tomato									
Control	192.39	100.00	192.39:1	1.758	100.00	1.758:1	0.046	100.00	0.046:1
Black	585.88	304.53	585.88:1	0.620	35.27	0.620:1	0.035	76.09	0.035:1
Red	260.90	135.61	260.90:1	0.296	16.84	0.296:	0.074	160.87	0.074:1
Red + Black	5659.42	2941.64	5659.42:1	2.135	+121.44	2.135:1	0.063	136.96	0.063:1
Blue	1329.06	690.82	1329.06:1	1.320	75.09	1.32:1	0.088	191.30	0.088:1
Sweet pepper									
Control	266.59	100.00	266.59:1	35.73	100.00	35.73:1	21.034	100.00	21.034:1
Black	1062.04	398.38	1062.04:1	0.4369	1.22	0.4369:1	2.249	10.69	2.249:1
Red	47249.24	177.24	47249.24:1	0.2267	0.63	0.2267:1	2.851	13.55	2.851:1
Red + Black	11268.81	4227.02	11268.81:1	0.7417	2.08	0.7417:1	2.866	13.63	2.866:1
Blue	602.46	225.99	602.46:1	0.1280	0.36	0.1280:1	19.466	92.55	19.466:1

le (4): Effect of polyethylene mulch surface color on certain anatomical features of tomato (*Lycopersicon esculentum*, Mill.) and sweet pepper (*Capsicum annuum*, L.) leaf blades at 60 days after transplanting during 2002 season.

Characters (µ) / Treatments	Blade		Upper epidermis thickness	Lower epidermis thickness	Palisade tissue		Spongy tissue		Mesophyll tissue	
	Thickness	% relative to the control			Thickness	% relative to the mesophyll tissue	Thickness	% relative to the mesophyll tissue	Thickness	% relative to the control
Tomato										
Control	205.30	100.00	19.80	17.10	83.70	49.73	84.60	50.27	168.30	100.00
Black	284.40	138.60	27.90	16.20	118.80	49.44	121.50	50.56	240.30	142.78
Red	301.50	146.93	28.80	18.00	126.00	49.47	128.70	50.53	254.70	151.34
Red + Black	337.50	164.47	30.60	20.70	138.60	48.43	147.60	51.57	286.20	170.05
Blue	279.90	136.40	23.40	19.80	106.20	44.87	130.50	55.13	236.70	140.64
Sweet pepper										
Control	352.80	100.00	25.20	15.30	134.10	42.94	178.20	57.06	312.30	100.00
Black	332.10	94.13	24.30	16.20	112.50	38.58	179.10	61.42	291.60	93.37
Red	436.50	123.72	21.60	17.10	148.50	37.33	249.30	62.67	397.80	127.38
Red + Black	379.80	107.65	22.50	18.00	139.50	41.11	199.80	58.89	339.30	108.65
Blue	494.10	140.05	23.40	18.00	202.50	44.73	250.20	55.27	452.70	144.96

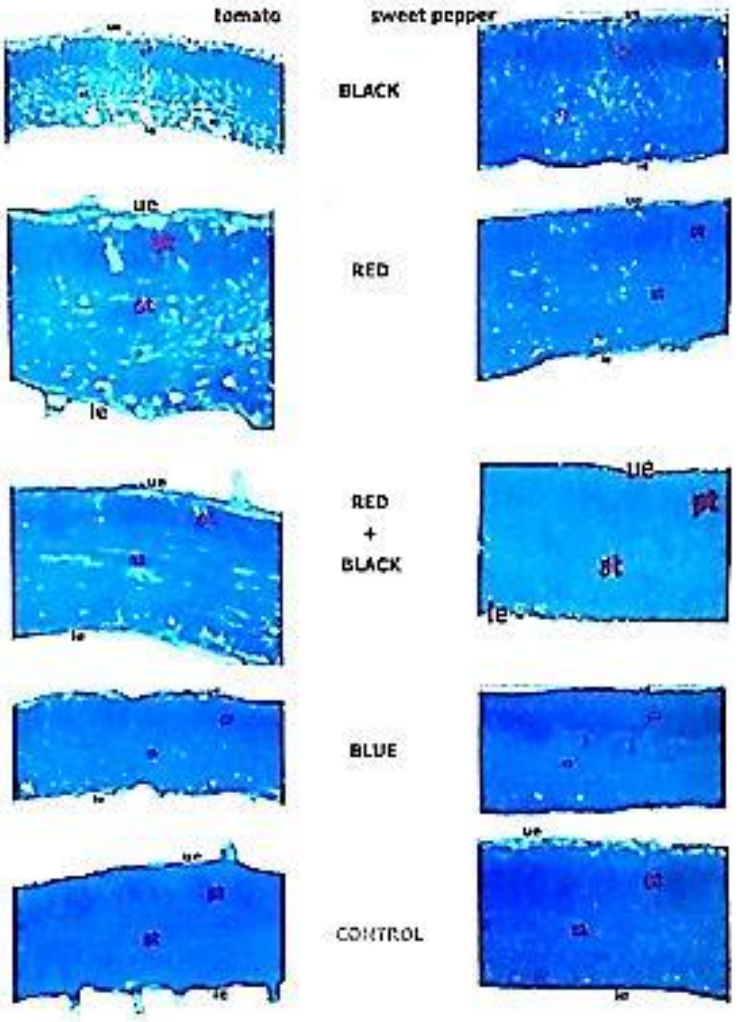

Fig. (1): Effect of mulch colors on certain anatomical features of tomato and sweet pepper leaf blade at 60 days after transplanting during 2002 season (X 100).
Where: ue = Upper epidermis, pt = Palisade tissue, st = Spongy tissue and le = Spongy tissue.

Table (5): Effect of polyethylene mulch surface color on certain anatomical features of tomato (*Lycopersicon esculentum*, Mill.) and sweet pepper (*Capsicum annuum*, L.) leaves midvein at 60 days after transplanting during 2002 season.

Characters (µ) / Treatments	Midrib		Vascular bundle				Phloem tissue thickness/ bundle				Xylem tissue / bundel					
	Thickness	% relative to the control	Length	% relative to the control	Width	% relative to the control	Uppermost phloem tissue	Lowermost phloem tissue	Total phloem tissue	% relative to the control	Thickness	% relative to the control	No. of vessels	% relative to the control	Widest vessel diameter	% relative to the control
Tomato																
Control	1058.40	100.00	340.20	100.00	576.00	100.00	57.60	48.60	106.20	100.00	234.00	100.00	52.00	100.00	27.90	100.00
Black	1319.4	124.66	372.60	109.52	778.50	135.16	50.40	30.60	81.00	76.27	291.60	124.62	56.00	107.69	30.60	109.68
Red	1608.30	151.96	468.00	137.57	880.20	152.81	89.10	78.30	167.40	157.63	300.60	128.46	69.00	132.69	37.80	135.48
Red + Black	1539.00	145.41	501.30	147.35	784.80	136.25	70.20	80.10	150.30	141.53	351.00	150.00	72.00	138.46	33.30	119.35
Blue	1102.50	104.17	381.60	112.17	601.20	104.38	54.90	72.90	127.80	120.34	253.80	108.46	58.00	111.54	29.70	106.45
Sweet pepper																
Control	1215.60	100.00	269.10	100.00	663.30	100.00	53.10	47.70	100.80	100.00	168.30	100.00	54.00	100.00	22.50	100.00
Black	1288.80	103.47	328.50	122.07	766.80	115.60	61.20	54.00	115.20	114.39	123.30	73.26	58.00	107.41	19.80	88.00
Red	1462.50	117.41	384.30	142.81	846.00	127.54	64.80	70.20	135.00	133.93	249.30	184.13	64.00	118.52	24.30	108.00
Red + Black	1590.30	127.67	382.50	142.14	1121.40	169.06	54.90	73.80	128.70	127.68	253.80	150.80	76.00	140.74	25.20	112.00
Blue	1651.50	132.59	375.30	139.46	831.60	131.31	48.60	40.50	89.10	88.39	286.20	170.05	66.00	122.22	26.10	116.00

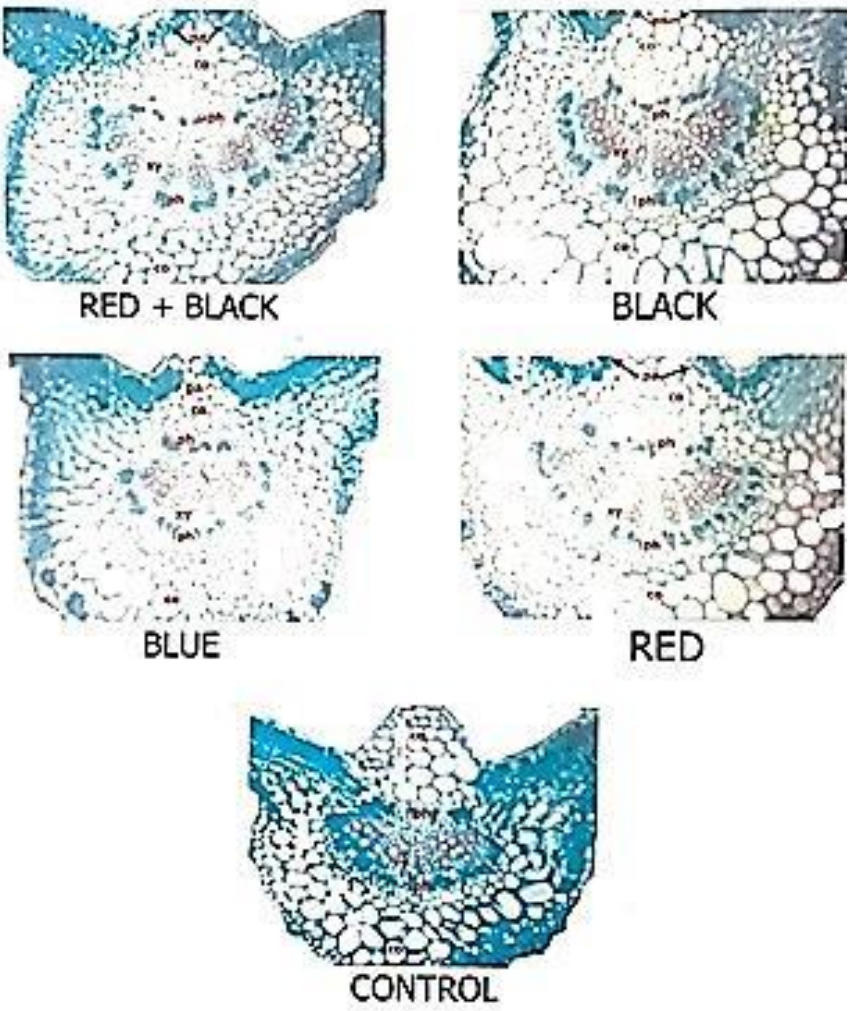

Fig. (2): Transverse sections in tomato leaf; showing the effect of mulch colors on certain anatomical features of midrib at 60 days after transplanting. (X 60)
Where: uph = Uppermost phloem tissue, xy = Xylem tissue and lph = Lowermost phloem tissue.

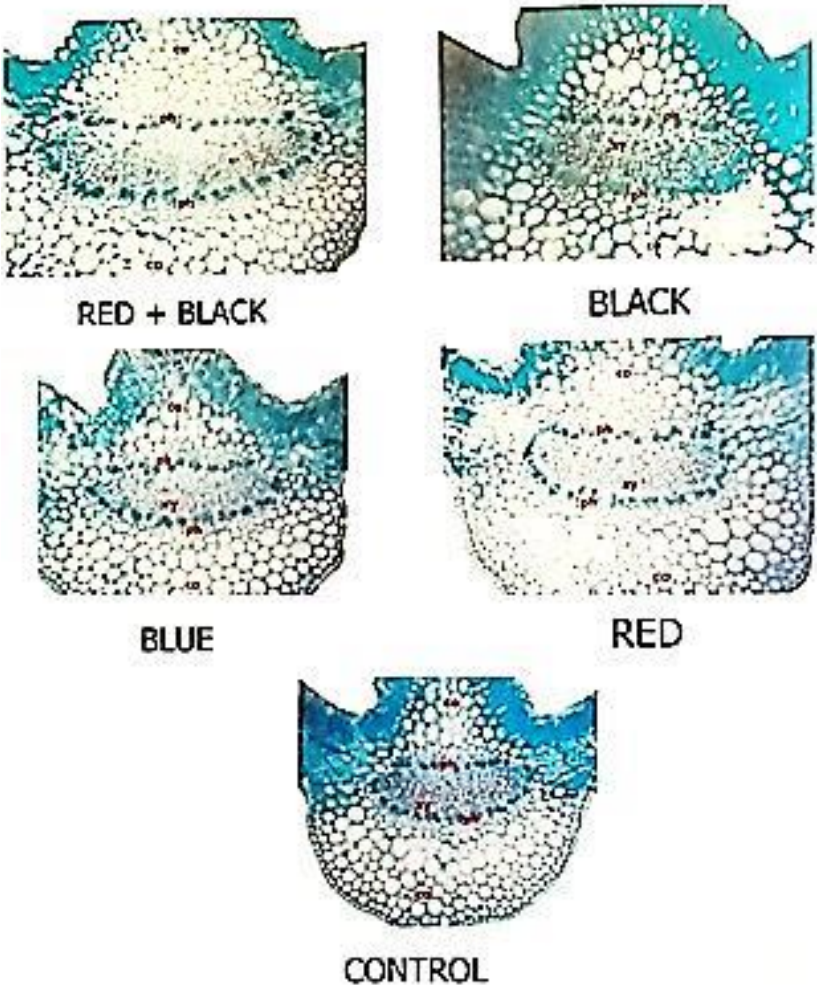

Fig. (3): Transverse sections in sweet pepper leaf midvein; showing the effect of mulch colors on certain anatomical features at 60 days after transplanting. (X60).
Where: uph = Uppermost phloem tissue, xy = Xylem tissue and Lph = Lowermost phloem tissue.

On the other hand, blue mulch gave the lowest value in the thickness of xylem tissue and in diameter of the widest xylem vessel as well. Meanwhile, black mulch gave the lowest increase only in the number of xylem vessels.

Yet, in pepper leaf, length and width of vascular bundle were increased also with various colors but its maximum length existed with the red mulch, yet it was with red + black treatment for the width.

On the other hand, it was noticed that the blue color obviously decreased the phloem tissue thickness with -11.61%, meanwhile its increase was existed with other colors to reach its maximum (+33.93%) with the red one. Also, it was noticed that the *vice versa* was true regarding xylem tissue, since blue color gave its maximum increase that reached +70.05%. But for the number of xylem vessels, its maximum existed with red + black treatment, meanwhile the highest diameter of xylem vessels existed with the blue mulch treatment. At the same time, black color decreased the thickness of xylem tissue, slightly increased number of xylem vessels and it is only the one that decreased diameter of the widest xylem vessel.

The above mentioned results are also of great importance because they could be also involved in the interpretation about why vigorous growth and high yielded fruits were existed with color mulch treatments specially with the red mulch applied alone or over black mulch. This strong suggestion could be interpreted as following: because color mulches specially the red one improved the circular passage for water and crude nutrients (from soil to leaves) across xylem tissue by widening it as well as the passage of photoassimilates (including also various biocanstituents) from leaves to other plant parts through phloem tissues. Thereby, high rates of translocation from soil to leaves and the same from leaves to other plant parts are being facilitated and achieved.

The above mentioned conclusion is of great interest because it clearly answered that arising question "how red mulch alone or above black one exhibited obvious and significant increases of all estimated vegetative and reproductive traits ofgrown tomato and pepper plants as well mentioned in the third part (El- Desouky *et al.*, 2005c).

Pioneer findings for sweet pepper plants:

Table (6) and Fig (4) showed firstly that transverse sections through sweet pepper stems (1/2 cm below and above the first fruiting node) exhibited percentage increase in diameter of the whole section with +44.9& and +29.86% (below the node) and +64.25 & +35.33% (above the node) by red and red + black treatments, respectively. Here, of interest to note that this increase was mainly due to the increases in thickness of the two conductive tissues (i.e. phloem and xylem). That is being directly related with the greatest mass flow of photoassimilates into sink organs (i.e. fruits), secondly the alternation of endogenous phytohormones profile (Tables, 1 & 2). is being in favor of not only more flowering primordial initiation but also increasing of branching capacity to reach its maximum (three branches on the same node (Fig., 5) with red + black treatment.

Table (6): Effect of polyethylene mulch surface color on certain anatomical traits of sweet pepper (*Capsicum annuum*, L.) stem (1/2 cm below and above the first fruiting node) at 75 days after transplanting during 2002 season.

Characters (µ) / Treatments	Epidermis		Cortex		Outermost Phloem tissue		Xylem tissue						Pith		Whole section (stem)	
	Thickness	% relative to the control	Thickness	% relative to the control	Thickness	% relative to the control	Thickness	% relative to the control	No. of vessels row	% relative to the control	Wider vessel diameter	% relative to the control	Diameter	% relative to the control	Diameter	% relative to the control
Below node																
Control	36.90	100.00	572.40	100.00	171.00	100.00	705.60	100.00	5.00	100.00	62.10	100.00	3942.90	100.00	6916.50	100.00
Black	38.70	104.88	750.60	131.13	155.70	91.05	988.20	140.05	10.00	200.00	77.40	124.64	2886.30	73.20	6752.70	106.35
Red	39.60	107.32	595.80	104.09	212.40	124.21	1592.10	225.64	18.00	360.00	79.20	127.54	5148.00	130.56	10027.80	144.98
Red + Black	31.50	85.37	607.50	106.13	215.10	125.79	1268.10	179.72	17.00	340.00	73.80	118.84	4737.60	120.16	8982.00	129.86
Blue	37.80	102.44	550.80	96.23	194.40	113.68	981.90	139.16	14.00	280.00	72.90	117.39	2819.70	71.51	6349.50	91.80
Above node																
Control	24.30	100.00	488.70	100.00	85.50	100.00	338.40	100.00	4.00	100.00	43.20	100.00	2607.30	100.00	4481.10	100.00
Black	30.60	125.93	403.20	82.51	119.70	140.00	358.20	105.85	6.00	150.0	45.00	104.17	362.70	338.87	544.10	121.49
Red	26.10	107.41	648.90	132.78	116.10	135.79	725.40	214.30	9.00	225.00	57.60	133.33	4327.20	165.96	7360.20	164.25
Red + Black	28.80	118.52	562.50	115.10	172.80	202.11	831.60	245.75	10.00	250.00	58.50	135.42	2872.80	110.18	6064.20	135.30
Blue	27.90	114.81	498.60	102.03	131.40	153.68	634.50	163.36	9.00	225.00	64.80	150.00	2584.80	99.14	5525.40	124.64

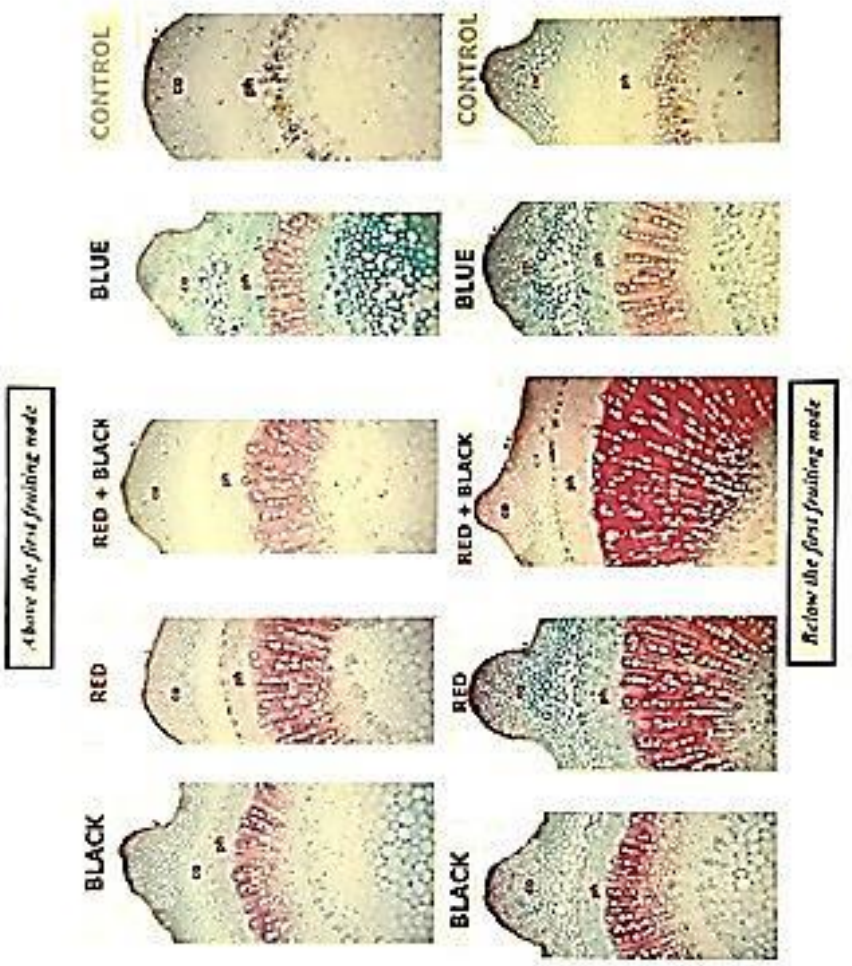

Fig. (4): Effect of mulch colors on anatomical traits of sweet pepper stem (1/2 cm below and above the first fruiting node) at 75 days after transplanting. (X 40)
Where: ep = Epidermis, cx = Cortex, ph = phloem tissue and xy = Xylem tissue.

Fig. (5): A) Red + Black treatment; showing five developed fruits in different ages.
B) Red treatment; indicating the formation of three branches on the same nolle.

Generally, creation a new or specific microenvironment for tomato and pepper plants by alteration of FR: R ratio with using color mulches gave vigorous vegetative growth (preceded with more; photosynthetic pigments synthesis (El-Desouky *et al.*, 2005a) and reproductive growth preceded with more flowers formation and setted fruits (El- Desouky *et al.*, 2005c).

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دراسات على التشكل الضوئي الظاهري في بعض النباتات الاقتصادية
٢ – الهرمونات النباتية والصفات التشريحيةللورقة في نباتات الطماطم والفلفل الحلو تحت تأثير الضوء الاحمر والاحمر البعيد المنعكس من الأغطية البلاستيكية الملونة.

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أخذت عينات من نباتات الطماطم صنف سوبر سترين بـى والفلفـل الحلـو صنف بلدى بعد ٦٠ يوم من الشتل فى موسم ٢٠٠٢ لدراسـة مسـتوى الهرمونـات النباتية الداخلية فى المجاميع الخضرية والصفات التشريحية للاوراق فى تلك النباتـات كنتيجة لتأثرها بالنمو فوق ألوان مختلفة من الاغطية البلاستيكية لسطح التربـة وهـى الحمراء ، الحمراء فوق السوداء ، الزرقاء ، السوداء بالإضافة إلى التربة غير المغطاة كاكنترول. وفى هذا الشأن ، حدث نقص من المستوى الكلـى للهرمونـات الداخليـة المشجعة للنمو (الجبريللينات + الاوكسينات + السيتوكينينات) فى المجاميع الخضـرية لكل من الطماطم والفلفل الحلو مع معظم الالوان المستخدمة من الاغطية البلاسـتيكية. وكان هذا النقص فى حالة الطماطم يرجع اساسا إلى النقص الذى حدث فى مستوى كل من الجبريللينات والاوكسينات ولكن فى الفلفل الحلو كان هذا النقص يرجع إلى النقص فى مستوى الاوكسينات فقط. وفى نفس الوقت زاد مستوى الستوكينينات الداخلية مـع

كل الالوان المستخدمة من الاغطية البلاستيكية. وكانت معاملة الاغطية الحمراء فوق السوداء هى الاكثر تأثيرا فى هذا الشأن.

علاوة على ذلك فإن النقص فى المستوى الكلى للهرمونات المشجعة للنمو كان مصحوبا بنقص اكثر وضوحا فى مستوى مثبط النمو حمض الابسيسيك والذى ادى تباعا إلى زيادة نسبة مشجعات النمو : مثبط النمو . ومن ثم فإن النمو القوى المتحصل عليه لنباتات الطماطم والفلفل الحلو يعزى بصفة اساسية إلى هذا النقص الواضح فى مستوى مثبط النمو. وبالاضافة إلى ذلك. تضمنت نسبة الأوكسينات: السيتوكينينات فى المجاميع الخضرية لكل من الطماطم والفلفل الحلو مع كل ألوان الاغطية البلاستيكية المستخدمة.

ومن جهة أخرى – حدثت زيادة فى العديد من الصفات التشريحية لأوراق كل من الطماطم والفلفل مثل سمك كل من النصل والنسيج الوسطى ، نسيجى اللحاء والخشب ، وابعاد الحزمة الوعائية وكذلك عدد الاوعية الخشبية / حزمة وعائية وذلك مع كل ألوان الاغطية البلاستيكية المستخدمة. وكانت معاملة الاغطية الحمراء سواء عند استخدامها بمفردها أو فوق الاغطية السوداء هى الاكثر ايجابية فى هذه الناحية.

علاوة على ذلك ، فإن من أهم تأثيرات معاملات الاغطية البلاستيكية الملونة هى تأثيراتها على الصفات التشريحية للساق سواء أعلى أو اسفل العقدة الثمرية الأولى فى الفلفل الحلو. حيث حدثت زيادة واضحة فى قطر الساق وكذلك سمك الانسجة الناقلة (الخشب واللحاء) مع كل الالوان المستخدمة من الاغطية البلاستيكية مع تفوق الاغطية الحمراء المستخدمة بمفردها أو فوق الاغطية السوداء. وذلك بجانب تلك التغيرات التى حدثت وفى مستويات وشعب الهرمونات الداخلية والتى تلائم زيادة عدد الافرع والمنشئات الزهرية المتكونة / نبات وكذلك زيادة قدرة اعضاء التخزين (الثمار) على تراكم وتخزين كمية كبيرة من نواتج التمثيل.