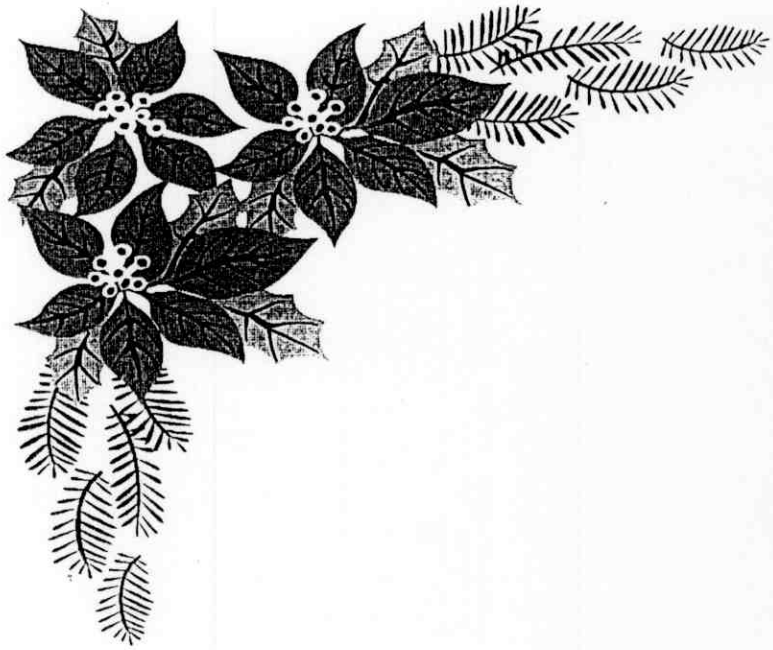
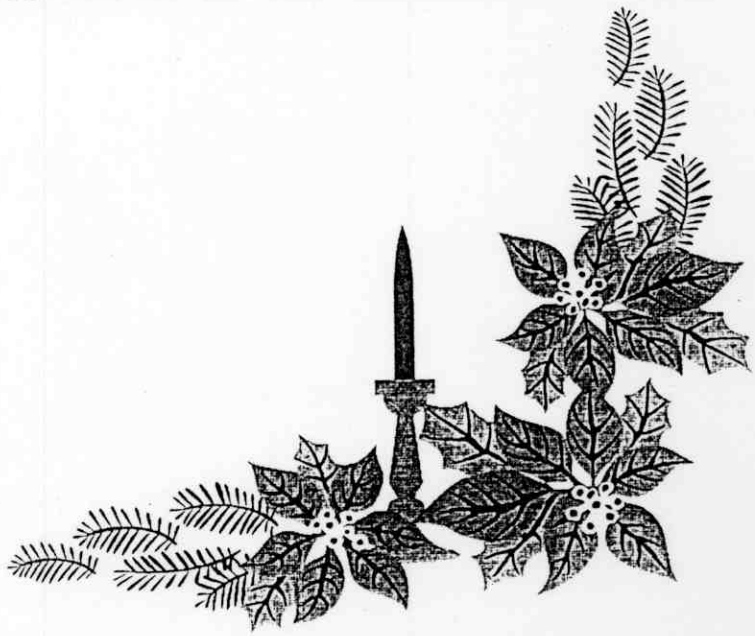


RESULTS & DISCUSSION



RESULTS AND DISCUSSION

I- Vegetative growth at 45 days after transplanting:

I.1. Tomato plants:

I.1.1. Vegetative characteristics:

As shown in Table (9) and Fig. (12) different estimated characteristics (i.e., plant height, stem diameter and the fresh weight of each of stems and leaves) of tomato in case of all mulch surface color were increased to reach the highest level of significance. The exception was only that insignificant increase of plant height existed in case of blue mulch surface color during 2001 season.

These results are of great interest, because at this early stage of growth great stimulative positive differences existed with various applied treatments. Since, that could be prolonged to the advanced growth stages including each of flowering and the final fruit yield as well as the high quality of yielded fruits.

Also, of interest to note that increase existed in stem diameter and that being preceded with basic anatomical modification in different stem tissues. Moreover, that could be accompanied with great variations in the nature of tomato branching.

Furthermore, some of the estimated growth characteristics in case of red mulch surface color reached more than three times of the control. Of these are branches and leaves fresh weights and their sum, as well. Also, in this respect, stem diameter showed its highest significant increase with red + black mulch

Table (9): Effect of polyethylene mulch surface color on some morphological characteristics of tomato (*Lycopersicon esculentum*, Mill.) plants at 45 days after transplanting during 2001 and 2002 seasons.

Growth character / Treatment		Plant height (cm)		Stem diameter (cm)		Stems fresh * weight (g)/plant		Leaves fresh weight (g)/plant		Shoots fresh weight (g)/plant	
		Seasons		Seasons		Seasons		Seasons		Seasons	
		2001	2002	2001	2002	2001	2002	2001	2002	2001	2002
Black		36.20	31.83	0.93	0.87	13.12	18.32	53.25	48.44	66.37	66.76
Red		32.33	29.67	1.13	0.97	24.17	29.11	75.42	69.02	99.59	98.13
Red + Black		31.50	28.53	1.20	1.00	23.08	32.33	65.97	56.51	89.05	88.84
Blue		24.80	26.33	0.97	0.90	21.32	24.83	62.29	53.34	83.61	78.17
Control		20.87	18.63	0.73	0.60	6.60	10.52	25.06	20.64	31.66	31.16
L.S.D.	0.05	4.51	2.27	0.14	0.25	2.99	4.08	6.29	5.81	8.27	7.22
	0.01	6.56	3.29	0.21	0.36	4.35	5.93	9.14	8.44	12.02	10.48

* stems are including each of main stem and branches .

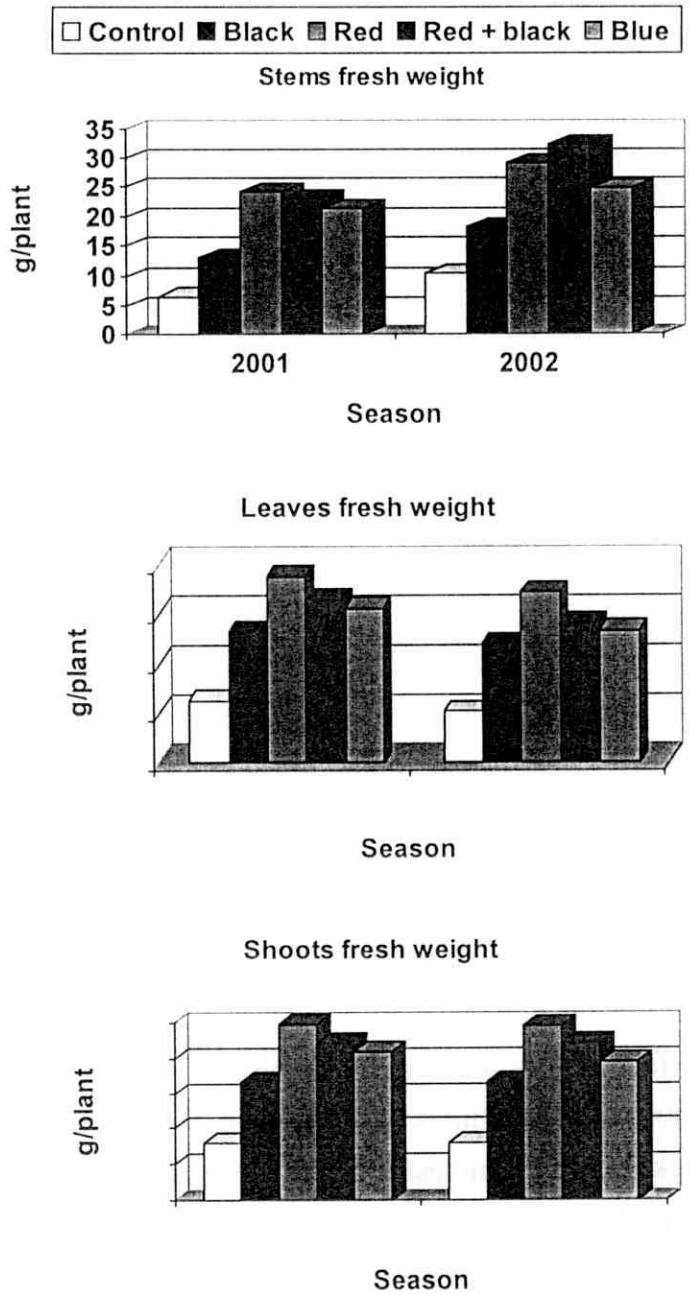


Fig. (12): Bar diagram indicating the effect of color mulches on some morphological characteristics of tomato (*Lycopersicon esculentum*, Mill.) plants at 45 days after transplanting during 2001 and 2002 seasons.

treatment. Meanwhile, plant height, branches and leaves fresh weights showed their maximum (significant) increase in case of red mulch surface color. The exception was that of branches fresh weight with red + black color since showed its maximum during 2002 season only but that was true with red color during 2001 season.

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

I.1.2. Branches and leaves characteristics:

Data in Table (10) and Fig. (13) clearly indicate that each of number of branches and leaves, leaf area per plant and the leaves dry weight were increased to reach the high level of significance with different mulch surface color applied during 2001 and 2002 seasons.

As for the number of branches per plant the only black mulch surface color increased this trait insignificantly during 2001 season and significantly only at 5% during 2002 season. Also, it could be noticed that each of red and red + black of mulch surface colors and the blue color as well increased this number more than two times of the control. Here the treatment of red + black gave the highest number those reached to 8 and 10 branch per plant during 2001 and 2002 seasons, respectively, meanwhile were 3 and 4 branches per plant in case of control plants. 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 finally the yielded fruits.

Table (10): Effect of polyethylene mulch surface color on leaf characteristics of tomato (*Lycopersicon esculentum*, Mill.) plants at 45 days after transplanting during 2001 and 2002 seasons.

Growth character / Treatment		No. of branches / plant		No. of leaves / plant		Leaf area / plant (cm^2)		Leaves dry weight (g)/plant		Leaf area ratio (L.A.R) (cm^2/g)		Specific leaf weight (S.L.W) (mg/cm^2)	
		Seasons		Seasons		Seasons		Seasons		Seasons		Seasons	
		2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002
Black		4.00	5.33	12.00	8.67	971.96	880.38	9.55	8.48	89.91	82.82	9.84	9.63
Red		7.67	8.67	18.67	15.33	1351.51	1085.59	13.60	11.43	83.89	74.25	10.06	10.53
Red + Black		8.00	10.00	15.67	12.00	1428.70	1093.37	12.43	10.67	96.21	75.61	8.70	9.76
Blue		6.67	8.67	15.00	10.67	1246.87	1074.42	10.98	9.08	95.04	92.62	8.81	8.45
Control		3.00	4.00	8.33	6.67	456.87	310.31	4.13	2.31	93.81	89.43	9.04	7.44
L.S.D.	0.05	1.52	1.67	2.13	2.24	151.48	69.75	1.09	1.44	9.13	10.55	0.75	1.27
	0.01	2.21	2.42	3.10	3.26	220.04	101.33	1.59	2.09	13.27	15.33	1.09	1.85

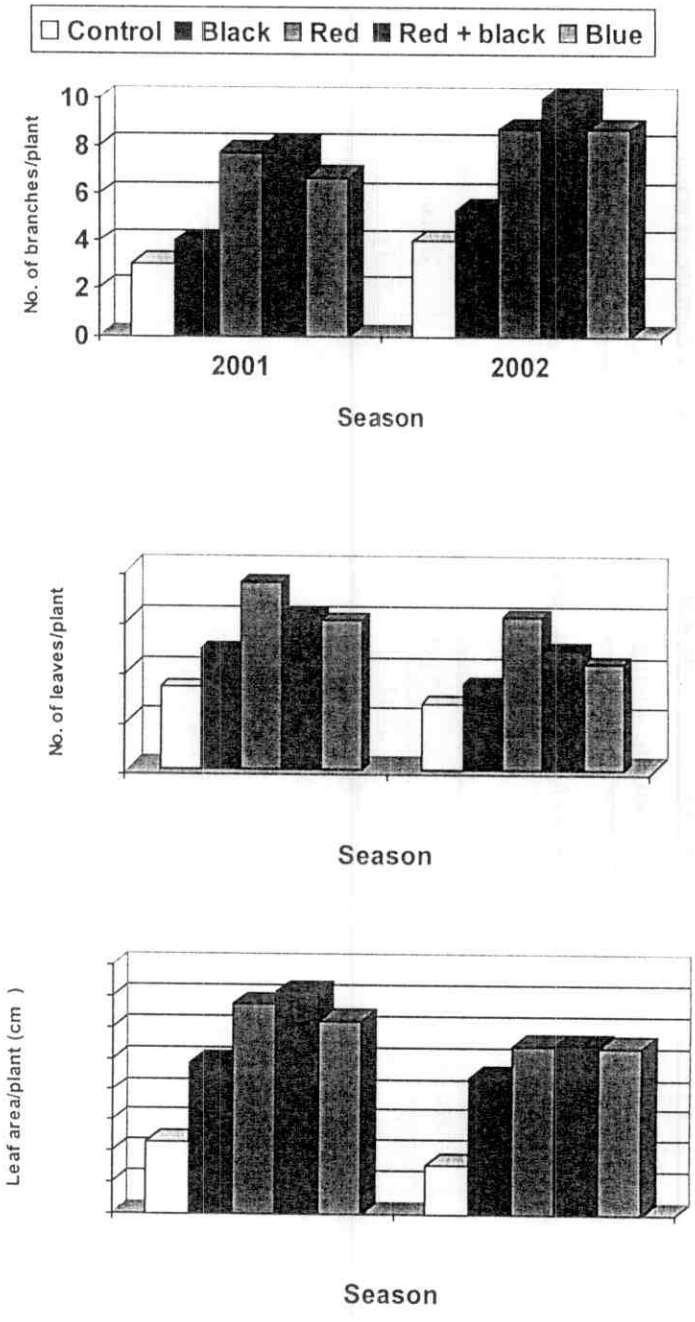


Fig. (13): Bar diagram indicating the effect of color mulches on some leaf characteristics of tomato (*Lycopersicon esculentum*, Mill.) plants at 45 days after transplanting during 2001 and 2002 seasons.

With regard to the number of leaves it could be also noticed that nearly behaved as the same as the number of branches. Since, the red and red + black gave the highest values but the red was preceding in this respect, since increase in leaves number reached more than two times of control values in two assigned seasons.

Regarding, the total leaf area per plant it behaved as the same as the two above mentioned characteristics. Since, all applied mulch colors showed its high significant increase but its maximum was also, obtained with the red and red + black treatments. Increment of leaf area is of great interest because that could be reflected upon the efficiency of photosynthesis by accumulating more assimilates and high rates of their translocation specially toward formed fruits. Also, it could be noticed that increment of this area was preceded with high number of branches and leaves as well.

As regards leaves dry weight, of interest to note that (Table 10) all applied mulch colors increased it to reach the high level of significance. Also, increment of this weight with red and red + black reached more than three times of the control value. These data go will with the above mentioned possibility for increasing yielded fruits. Since, vigorous growth of tomato plants above different mulch colors was the permanent result during this early stage of growth. Also, these data will interpret those data about flowering and will answer many questions specially why tomato plants grown above mulch colors (red and red + black) flowered earlier than those grown above black and blue colors or the control, as well.

Moreover, the calculated data of each of leaf area ratio and specific leaf weight could be support the above mentioned data about the vigorous growth of tomato plants grown above the assigned mulch colors specially that red one.

Regarding the effect of mulch colors treatment upon vegetative characteristics of tomato plants were studied by **Decoteau *et al.* (1986, 1988 and 1989); Kasperbauer and Karlen (1994) and Kasperbauer and Hunt (1998).** They reported that light reflected from the surface of plastic mulch can have a photoregulatory role in growth of young tomato (*Lycopersicon esculentum,* Mill.) plants.

I.1.3. Dry matter distribution:

Table (11) and Fig, (14) indicate the effect of different applied mulch surface colors on dry matter production and distribution in branches (including the main stem) and leaves of tomato plants at 45 days after transplanting. Data clearly indicated that different mulch colors, i.e. black, red and blue increased dry weight of branches at this early stage of growth. Increases reached the high level of significance, yet, the red color gave the highest value during 2001 season but red + black showed its maximum during 2002 season, these two treatments exceeded branches 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.

As for leaves dry weight, data in Table (11) evidently confirmed the stimulatory and significantly effects of applied

Table (11): Effect of polyethylene mulch surface color on dry matter distribution in different organs of tomato (*Lycopersicon esculentum*, Mill.) plants at 45 days after transplanting during 2001 and 2002 seasons.

Growth character / Treatment		Branches (including main stem) dry weight (g)/plant		Branches (including main stem) dry weight % relative to the control		Leaves dry weight (g)/plant		Leaves dry weight % relative to the control		Total dry* weight (g)/plant		% distribution of dry matter in different plant organs: Branches (including main stem)		% distribution of dry matter in different plant organs: Leaves		Dry weight % of total dry weight relative to the control	
		Seasons		Seasons		Seasons		Seasons		Seasons		Seasons		Seasons		Seasons	
		2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002
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	221.97	306.34
Red		2.51	3.19	339.19	275.00	13.60	11.43	329.30	494.81	16.11	14.62	15.58	21.82	84.42	78.81	330.80	421.33
Red + Black		2.42	3.79	327.03	326.72	12.43	10.67	300.97	461.90	14.85	14.46	16.30	26.21	83.70	73.79	304.93	416.71
Blue		2.14	2.52	289.29	217.24	10.98	9.08	265.86	393.07	13.12	11.60	16.31	21.72	83.69	78.28	269.41	334.29
Control		0.74	1.16	100.00	100.00	4.13	2.31	100.00	100.00	4.87	3.47	15.20	33.43	84.80	66.57	100.00	100.00
L.S.D.	0.05	0.53	0.47	85.07	41.36	1.09	1.44	36.45	62.38	1.12	1.46	3.89	3.89	3.89	3.88	35.39	42.63
	0.01	0.78	0.68	123.57	60.09	1.59	2.09	52.95	90.61	1.62	2.13	5.65	5.65	5.65	5.64	51.41	61.93

* Total dry weight = dry weight of shoots only without dry weight of roots.

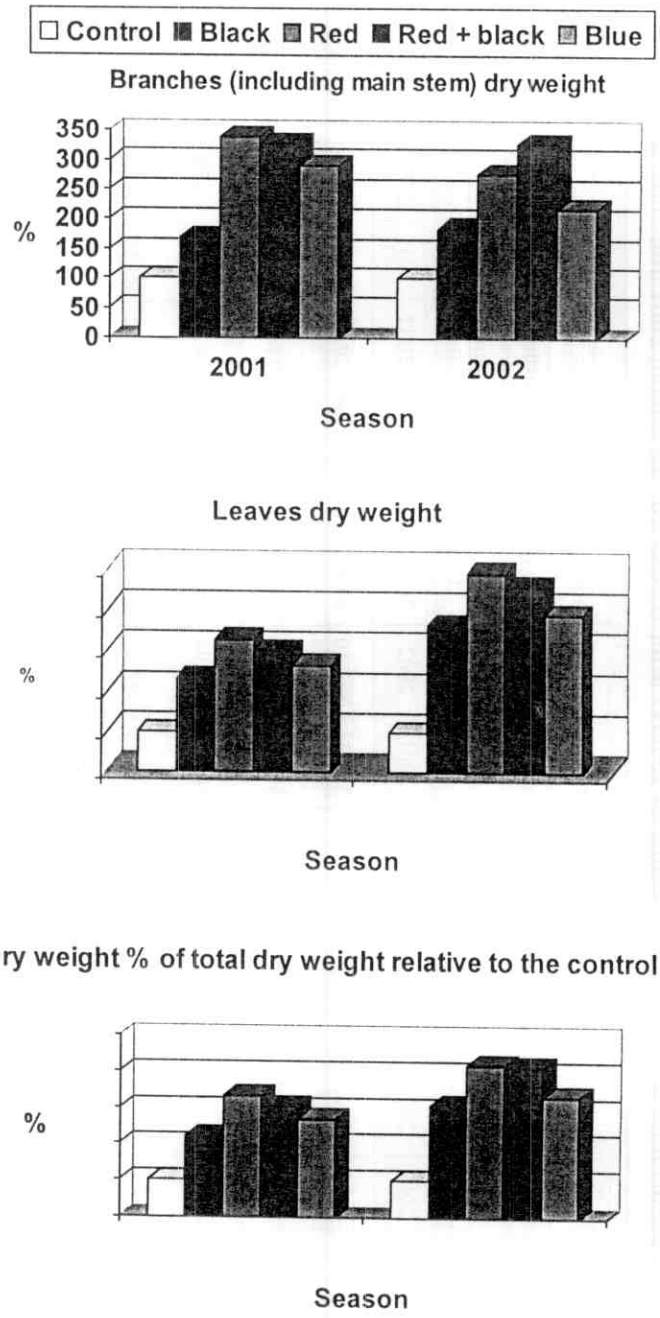


Fig. (14): Bar diagram indicating the effect of color mulches on dry matter distribution in different organs of tomato (*Lycopersicon esculentum*, Mill.) plants at 45 days after transplanting during 2001 and 2002 seasons.

mulch colors upon dry matter production and accumulation in leaves. Also, red color was more pronounced in this respect. Since, increases reached to more than three times during first season and reached to nearly fifth times in second season comparing with control values. Therefore, total dry weight of shoots also behaved as the same as branches and leaves with different mulch colors and also with priority of the red one. Moreover, dry matter distribution was highly 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.

In general, data in Table (11) not only being a direct results for that vigorous growth obtained in Tables (9 & 10) but also could be considered an indicator for expectable high yield of fruits.

I.1.4. Photosynthetic pigments:

As shown in Table (12) and Fig. (15), effect of mulch colors on photosynthetic pigments in 2001 and 2002 seasons, different used colors increased each of chlorophyll a & b and carotenoids as well. Also, treatment of red + black was more efficient in this respect followed by the red one. The exception was only that slight reduction of chlorophyll (b) in the blue mulch treatment during 2001 season.

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 plants grown above applied mulch colors (Table 11). Also, of interest to note that, this

Table (12): Effect of polyethylene mulch surface color on photosynthetic pigments of tomato (*Lycopersicon esculentum*, Mill.) plants at 45 days after transplanting during 2001 and 2002 seasons (calculated as mg/g fresh weight).

Plant pigments / Treatment	Chlorophyll						Carotenoids		Chl. (a + b) / Carot.	
	(a)		(b)		(a + b)					
	Seasons		Seasons		Seasons		Seasons		Seasons	
	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002
Black	0.469	0.669	0.394	0.520	0.863	1.189	0.224	0.498	3.853	2.388
Red	0.570	0.823	0.447	0.625	1.017	1.448	0.312	0.579	3.260	2.501
Red + Black	0.618	0.851	0.495	0.679	1.113	1.530	0.321	0.634	3.467	2.413
Blue	0.503	0.664	0.342	0.538	0.845	1.202	0.223	0.492	3.789	2.443
Control	0.406	0.613	0.383	0.458	0.789	1.071	0.202	0.483	3.906	2.217

Chl. = Chlorophyll

Carot. = Carotenoids

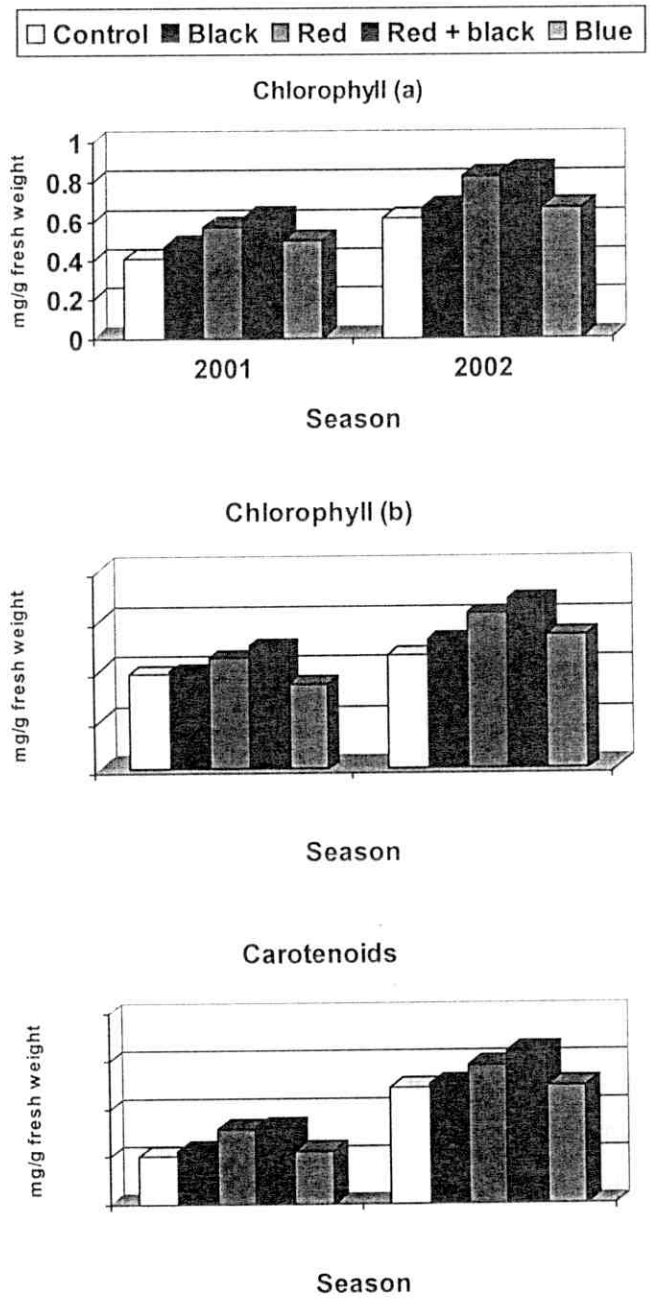


Fig. (15): Bar diagram indicating the effect of color mulches on photosynthetic pigments of tomato (*Lycopersicon esculentum*, Mill.) plants at 45 days after transplanting during 2001 and 2002 seasons.

stimulatory effect of mulch colors upon photosynthetic pigments creation was started at this early stage of growth, i.e. at 45 days after planting.

I.2. Sweet pepper plants:

I.2.1. Vegetative characteristics:

Data presented in Table (13) and Fig. (16) clearly indicate the effect of different mulch colors on plant height, stem diameter and fresh weight of branches and leaves during 2001 & 2002 seasons.

In this respect, as in case of tomato plant, with sweet pepper high significant increase of plant height was the dominant result with various applied mulch colors during the two assigned seasons. The exception was only that significant increase at 5% level with blue mulch color during 2001 season. Also, it could be noticed that red + black mulch color gave the highest value during 2001 season but red mulch color showed its maximum during 2002 season.

As for stem diameter, its high significant increase existed with different mulch colors during 2001 season but red and blue mulch colors significantly increased it at 5% level of significance and insignificant increase with red and black mulch colors during 2002 season were existed.

With regard to the fresh weight of branches, it was highly significantly increased during the two assigned seasons with different applied mulch colors. The exception was that insignificant increase with black mulch color existed during 2001 and 2002 seasons.

Table (13): Effect of polyethylene mulch surface color on some morphological characteristics of sweet pepper (*Capsicum annuum* L.) plants at 45 days after transplanting during 2001 and 2002 seasons.

Growth character / Treatment		Plant height (cm)		Stem diameter (cm)		stems fresh* weight (g)/plant		Leaves fresh weight (g)/plant		Shoots fresh weight (g)/plant	
		Seasons		Seasons		Seasons		Seasons		Seasons	
		2001	2002	2001	2002	2001	2002	2001	2002	2001	2002
Black		22.63	16.77	0.57	0.53	3.77	3.67	7.48	10.14	11.25	13.81
Red		21.27	19.50	0.73	0.67	5.78	8.81	17.17	17.54	22.95	26.35
Red + Black		22.80	19.03	0.63	0.60	5.23	6.51	13.64	16.03	18.87	22.54
Blue		20.37	17.77	0.63	0.63	4.81	6.14	14.55	15.13	19.36	21.27
Control		17.67	14.90	0.43	0.47	2.59	2.52	5.57	4.67	8.16	7.19
L.S.D.	0.05	2.36	1.43	0.10	0.15	1.48	2.67	4.98	3.33	6.11	4.84
	0.01	3.43	2.08	0.13	0.21	2.14	3.88	7.23	4.83	8.87	7.03

* Stems are including each of main stem and branches.

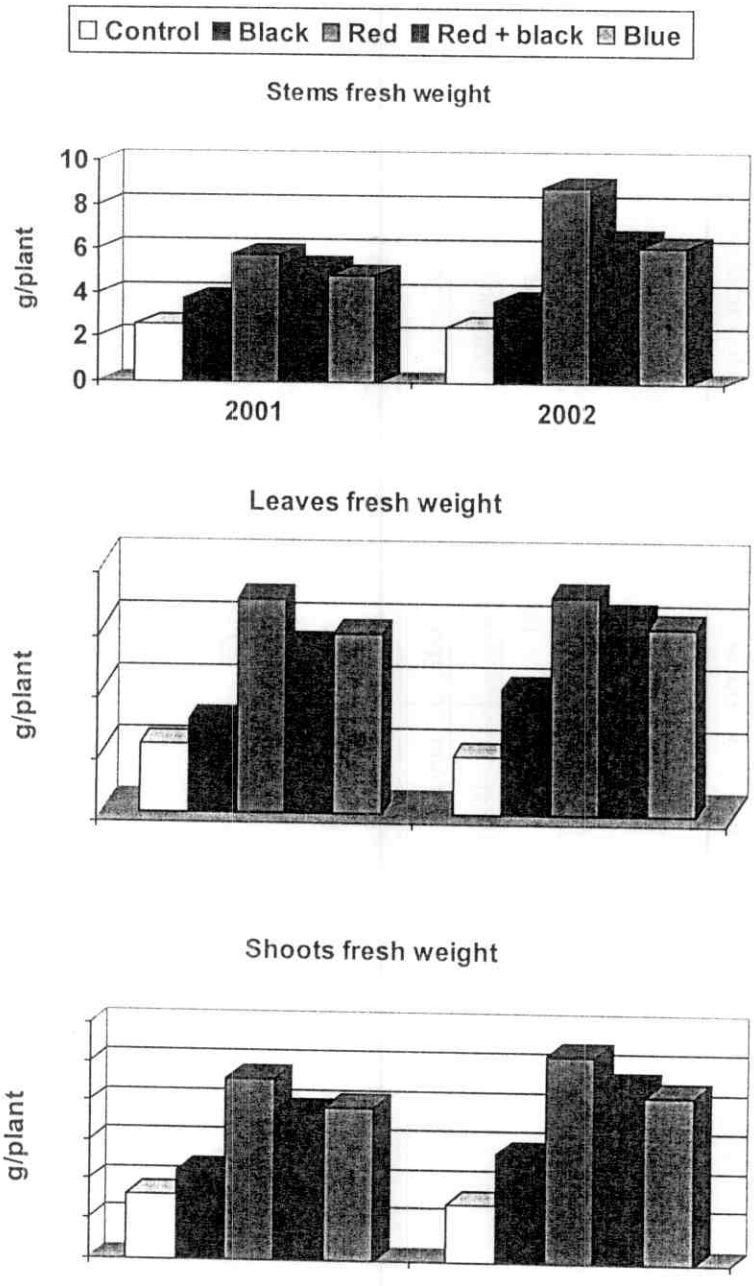


Fig. (16): Bar diagram indicating the effect of color mulches on some morphological characteristics of pepper (*Capsicum annuum*, L.) plants at 45 days after transplanting during 2001 and 2002 seasons.

Furthermore, high significant increases existed in leaves fresh weight with various colors of used mulch surface but only black color gave insignificant increase during 2001 season. Also, it could be noticed that red color gave highest values during the two assigned seasons, since, it was evident that increases reached to more than three times during first season and reached to nearly four times in second season comparing with control values.

Regarding shoots fresh weight, it was increased with different mulch colors to reach the two levels of significance with red, red + black and blue colors in the two seasons. The only exception was that significant increase at 5% level with black mulch color during 2002 season but insignificantly was increased during 2001 season.

I.2.2. Branches and leaves characteristics:

As shown in Table (14) and Figs. (17, 18, 19 & 20) all vegetative characteristics expressed as number of branches and leaves, leaf area per plant and leaves dry weight were increased to reach the high level of significance with different mulch surface colors applied during 2001 and 2002 seasons. The only exception was that insignificant increase in the number of branches per plant with black mulch color during the two assigned seasons.

Also, it could be noticed that each of red and red + black mulch surface colors increased this number more than 5 and 7 times of the control value during 2001 and 2002 seasons, respectively.

Table (14): Effect of polyethylene mulch surface color on leaf characteristics of sweet pepper (*Capsicum annuum* L.) plants at 45 days after transplanting during 2001 and 2002 seasons.

Growth character / Treatment		No. of branches / plant		No. of leaves / plant		Leaf area / plant (cm^2)		Leaves dry weight (g)/plant		Leaf area ratio (L.A.R) (cm^2/g)		Specific leaf weight (S.L.W) (mg/cm^2)	
		Seasons		Seasons		Seasons		Seasons		Seasons		Seasons	
		2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002
Black		1.33	1.67	24.00	21.67	127.93	148.02	1.29	0.95	68.05	104.24	10.08	6.42
Red		5.67	7.67	47.33	41.00	222.18	234.95	2.31	2.46	67.53	65.08	10.40	10.47
Red + Black		5.67	7.00	41.33	38.00	179.14	194.37	2.07	2.19	61.99	64.36	11.56	11.27
Blue		4.00	5.33	36.67	36.33	173.31	169.95	1.92	1.44	61.24	71.41	11.08	8.47
Control		1.00	1.00	19.33	13.00	82.50	70.39	0.81	0.42	68.18	92.62	9.82	5.97
L.S.D.	0.05	1.77	2.05	5.59	4.44	50.17	56.30	0.41	0.58	14.38	34.39	1.34	2.66
	0.01	2.57	2.98	8.12	6.46	72.88	81.79	0.60	0.84	20.89	49.95	1.94	3.80

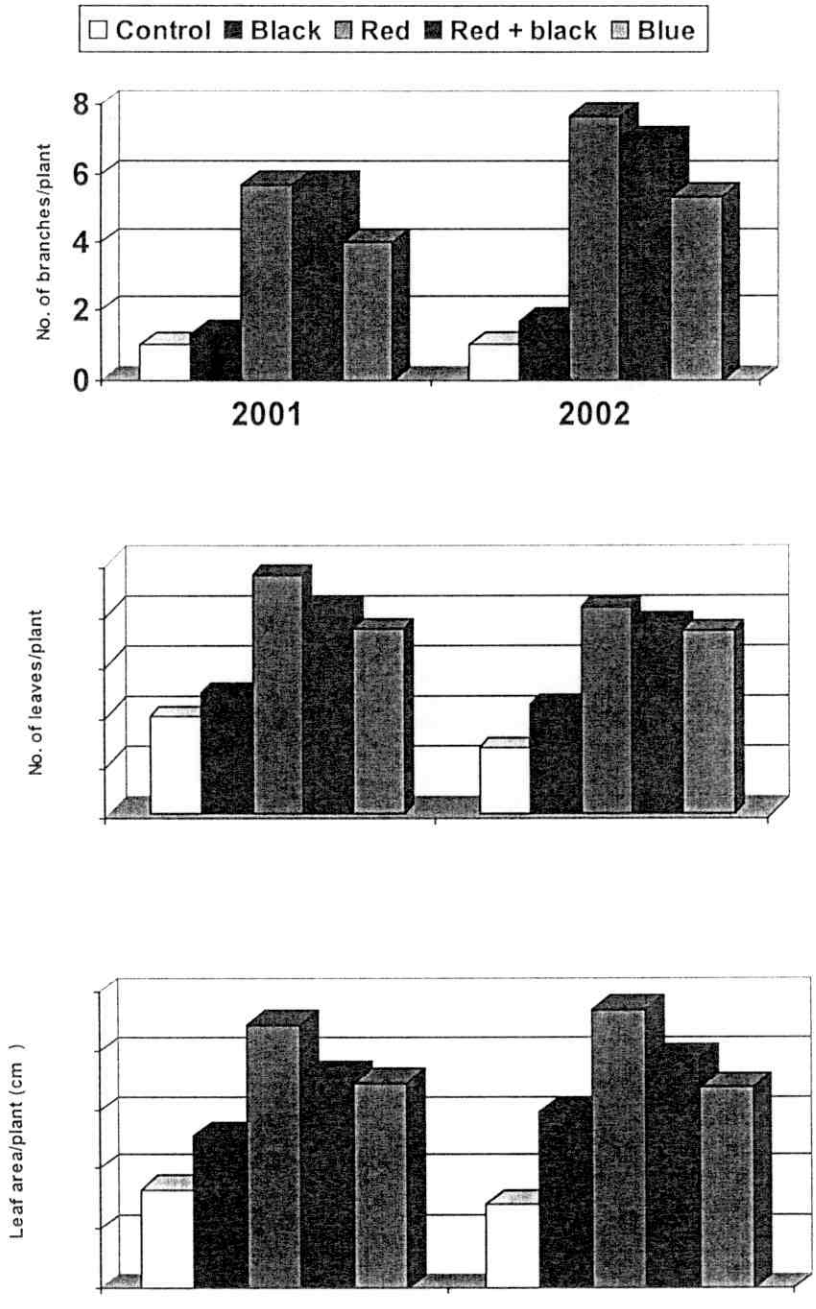


Fig. (17): Bar diagram indicating the effect of color mulches on some leaf characteristics of pepper (*Capsicum annuum*, L.) plants at 45 days after transplanting during 2001 and 2002 seasons.

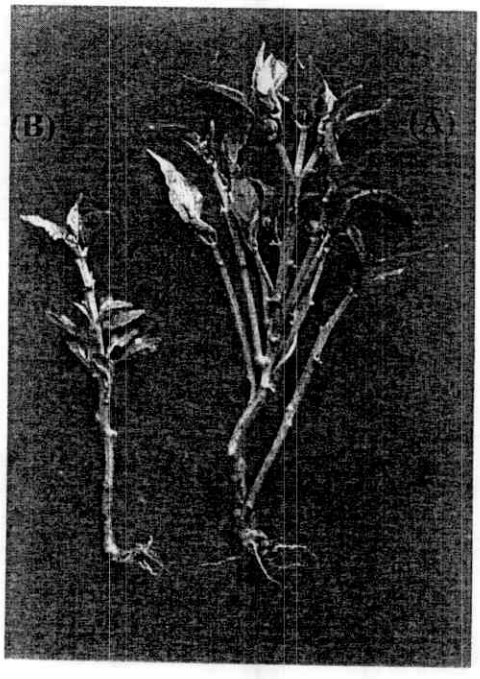


Fig. (18) : **Showing number of branches at the early stage of growth (A) in case of red treatment compared with the control (B).**

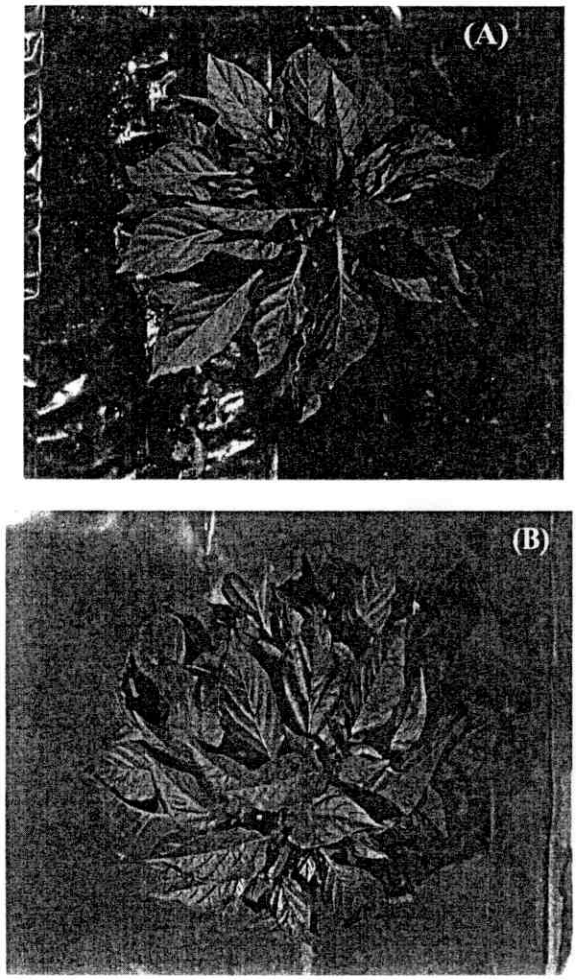


Fig.(19): Indicating shoot size at 45 days after transplanting during 2002 season, (A) black and (B) blue treatments.

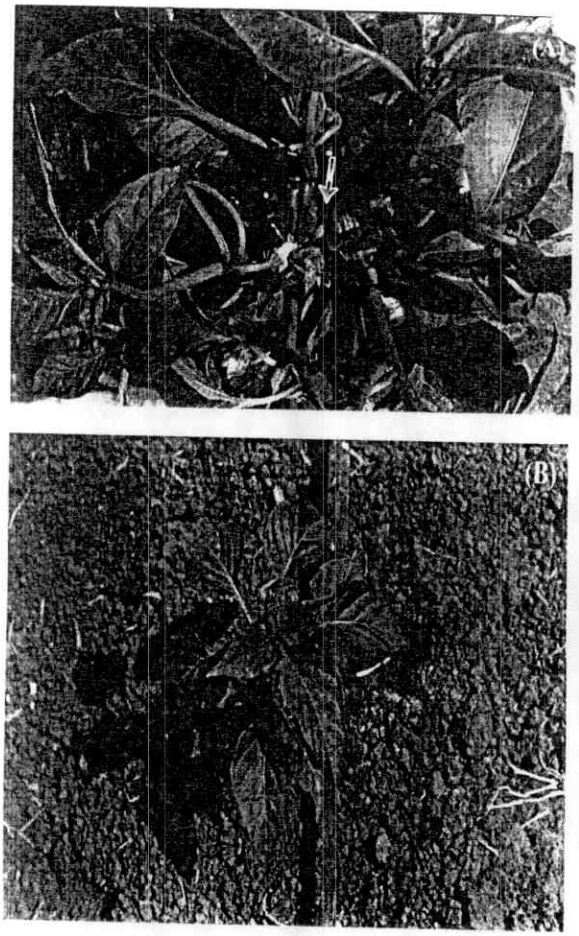


Fig . (20) : showing developed fruit at 45 days after transplanting (A) red treatment compared with control plants (B).

As for number of leaves per plant, the only black mulch surface color increased this trait insignificantly during 2001 season. But each of red, red + black and blue increased it to reach the high level of significance during 2001 and 2002 seasons. Here, the treatment of red gave the highest number of leaves per plant that reached to 47.33 and 41.00 leaves per plant during 2001 and 2002 seasons, respectively, meanwhile were 19.33 and 13.00 leaves per plant in case of control plants.

With regard to the total leaf area per plant it behaved as the same as the two above mentioned characters. Since high significant increase during the two seasons with different applied mulch colors was existed. Exception was only that insignificant increase during 2001 season and significant increase only at 5% level during 2002 season existed with black mulch. Also, the red mulch color gave the highest value during 2001 and 2002 seasons. Also, it could be noticed that increment of this area was preceded with high number of branches and leaves as well.

Furthermore, dry matter accumulation in leaves of different applied treatments were highly significantly increased with different colors but increased significantly only at 5% level and insignificantly with black one during 2001 and 2002 seasons, respectively. These results could be reflected upon more assimilates translocation to other plant organs including the setted fruits. So, high yielded fruits being more expected.

On the other hand, leaf area ratio and specific leaf weight could be support the above mentioned data about the vigorous growth of sweet pepper plants grown over mulch colors specially that red color.

These results are in agreement with those obtained by **Decoteau *et al.* (1990), Korner (1991) and Flores and Ibarra (1998).**

I.2.3. Dry matter distribution:

The dry matter distribution, i.e. partitioning and allocation among shoots (main stem and branches) and leaves of sweet pepper plants under the different applied mulch colors treatment are indicated in Table (15) and Fig. (21). Data clearly indicate that different mulch colors, i.e. red, red + black and blue were highly significantly increased dry weight of branches at this early stage of growth. The exception was only insignificant increase with black color during the two assigned seasons. Increases reached the level of high significance, yet, the red color gave the highest value during the two assigned seasons. Also, red mulch color increased branches dry weight more than two and three times during 2001 and 2002 seasons, respectively, when compared with the control value. That could be more evident when related to the control value since the 100 percentage of control rose to 245.00 and 338.24% with red mulch color during 2001 and 2002 seasons, respectively.

As for leaves dry weight, data in Table (15) clearly indicate that different mulch colors increased it to reach the high level of significance. The only exception was that increase at 5% level during 2001 season and insignificant increase during 2002 season with black one. Also, red color was pronounced in this respect. Since increases reached to nearly three times in first season and more than fifth times in second season comparing with control values. Therefore, total dry weight of shoots also

Table (15): Effect of polyethylene mulch surface color on dry matter distribution in different organs of sweet pepper (*Capsicum annuum* L.) plants at 45 days after transplanting during 2001 and 2002 seasons.

Growth character / Treatment		Branches (including main stem) dry weight				Leaves dry weight				Total dry* weight (g/plant)		% distribution of dry matter in different plant organs				Dry weight % of total dry weight relative to the control	
		(g)/plant		% relative to the control		(g)/plant		% relative to the control				Branches (including main stem)		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
Black		0.59	0.47	147.50	138.24	1.29	0.95	159.26	226.19	1.88	1.42	31.38	33.10	68.62	66.90	155.37	186.84
Red		0.98	1.15	245.00	338.24	2.31	2.46	285.19	585.71	3.29	3.61	29.79	31.86	70.21	68.14	271.90	475.00
Red + Black		0.82	0.83	205.00	244.12	2.07	2.19	255.56	521.43	2.89	3.02	28.37	27.48	71.63	72.52	238.84	397.37
Blue		0.91	0.94	227.50	276.47	1.92	1.44	237.04	342.86	2.83	2.38	32.16	39.50	67.84	60.50	233.88	313.16
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	100.00	100.00
L.S.D.	0.05	0.22	0.25	58.00	127.68	0.41	0.58	67.28	200.69	0.60	0.70	6.57	10.56	6.59	9.58	54.55	152.82
	0.01	0.32	0.37	84.25	185.46	0.60	0.84	97.73	291.53	0.88	1.02	9.55	15.38	8.56	14.37	79.25	221.99

* Total dry weight = dry weight of shoots only without dry weight of roots.

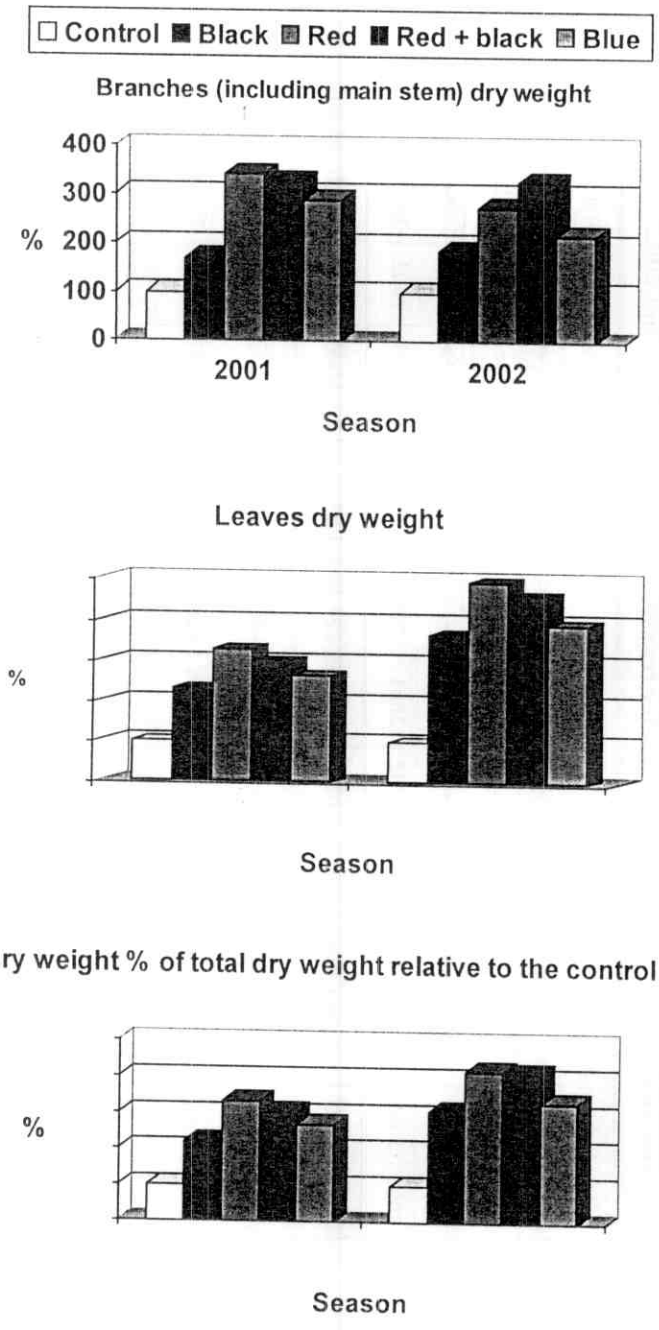


Fig. (21): Bar diagram indicating the effect of color mulches on dry matter distribution in different organs of pepper (*Capsicum annuum*, L.) plants at 45 days after transplanting during 2001 and 2002 seasons.

behaved as the same as that of branches and leaves with different mulch colors and also with priority of the red one.

Moreover, of great interest also to note that different applied mulch colors caused insignificant reduction in dry matter of branches but insignificantly increased it in leaves.

In general, data in Table (15) not only being a direct results for that vigorous growth obtained in Tables (13 & 14) but also could 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 photoassimilates 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. We conclude that it is important to be aware of these adaptive morphological 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.2.4. Photosynthetic pigments:

In this respect as in case of tomato different applied mulch colors increased each of chlorophyll a & b and carotenoids as well. Also, it could be noticed that red + black treatment followed by red one during 2001 and 2002 seasons (Table, 16 and Fig., 22). The only exception was that slight reduction of chlorophyll (b) in the blue mulch treatment and black one during 2001 and 2002 seasons, respectively. Also, blue mulch color showed the reduction of carotenoids during 2002 season.

These results are of great interest, because it could be reversed upon high photosynthesis and creation more assimilates in different plant organs.

Spectral quality can have profound effects on the growth, development and physiology of plants **(Smith, 1982 and Sage, 1992).** The effects of red and far-red radiation on plant growth and development constitute much of the focus of past and current research **(Britz and Sager, 1990; Mc-Mahon *et al.*, 1991 and Rajapaske *et al.*, 1992).** Radiation in the blue region of the spectrum is also of critical importance to plant growth and morphology **(Senger, 1984; Wheeler *et al.*, 1991 and Barnes and Bughee, 1992).**

Table (16): Effect of polyethylene mulch surface color on photosynthetic pigments of sweet pepper (*Capsicum annuum*, L.) plants at 45 days after transplanting during 2001 and 2002 seasons (calculated as mg/g fresh weight).

Plant pigments / Treatment	Chlorophyll						Carotenoids		Chl. (a + b) / Carot.	
	(a)		(b)		(a + b)					
	Seasons		Seasons		Seasons		Seasons		Seasons	
	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002
Black	0.626	0.549	0.355	0.387	0.981	0.936	0.332	0.365	2.955	2564
Red	0.734	0.607	0.492	0.487	1.226	1.094	0.434	0.493	2.825	2.219
Red + Black	0.751	0.713	0.558	0.572	1.309	1.285	0.498	0.548	2.629	2.345
Blue	0.635	0.559	0.332	0.420	0.967	0.979	0.318	0.314	3.041	3.118
Control	0.604	0.501	0.342	0.396	0.946	0.897	0.296	0.322	3.196	2.786

Chl. = Chlorophyll

Carot. = Carotenoids

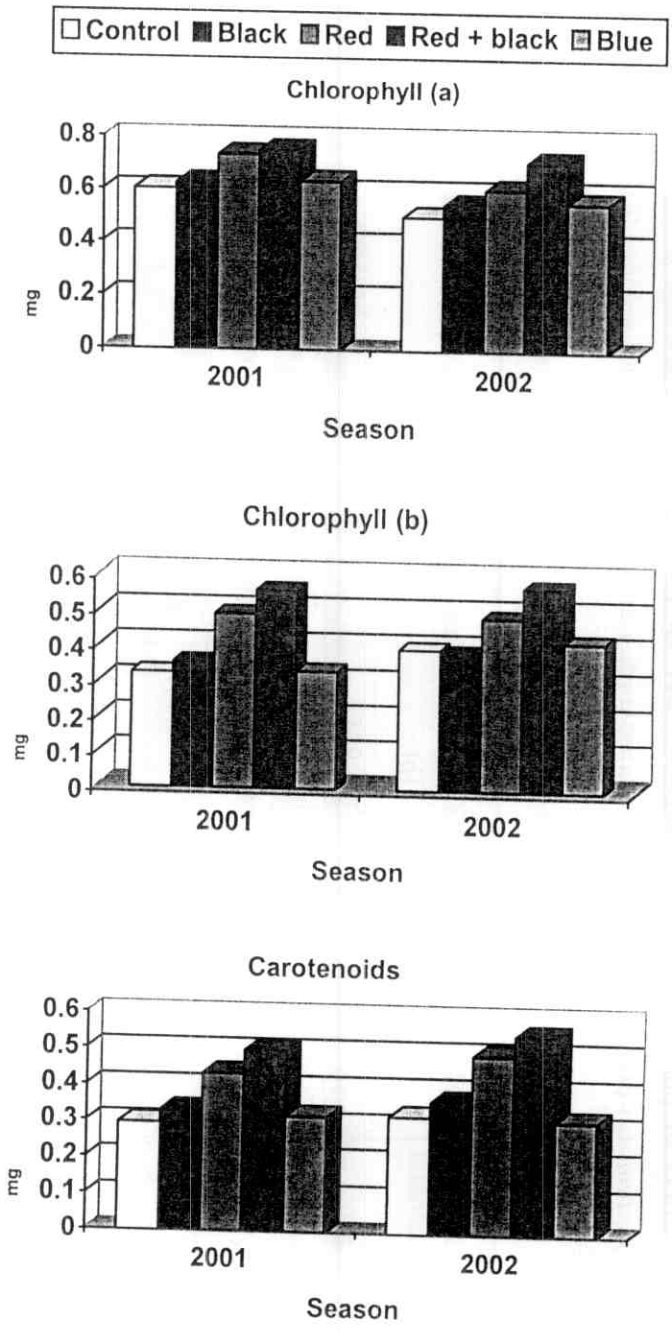


Fig. (22): Bar diagram indicating the effect of color mulches on photosynthetic pigments of pepper (*Capsicum annuum*, L.) plants at 45 days after transplanting during 2001 and 2002 seasons.

II- Vegetative growth at 60 days after transplanting:

II.1. Tomato plants:

II.1.1. Vegetative characteristics:

Data in Table (17) and Fig. (23) indicate the effect of mulch colors on plant height, stem diameter and fresh weight of branches and leaves during 2001 & 2002 seasons.

In this respect, high significant increase of plant height was the dominant result with various applied mulch colors during the two seasons. Here, also it could be noticed that red mulch ranked the first in this respect followed by blue, red + black and black mulches during 2001 season but it was followed by black, red + black and blue mulches during 2002 season.

As for stem diameter, its high significant increase existed with different colors except that significant increase at 5% level with black and blue mulches during 2001 season and only insignificant increase with black one during 2002 season. Here, it is of interest to note that increasing of stem diameter accompanied with increasing of plant height means that mulch colors led to vigorous growth and more healthy tomato plants.

With regard to the fresh weight of branches it was high significantly increased during the two seasons with different applied colors. The exception was that significant increase only at 5% level with black and blue colors during 2001 season.

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

Table (17): Effect of polyethylene mulch surface color on some morphological characteristics of tomato (*Lycopersicon esculentum*, Mill.) plants at 60 days after transplanting during 2001 and 2002 seasons.

Growth character / Treatment		Plant height (cm)		Stem diameter (cm)		stems fresh* weight (g/plant)		Leaves fresh weight (g/plant)		Shoots fresh weight (g/plant)	
		Seasons		Seasons		Seasons		Seasons		Seasons	
		2001	2002	2001	2002	2001	2002	2001	2002	2001	2002
Black		43.27	51.97	1.27	1.13	44.15	55.97	155.79	147.73	199.94	203.70
Red		50.87	52.13	1.30	1.37	54.77	64.30	192.58	196.39	247.35	260.69
Red + Black		47.10	49.97	1.47	1.30	84.61	80.51	286.92	243.94	371.53	324.45
Blue		47.57	48.77	1.23	1.27	41.41	46.95	137.26	135.32	178.67	182.27
Control		28.43	30.93	1.03	0.97	30.22	27.91	85.27	70.57	115.49	98.48
L.S.D.	0.05	4.90	4.24	0.18	0.16	10.09	11.14	28.81	27.23	92.95	93.79
	0.01	7.12	6.16	0.26	0.24	14.65	15.90	41.85	39.21	135.02	136.25

* Stems are including each of main stem and branches.

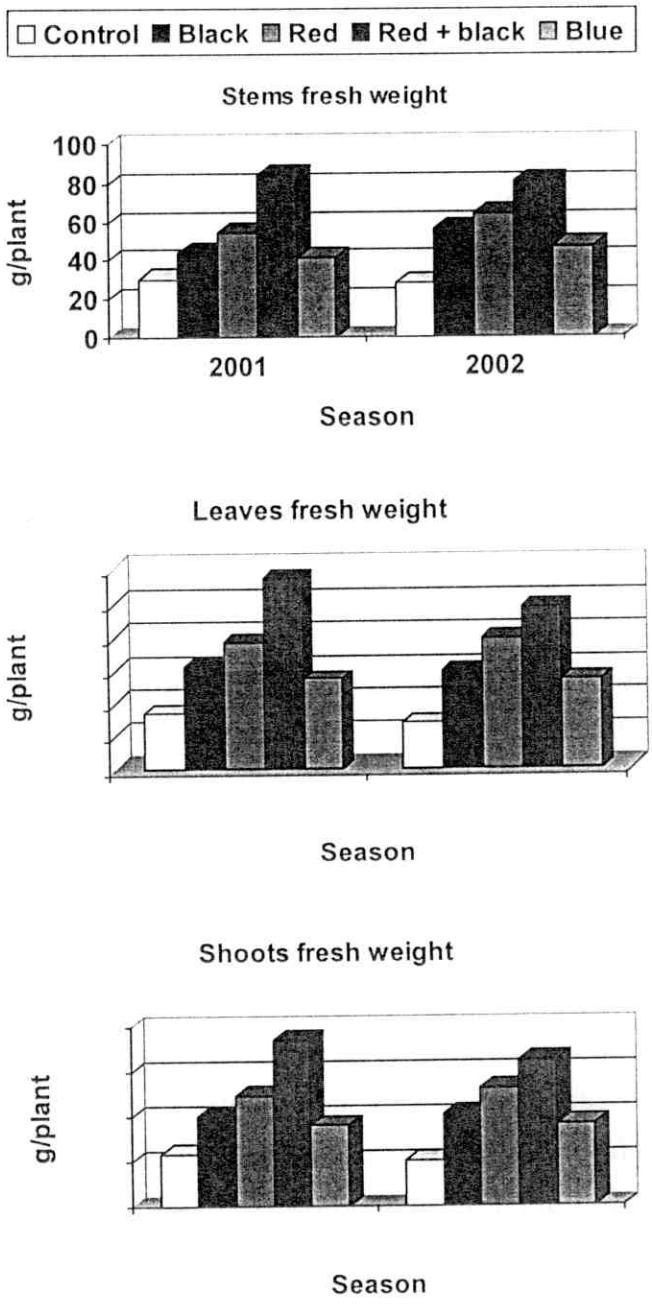


Fig. (23): Bar diagram indicating the effect of color mulches on some morphological characteristics of tomato (*Lycopersicon esculentum*, Mill.) plants at 60 days after transplanting during 2001 and 2002 seasons.

In general, shoots fresh weight 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) but reached the level of 5% significance with red and black colors in first and second season, respectively, yet, the rest was showed only insignificant increase.

II.1.2. Branches and leaves characteristics:

As shown in Table (18) and Fig. (24) the number of branches formed on tomato plants at 60 days after transplanting in most cases were significantly increased. Increases reached to high level of significance (1%) with red + black, red and black mulches. Meanwhile, significantly at the level of 5% existed only in 2002 season with blue mulch meanwhile it was only insignificantly increased with the same mulch in 2001 season.

In this respect, increasing of branches number could be later accompanied with increasing of formed flowers, thereby, the yielded fruits also. Here, also, it could be noticed that each of red + black and red mulches were more pronounced in this respect.

As for the number of leaves it could also be noticed that high significant results were dominantly existed with different used mulch colors. 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, it could also be noticed clearly its high significant increase with each of red + black and red mulches in the two seasons but only at 5% level of significance with black and blue mulches during 2002 and 2001

Table (18): Effect of polyethylene mulch surface color on leaf characteristics of tomato (*Lycopersicon esculentum*, Mill.) plants at 60 days after transplanting during 2001 and 2002 seasons.

Growth character / Treatment		No. of branches / plant		No. of leaves / plant		Leaf area / plant (cm^2)		Leaves dry weight (g/plant)		Leaf area ratio (L. A. R.) (cm^2/g)		Specific leaf weight (S. L.W.) (mg/cm^2)	
		Seasons		Seasons		Seasons		Seasons		Seasons		Seasons	
		2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002
Black		12.67	12.00	32.67	26.67	1795.08	2294.07	25.71	32.61	52.67	53.95	14.32	14.22
Red		17.33	20.67	37.33	37.43	2842.57	3684.11	33.62	41.75	64.91	66.75	11.83	11.33
Red + Black		19.00	18.33	48.33	40.33	4551.99	3609.59	47.77	39.37	74.31	70.03	10.49	10.91
Blue		10.33	11.00	30.00	29.33	2151.98	1721.52	23.31	24.50	70.10	53.51	10.83	14.23
Control		8.33	7.00	18.33	12.67	1077.18	760.87	11.79	8.74	66.04	65.31	10.95	11.49
L.S.D.	0.05	2.16	3.38	6.58	5.04	814.15	1171.04	5.49	11.04	13.79	17.13	2.11	3.11
	0.01	3.14	4.91	9.56	7.32	1182.65	1701.07	7.97	16.03	20.04	24.88	3.06	4.52

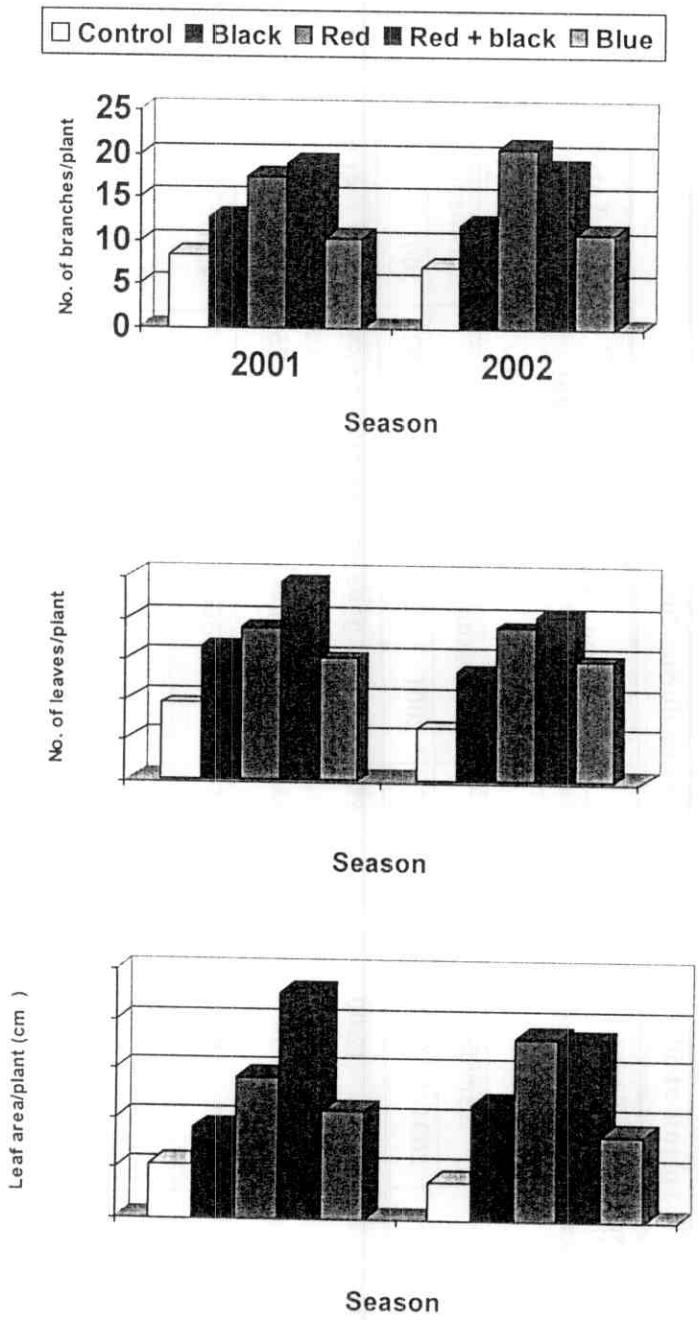


Fig. (24): Bar diagram indicating the effect of color mulches on some leaf characteristics of tomato (*Lycopersicon esculentum*, Mill.) plants at 60 days after transplanting during 2001 and 2002 seasons.

seasons, respectively. Meanwhile, insignificant increase of this area only existed with black mulch in 2001 season and with blue mulch during 2002 season. These results could also be considered as a complete reflection of increasing of each of branches and leaves number. Moreover, these data were directly affected the dry weight of leaves with various mulching colors. Since, its high significant increase existed in both seasons except that increase only at 5% level of significance with blue mulch color during 2002 season.

Furthermore, increasing dry matter accumulation in leaves of different applied treatments specially those of red and red + black; could be further reflected upon assimilates translocation to other plant parts including the setted fruits. So, high yielded fruits being more expected.

On the other hand, leaf area ratio and 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.1.3. Dry matter distribution:

As shown in Table (19) and Fig. (25) different applied mulch colors significantly in most cases affected dry matter distribution, i.e. partitioning and allocation.

In this respect, shoots (main stem + branches) dry weight showed its high maximum increase with different colors of applied mulches during the two seasons. The exception was only that significant increase only at the 5% level with the blue mulch color only during 2001 season. These data being also more evident when related to the control value. These values reached more than two times in 2001 season and more than fourth times in 2002 season with the red and the red + black color mulches.

As for leaves dry weight; 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 during 2002 season. 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. Also, these data being more evident when related to the control one.

In addition, total dry weight of shoots as well as their relation to control make them also more evident.

Moreover, of great interest also those results obtained about dry matter accumulation in branches and leaves, since increases in leaves mostly on the account of that being accumulated or directed to branches. That, because values in leaves exhibited insignificant increase but insignificant reduction was dominantly existed in case of branches, that was true only at

Table (19): Effect of polyethylene mulch surface color on dry matter distribution in different organs of tomato (*Lycopersicon esculentum*, Mill.) plants at 60 days after transplanting during 2001 and 2002 seasons.

Growth character / Treatment		Branches (including main stem) dry weight				Leaves dry weight				Total dry* weight (g/plant)		% distribution of dry matter in different plant organs				Dry weight % of total dry weight relative to the control	
		(g)/plant		% relative to the control		(g)/plant		% relative to the control				Branches (including main stem)		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
Black		8.37	9.91	185.18	340.55	25.71	32.61	218.07	373.11	34.08	42.52	24.56	23.31	75.44	76.69	208.95	364.98
Red		10.17	13.44	225.00	461.86	33.62	41.75	285.16	477.69	43.79	55.19	23.22	24.35	76.78	75.65	268.49	473.73
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	375.60	442.40
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	188.23	276.14
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	100.00	100.00
L.S.D.	0.05	1.83	2.55	77.27	112.27	5.49	11.04	45.28	128.42	6.91	12.21	5.64	5.33	5.60	7.52	40.40	106.48
	0.01	2.65	3.71	112.24	163.09	7.97	16.03	65.78	186.54	10.04	17.73	8.19	7.74	8.14	10.93	58.69	154.67

* Total dry weight = dry weight of shoots only without dry weight of roots.

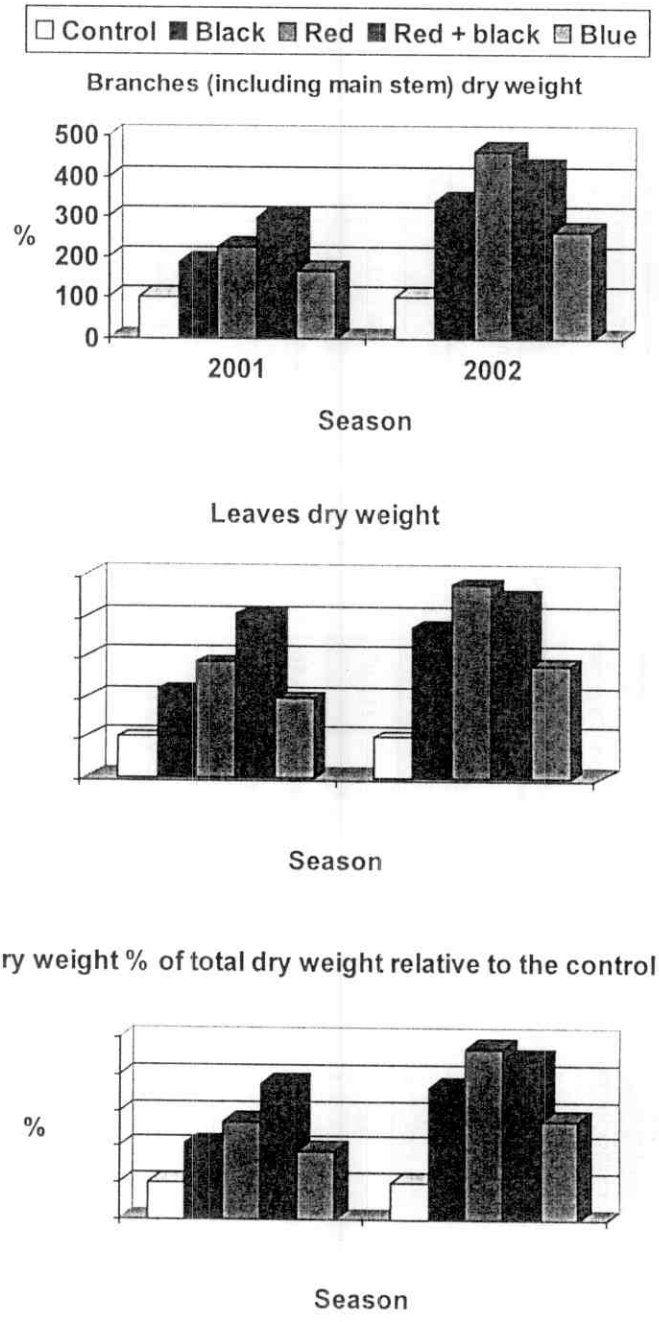


Fig. (25): Bar diagram indicating the effect of color mulches on dry matter distribution in different organs of tomato (*Lycopersicon esculentum*, Mill.) plants at 60 days after transplanting during 2001 and 2002 seasons.

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.

II.1.4. Photosynthetic pigments:

Data in Table (20) and Fig. (26) clearly indicate that different used colors of applied mulches increased each of chlorophyll a, b and carotenoids in leaves of tomato at 60 days of plant age during the two assigned seasons.

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.

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

II.1.5. Effect of mulch surface colors on absolute growth rate :

Data in Table (21) and Fig. (27) indicate, the effect of various applied mulch colors on absolute growth rate in different plant organs of tomato plant (i.e., branches and leaves) during 2001 and 2002 seasons.

As for absolute growth rate of branches was highly significantly increased in most treatments with different used mulch colors. The exception was that insignificant increase and

Table (20): Effect of polyethylene mulch surface color on photosynthetic pigments of tomato (*Lycopersicon esculentum,* Mill.) plants at 60 days after transplanting during 2001 and 2002 seasons (calculated as mg/g fresh weight).

Plant pigments / Treatment	Chlorophyll						Carotenoids		Chl. (a + b) / Carot.	
	(a)		(b)		(a + b)					
	Seasons		Seasons		Seasons		Seasons		Seasons	
	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002
Black	0.604	0.716	0.452	0.557	1.056	1.273	0.359	0.413	2.942	3.082
Red	0.714	0.795	0.552	0.597	1.266	1.392	0.443	0.465	2.858	2.994
Red + Black	0.861	0.837	0.728	0.723	1.589	1.560	0.514	0.579	3.091	2.694
Blue	0.629	0.759	0.450	0.572	1.079	1.331	0.358	0.437	3.014	3.046
Control	0.603	0.676	0.446	0.509	1.049	1.188	0.352	0.451	2.980	2.634

Chl. = Chlorophyll

Carot. = Carotenoids

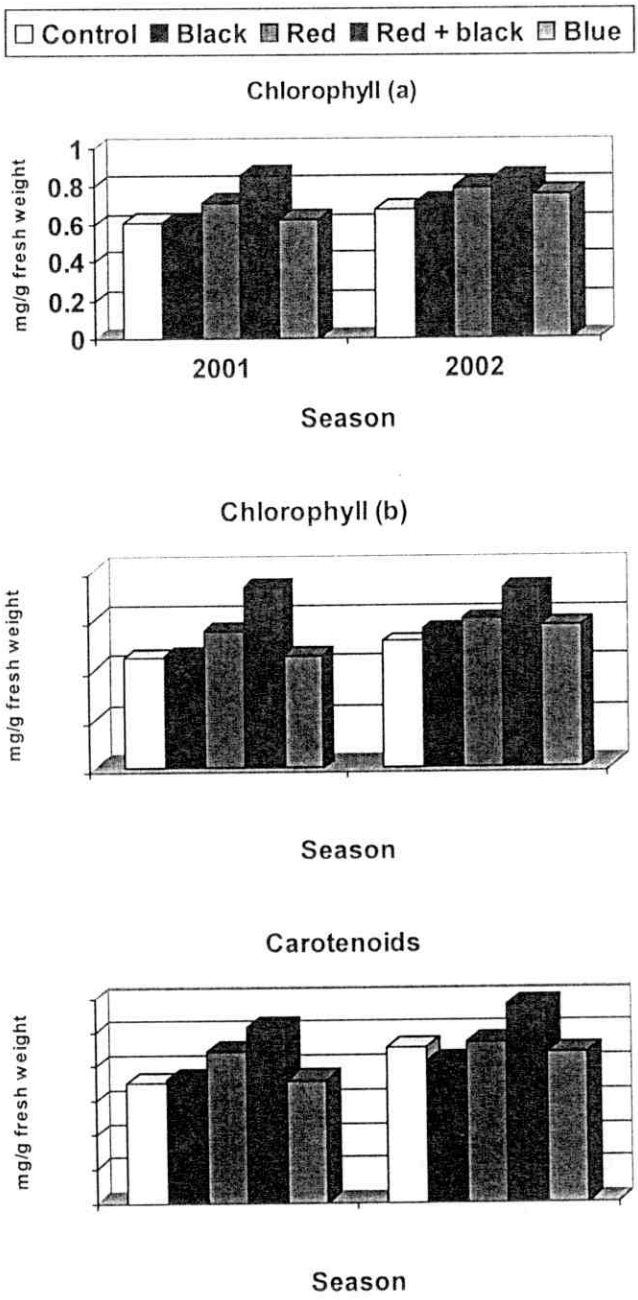


Fig. (26): Bar diagram indicating the effect of color mulches on photosynthetic pigments of tomato (*Lycopersicon esculentum*, Mill.) plants at 60 days after transplanting during 2001 and 2002 seasons.

significant increase only at 5% level with blue mulch color during 2001 and 2002 seasons, respectively. Also, it could be noticed that each of red + black and red treatment gave the highest values in this respect compared with the control. That could be more evident when related to the control values since the 100 percentage of control rose to 202.78 & 292.86 and 583.76 & 477.78% with red and red + black treatments during 2001 and 2002 seasons, respectively.

With regard to the absolute growth rate in leaves of tomato plants in case of all mulch color, it was increased to reach the highest level of significance except its significant increase only at 5% level with black mulch color during 2001 season. Meanwhile, it was only insignificantly increased with blue mulch color during the two assigned seasons. Here, also it could be noticed that red + black ranked the first followed by red during 2001 season meanwhile red ranked the first followed by red + black during 2002 season in this respect.

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 value during 2001 season meanwhile the red treatment ranked the first during 2002 season.

Recently, a photoregulatory 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.*,**

Table (21): Effect of polyethylene mulch surface color on absolute growth rate of tomato (*Lycopersicon esculentum*, Mill.) plants from 45 to 60 days after transplanting during 2001 and 2002 seasons.

Growth character / Treatment		Absolute growth rate (AGR)																	
		Branches						Leaves						Total					
		g/gm/day		% relative to the control				g/gm/day		% relative to the control				g/gm/day		% relative to the control			
		Seasons		Seasons				Seasons		Seasons				Seasons		Seasons			
		2001	2002	2001	% ±	2002	% ±	2001	2002	2001	% ±	2002	% ±	2001	2002	2001	% ±	2002	% ±
Black		0.474	0.517	188.10	+88.10	441.88	+341.88	1.077	1.609	210.76	+110.76	375.06	+275.06	1.551	2.126	203.28	+103.28	389.38	+289.38
Red		0.511	0.683	202.78	+102.78	583.76	+483.76	1.335	2.021	261.25	+161.25	471.10	+371.10	1.846	2.704	241.94	+141.94	495.24	+395.24
Red + Black		0.738	0.559	292.86	+192.86	477.78	+377.78	2.356	1.913	461.06	+361.06	445.92	+345.92	3.094	2.472	405.50	+305.50	452.75	+352.75
Blue		0.350	0.343	138.89	+ 38.89	293.16	+193.16	0.822	1.028	160.86	+60.86	239.63	+139.63	1.172	1.371	153.60	+ 53.60	251.10	+151.10
Control		0.252	0.117	100.00	0.00	100.00	0.00	0.511	0.429	100.00	0.00	100.00	0.00	0.763	0.546	100.00	0.00	100.00	0.00
L.S.D.	0.05	0.108	0.183	58.70	-	97.82	-	0.431	0.770	62.12	-	78.20	-	0.499	0.861	55.80	-	84.72	-
	0.01	0.157	0.265	72.84	-	159.42	-	0.626	1.119	106.40	-	138.26	-	0.724	1.250	107.44	-	152.70	-

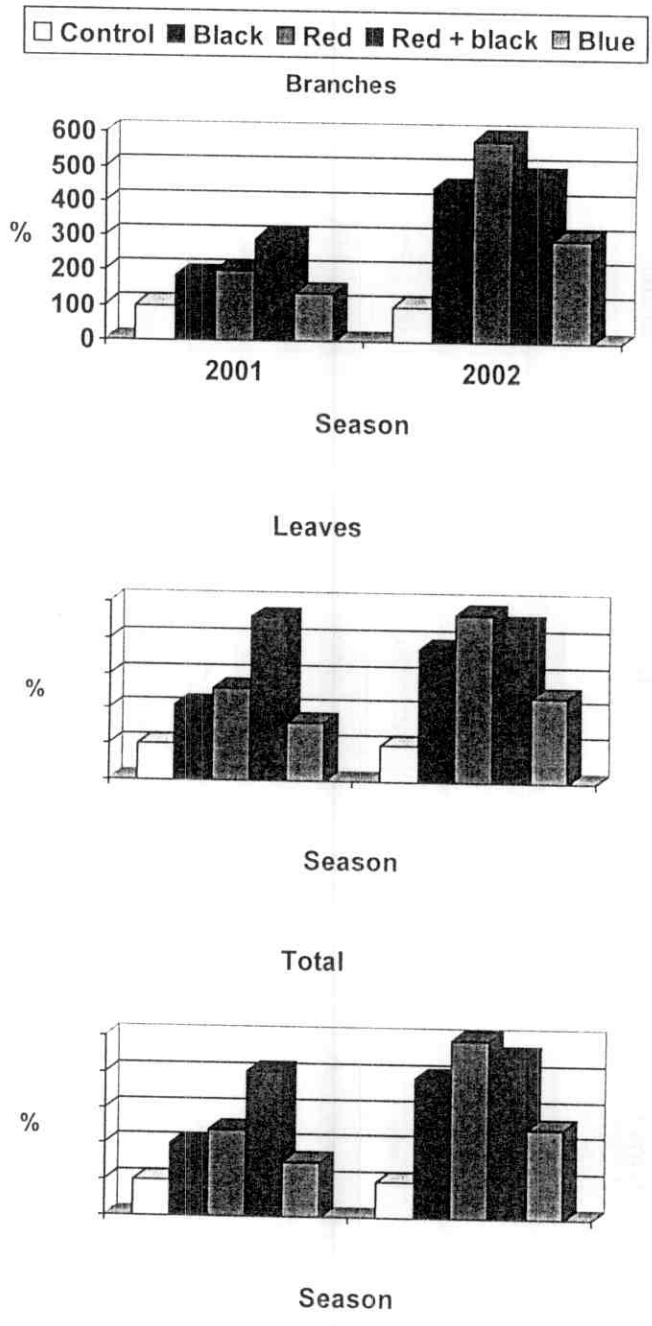


Fig. (27): Bar diagram indicating the effect of color mulches on absolute growth rate of tomato (*Lycopersicon esculentum*, Mill.) plants from 45 to 60 days after transplanting during 2001 and 2002 seasons.

1986). Differences in tomato plant development can be induced in controlled environments by exposure to red (R) and far-red (FR) light, implicating phytochrome 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.

II.2. Sweet pepper plants:

II.2.1. Vegetative characteristics:

As for plant height, insignificant increase was existed with different applied mulch colors during the two assigned seasons. The only exception was that insignificant decrease with black mulch surface color during 2001 season Table (22) and Fig. (28).

With regard to the stem diameter its high significant increase existed with different mulch colors except that significant increase at 5% level with blue and black mulch colors during 2001 and 2002 seasons, respectively. Also, in this respect black and red colors exhibited insignificant increase during 2001 season. Here, it is of interest to note that increasing stem diameter led to vigorous growth and more healthy sweet pepper plants.

Table (22): Effect of polyethylene mulch surface color on some morphological characteristics of sweet pepper (*Capsicum annuum* L.) plants at 60 days after transplanting during 2001 and 2002 seasons.

Growth character / Treatment		Plant height (cm)		Stem diameter (cm)		stems fresh* weight (g/plant)		Leaves fresh weight (g/plant)		Shoots fresh weight (g/plant)	
		Seasons		Seasons		Seasons		Seasons		Seasons	
		2001	2002	2001	2002	2001	2002	2001	2002	2001	2002
Black		20.00	20.93	1.20	0.80	26.52	14.56	36.53	27.04	63.05	41.60
Red		25.17	22.00	1.27	1.15	42.51	36.81	68.21	54.11	110.72	90.92
Red + Black		21.67	23.83	1.40	1.25	60.27	38.27	93.27	71.73	153.54	110.00
Blue		24.83	20.67	1.33	1.07	38.96	26.03	52.52	45.94	91.48	71.97
Control		21.60	19.30	1.03	0.70	23.42	10.25	20.34	17.44	43.76	27.69
L.S.D.	0.05	4.66	5.67	0.25	0.08	16.03	4.60	16.43	14.35	25.65	15.76
	0.01	6.76	8.24	0.36	0.12	23.28	6.69	23.86	20.84	37.26	22.90

* Stems are including each of main stem and branches.

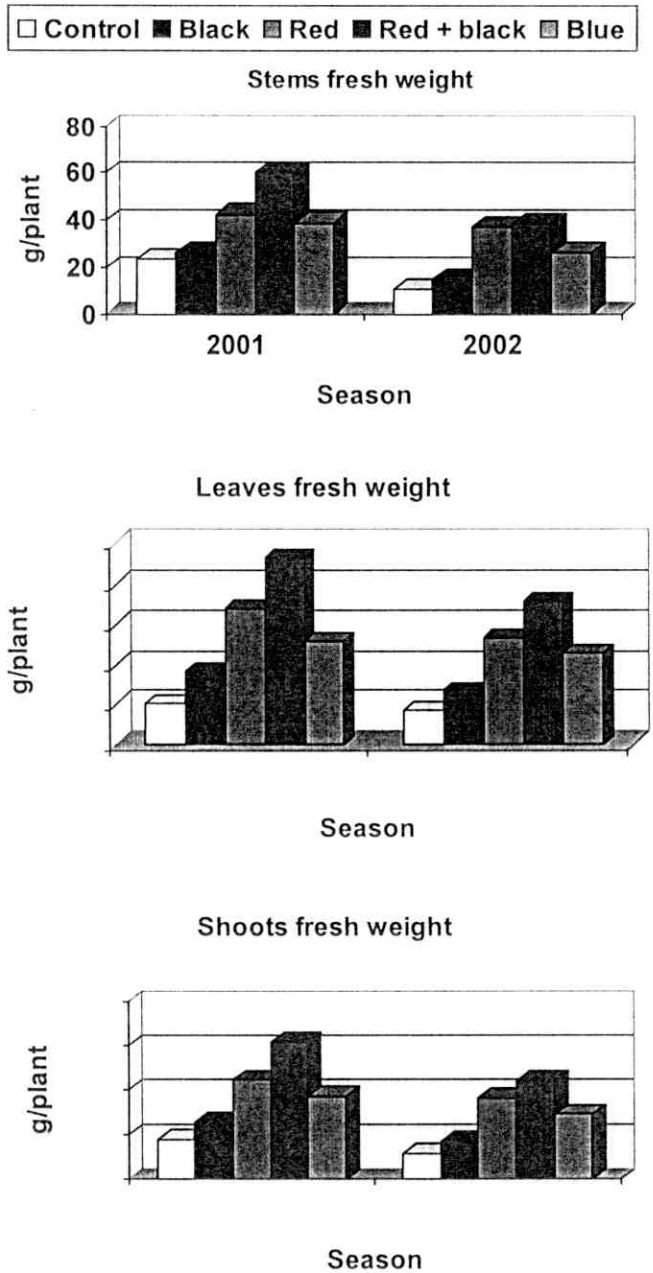


Fig. (28): Bar diagram indicating the effect of color mulches on some morphological characteristics of pepper (*Capsicum annuum*, L.) plants at 60 days after transplanting during 2001 and 2002 seasons.

Concerning the effect of different applied mulch colors on the fresh weight of stems and leaves, data shown in Table (22) indicate that, stems fresh weight was highly significantly increased with different mulch colors except that significant increase only at 5% level with red mulch color during 2001 season and insignificantly increased with black mulch color during the two seasons and with blue one during first season.

In addition, high significant increases existed in leaves fresh weight with various applied mulch surface colors. The exception was that only insignificant increase with black mulch color during 2001 and 2002 seasons. Also, it could be noticed that red + black ranked the first in this respect followed by red, blue and black mulch colors during the two assigned seasons.

In general, shoots fresh weight was significantly increased with all various used mulch colors to reach the two levels of significance but the exception was only that insignificant increase with black mulch color during 2001 and 2002 seasons.

In addition, **Erwin (1998)** reported that diurnal temperature fluctuation interacts with light quality and photoperiod to affect plant stem elongation. Stem cell elongation but not division increases as day temperature increases relative to night temperature and as day length increases for many species. The effect of diurnal temperature fluctuation and photoperiod on stem elongation are mediated *via* phytochrome where stem elongation increases as % Pfr decreases.

II.2.2. Branches and leaves characteristics:

Data presented in Table (23) and Fig. (29) reveal that the number of branches formed on sweet pepper plants at 60 days

Table (23): Effect of polyethylene mulch surface color on leaf characteristics of sweet pepper (*Capsicum annuum* L.) plants at 60 days after transplanting during 2001 and 2002 seasons.

Growth character / Treatment		No. of branches / plant		No. of leaves / plant		Leaf area / plant (cm^2)		Leaves dry weight (g/plant)		Leaf area ratio (L.A.R.) (cm^2/g)		Specific leaf weight (S.L.W.) (mg/cm^2)	
		Seasons		Seasons		Seasons		Seasons		Seasons		Seasons	
		2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002
Black		17.00	12.67	56.33	41.33	371.15	390.35	4.87	4.44	34.75	59.41	13.12	11.37
Red		30.33	27.33	116.00	96.00	998.38	945.03	12.34	9.64	50.22	64.03	12.36	10.20
Red + Black		34.00	30.67	116.14	114.33	1333.13	1348.72	16.83	14.03	50.40	69.49	12.62	10.40
Blue		17.33	17.00	91.33	90.33	679.19	678.37	8.45	7.38	47.46	55.47	12.44	10.88
Control		11.33	6.67	48.33	42.33	245.25	225.57	3.06	2.64	33.74	53.96	12.48	11.70
L.S.D.	0.05	5.94	3.43	12.50	10.79	155.91	193.43	3.06	3.11	14.33	15.82	2.13	3.09
	0.01	8.63	4.98	18.16	15.67	226.47	280.97	4.44	4.52	20.81	22.98	3.09	4.49

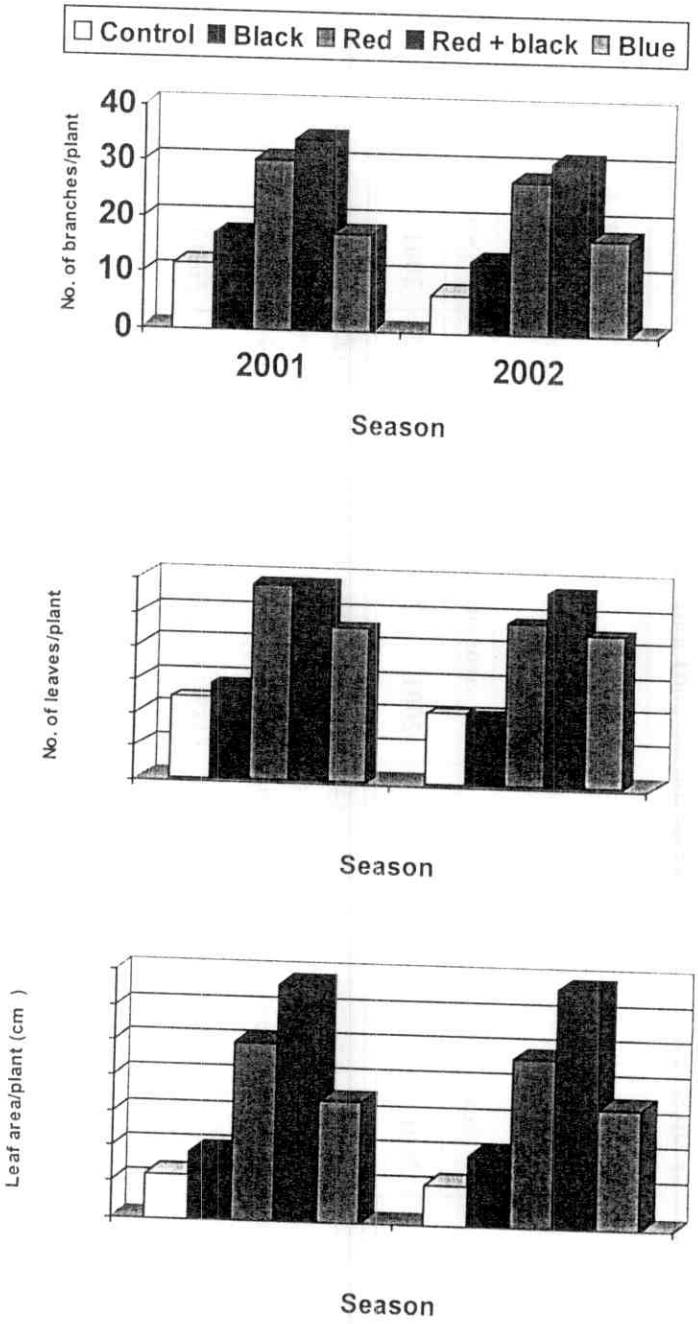


Fig. (29): Bar diagram indicating the effect of color mulches on some leaf characteristics of pepper (*Capsicum annuum*, L.) plants at 60 days after transplanting during 2001 and 2002 seasons.

after transplanting in most cases significant increase only at 5% level with blue mulch color and insignificant increase with black one were existed during first season. In this respect, red +black gave the highest number those reached to 34.00 and 30.67 branch per plant during 2001 and 2002 season, respectively, meanwhile values were 11.33 and 6.67 branch per plant in case of control plants. In general, 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.

As for number of leaves it could be noticed that it was increased to reach the high level of significance with different mulch colors applied during 2001 and 2002 seasons while black color gave insignificant increase during first season and insignificant decrease during second season.

Also, the red + black and red treatment gave the highest values in this respect.

Regarding, the total leaf area per plant it could be noticed that, nearly behaved as the same as the number of leaves. Since, the red and red + black gave the highest values when compared with the bare soil. These values reached more than fourth and fifth times with red and red + black in 2001 and 2002 seasons, respectively. Enhancement of leaf area is of great interest because that could be led to not only more efficiency of photosynthesis but also synthesizing more assimilates and high rates of their translocation specially toward sink sites, i.e. the formed fruits.

With regard to leaves dry weight, all used mulch colors increased it to reach the highest level of significance. The exception was only that insignificant increase with black mulch surface color during the two assigned seasons. Also, this weight was increased with red + black and red mulch colors to reach more than fifth and fourth times, respectively during first season and more than fifth and three times during second season comparing with control values. These data led to the above mentioned possibility for increasing early and total yielded fruits. Also, these data clearly indicate that sweet pepper plants grown above mulch colors specially red and red +black not only flowered earlier than those grown above black and blue colors but also could more of total yielded fruits.

Furthermore, the calculated leaf area ratio and specific leaf weight could be support the previously mentioned data about the vigorous growth of sweet pepper plants grown above mulch colors comparing with the control plants.

In addition, a part from being able to use light signals in controlling vertical and radial shoot expansion, plants have mechanisms that relay information about the canopy light environment into system that control branching patterns and assimilate allocation to reproductive structures and vegetative storage organs (e.g., bulbs and roots). Thus, experiments under natural radiation have demonstrated that, in open grass canopies, the decrease in the R: FR ratio caused by neighboring plants can reduce branching (tillering) rate even if the production of new branches is not limited by the availability of the photosynthetically active radiation (PAR) **(Casal *et al.*, 1986 and Ballare *et al.*, 1995).**

II.2.3. Dry matter distribution:

Data in Table (24) and Fig. (30) clearly indicate the effect of various applied mulch surface colors on dry matter production and distribution in branches (including main stem) and leaves of sweet pepper plants at 60 days after transplanting.

As for branches dry weight, it could be noticed that it was increased to reach the high level of significance in most cases of applied mulch colors meanwhile, significantly increased at 5% level with red mulch color during 2001 season and insignificantly increased with black mulch color during 2001 & 2002 seasons and blue one as well in the first season. Also, it could be noticed that red + black color gave the highest value when related to the control value. Since, the 100 percentage of control rose to 228.5 and 349.35% with red + black mulch during 2001 and 2002 seasons, respectively.

Regarding, leaves dry weight it was increased to reach the high level of significance with red, red + black and blue mulch colors during the two assigned seasons. Meanwhile, black one was insignificantly increased it. Also, red + black treatment was more pronounced in this respect followed by red, blue and black one. Therefore, total dry weight of shoots also behaved as the same as the branches and leaves dry weights with different applied mulch colors and also with the priority of red + black one. Moreover, the percentage of dry matter distribution exhibited significant increase in leaves with red and red + black mulch colors during first season meanwhile blue one was significantly increased it at 5% level in the same season. Also, it could be noticed the priority of red + black mulch color in this respect.

Table (24): Effect of polyethylene mulch surface color on dry matter distribution in different organs of sweet pepper (*Capsicum annuum* L.) plants at 60 days after transplanting during 2001 and 2002 seasons.

Growth character / Treatment		Branches (including main stem) dry weight				Leaves dry weight				Total dry* weight (g/plant)		% distribution of dry matter in different plant organs				Dry weight % of total dry weight relative to the control	
		(g)/plant		% relative to the control		(g)/plant		% relative to the control				Branches (including main stem)		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
Black		5.81	2.13	138.00	138.31	4.87	4.44	159.15	168.18	10.68	6.57	54.40	32.42	45.60	67.58	146.91	157.18
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	270.70	353.11
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	363.82	464.35
Blue		5.86	4.85	139.19	314.94	8.45	7.38	276.14	279.55	14.31	12.23	40.95	39.66	59.05	60.34	196.84	292.58
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	100.00	100.00
L.S.D.	0.05	3.03	1.16	62.30	81.18	3.06	3.11	105.85	124.98	6.77	3.27	12.61	10.90	12.58	10.92	133.91	83.32
	0.01	4.40	1.68	135.77	117.92	4.44	4.52	153.76	181.55	9.83	4.76	18.32	15.85	18.27	15.87	194.52	121.03

* Total dry weight = dry weight of shoots only without dry weight of roots.

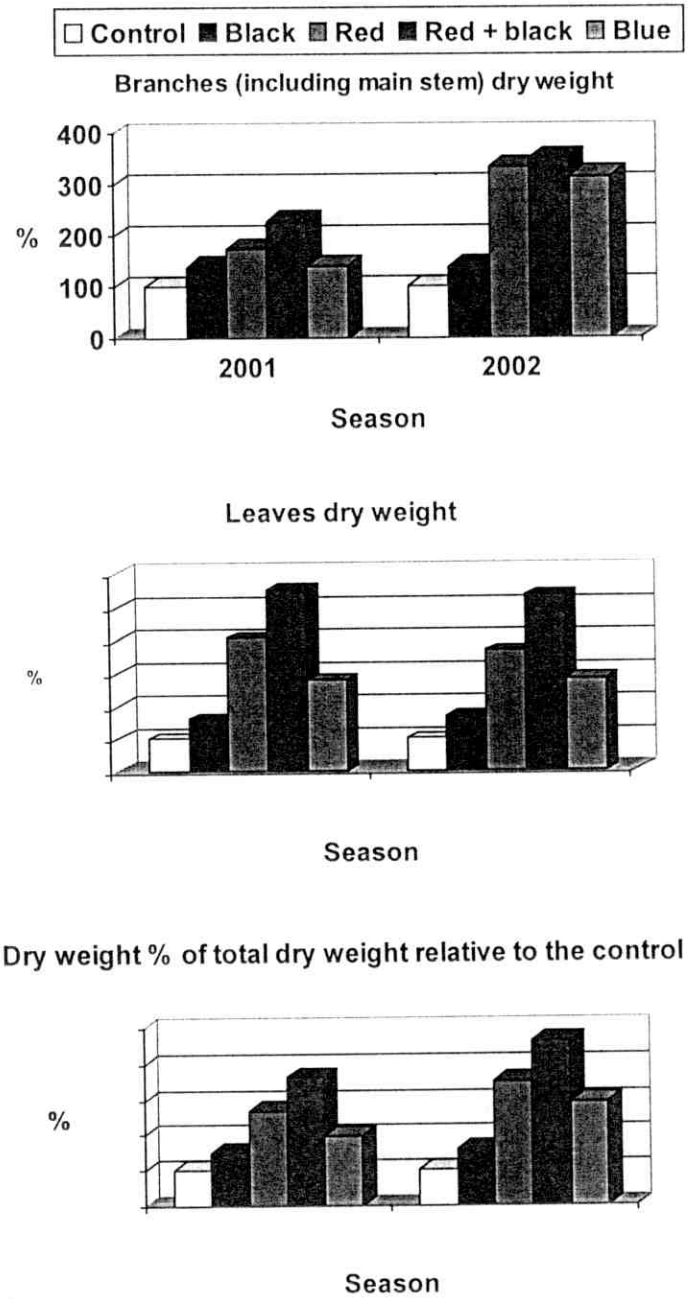


Fig. (30): Bar diagram indicating the effect of color mulches on dry matter distribution in different organs of pepper (*Capsicum annuum*, L.) plants at 60 days after transplanting during 2001 and 2002 seasons.

In general, data in Table (24) clearly indicate that, the direct results for vigorous growth obtained in Tables (22 & 23) could be considered on indicator for expectable not only high early but also total yielded fruits.

The FR: R ratio plays a major role in assimilate portioning during growth and influences plant adaptation to competition from other plants **(Kasperbauer, 1988).** The ratio acts through the phytochrome system to regulate stem elongation, chloroplast development and photosynthate partitioning among shoots, roots and developing fruits **(Kasperbauer, 1987).**

II.2.4. Photosynthetic pigments:

Data in Table (25) and Fig. (31) indicate that different photosynthetic pigments as chlorophylla, b and carotenoids were positively responded to the different applied mulch colors treatment during the two assigned seasons. Also, red + black and red one gave the highest values in this respect comparing with the control plants. Also, the stimulation of photosynthetic pigments formation could be attributed to the vigorous growth obtained in Tables (22 & 23). Increasing of chlorophylls and carotenoids concentration were enhanced photosynthesis efficiency and increase dry matter production. Also, this enhancement could be indicator for expectable high early and total yielded fruits.

II.2.5. Effect of mulch surface colors on absolute growth rate:

As for absolute growth rate of branches was highly significantly increased in most treatments with different used

Table (25): Effect of polyethylene mulch surface color on photosynthetic pigments of sweet pepper (*Capsicum annuum*, L.) plants at 60 days after transplanting during 2001 and 2002 seasons (calculated as mg/g fresh weight).

Plant pigments / Treatment	Chlorophyll						Carotenoids		Chl. (a + b) / Carot.	
	(a)		(b)		(a + b)					
	Seasons		Seasons		Seasons		Seasons		Seasons	
	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002
Black	0.593	0.572	0.415	0.403	1.008	0.975	0.366	0.391	2.754	2.494
Red	0.752	0.713	0.549	0.508	1.301	1.221	0.476	0.412	2.733	2.964
Red + Black	0.839	0.794	0.644	0.529	1.483	1.323	0.516	0.443	2.874	2.986
Blue	0.722	0.650	0.474	0.445	1.196	1.095	0.351	0.349	3.407	3.138
Control	0.551	0.553	0.357	0.328	0.908	0.881	0.344	0.308	2.640	2.860

Chl. = Chlorophyll

Carot. = Carotenoids

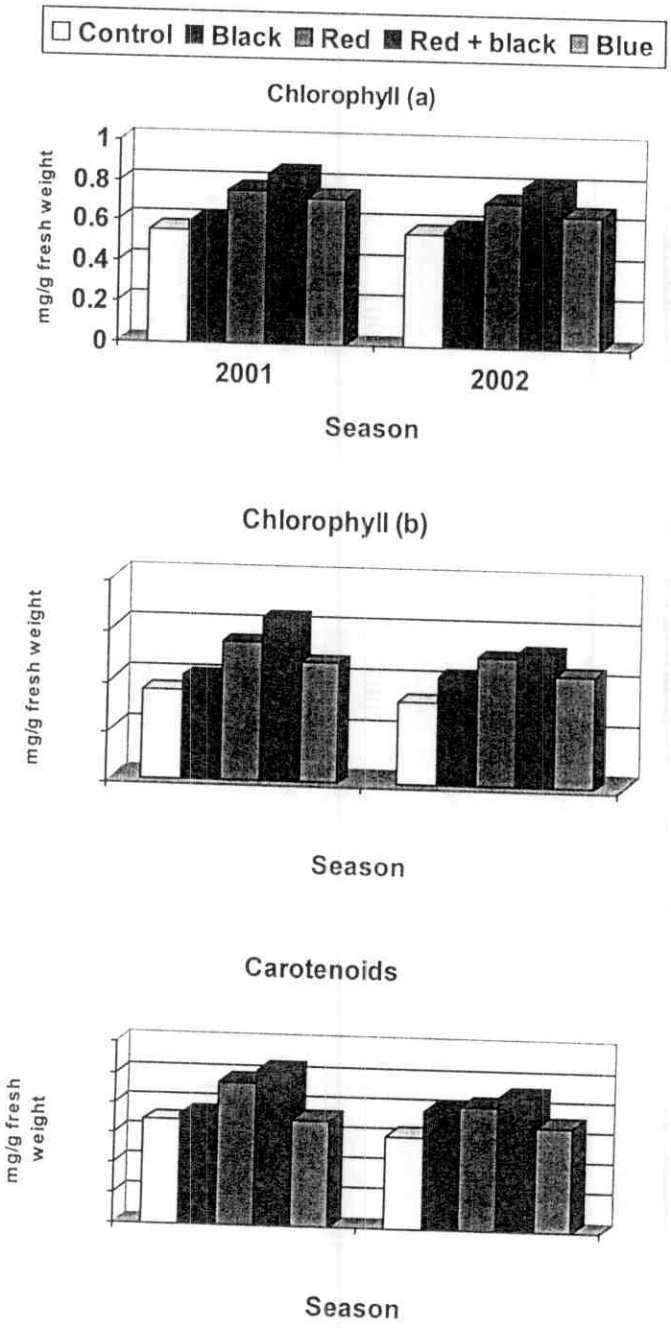


Fig. (31): Bar diagram indicating the effect of color mulches on photosynthetic pigments of pepper (*Capsicum annuum*, L.) plants at 60 days after transplanting during 2001 and 2002 seasons.

mulch colors (Table, 26) and Fig. (32). The exception was that insignificant increase with black mulch color during 2001 and 2002 seasons as well as with red and blue mulch colors during fist season. Also, it could be noticed that each of red + black and red treatments gave the highest values in this respect 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 166.93 & 231.10 and 331.25 & 378.75% with red and red + black mulch colors during 2001 and 2002 seasons, respectively.

With regard to the absolute growth rate in leaves of sweet pepper plants in case of all mulch surface color, it was increased to reach the highest level of significance except its significant increase only at 5% level with blue mulch color during 2002 season. Meanwhile, it was only insignificantly increased with black color during the two assigned seasons. Here, also it could be noticed that red + black ranked the first in this respect followed by red, blue and black mulch colors in descending order during the two seasons. Also, red + black treatment was more pronounced in this respect. Since, increases reached to about six times more than the control value during 2001 and reached to more than fifth times during 2002 season. 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 value in this respect followed by red one.

Table (26): Effect of polyethylene mulch surface color on absolute growth rate of sweet pepper (*Capsicum annuum* L.) plants from 45 to 60 days after transplanting during 2001 and 2002 seasons.

Growth character / Treatment		Absolute growth rate (AGR)																	
		Branches						Leaves						Total					
		g/gm/day		% relative to the control				g/gm/day		% relative to the control				g/gm/day		% relative to the control			
		Seasons		Seasons				Seasons		Seasons				Seasons		Seasons			
		2001	2002	2001	% ±	2002	% ±	2001	2002	2001	% ±	2002	% ±	2001	2002	2001	% ±	2002	% ±
Black		0.348	0.111	137.01	+37.01	138.75	+38.75	0.239	0.233	159.33	+59.33	157.43	+57.43	0.578	0.344	145.30	+45.30	150.88	+50.88
Red		0.424	0.265	166.93	+66.93	331.25	+231.25	0.669	0.479	446.00	+346.00	323.65	+223.65	1.093	0.744	270.54	+170.54	326.32	+226.32
Red + Black		0.587	0.303	231.10	+131.10	378.75	+278.75	0.984	0.789	656.00	+556.00	533.11	+433.11	1.751	1.092	388.86	+288.86	478.95	+378.95
Blue		0.330	0.259	129.92	+ 29.92	323.75	+223.75	0.453	0.396	290.00	+190.00	267.57	+167.57	0.765	0.655	189.36	+ 89.36	287.28	+187.28
Control		0.254	0.080	100.00	0.001	100.00	0.00	0.150	0.148	100.00	0.00	100.00	0.00	0.404	0.228	100.00	0.00	100.00	0.00
L.S.D.	0.05	0.208	0.093	62.80	-	77.12	-	0.186	0.202	92.70	-	84.70	-	0.351	0.215	68.40	-	72.20	-
	0.01	0.302	0.135	98.75	-	104.98	-	0.271	0.293	153.42	-	118.92	-	0.509	0.311	99.18	-	109.82	-

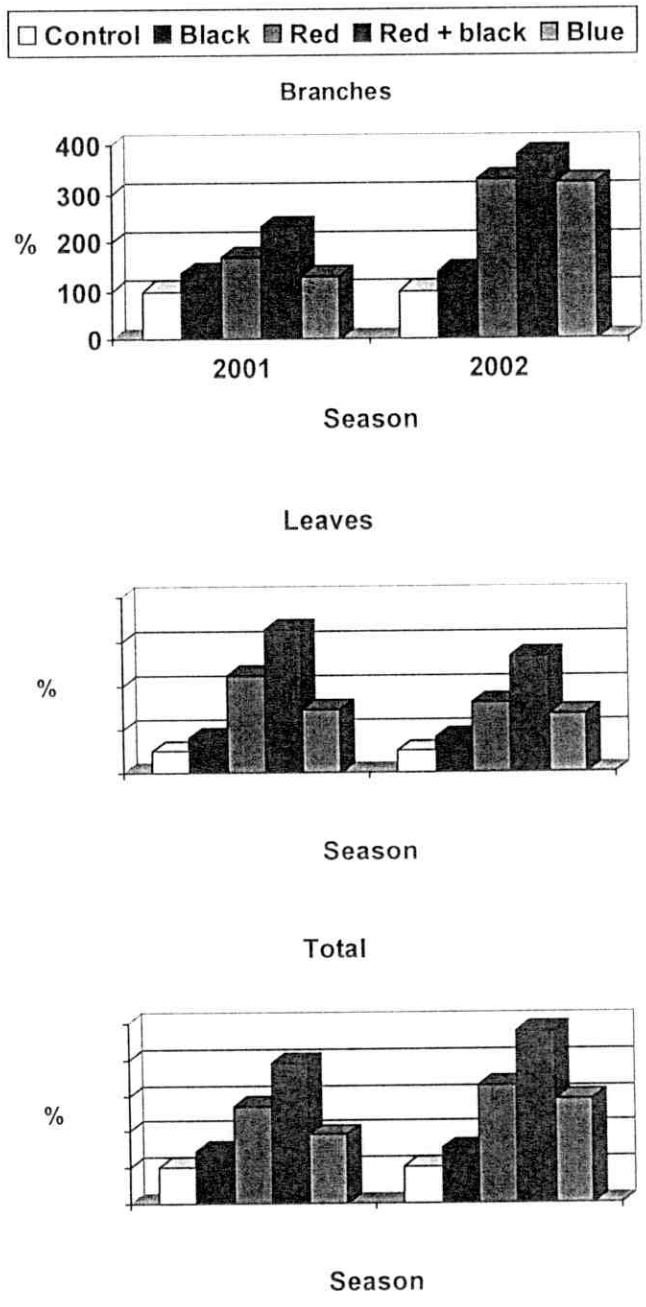


Fig. (32): Bar diagram indicating the effect of color mulches on absolute growth rate of pepper (*Capsicum annuum*, L.) plants from 45 to 60 days after transplanting during 2001 and 2002 seasons.

III. Chemical composition:

III.1. Tomato plants:

III.1.1. Minerals and crude protein concentration:

III.1.1.1. At 45 days after transplanting:

With regard to the mineral concentration in tomato leaves data in Table (27) and Fig. (33) clearly indicate that different used mulch colors increased N, P, K, Ca and Mg concentrations in leaves of tomato plants at 45 days after transplanting during 2001 & 2002 seasons. Also, it could be noticed that the highest increase of any of these elements reached with red mulch alone or that used as red +black treatment. Since, red color gave the highest concentration of N & K during the two seasons and P, Mg and Ca during second and first seasons, respectively. Meanwhile, red +black treatment gave the highest concentration of P and Ca during first and second seasons, respectively. These results being reached their maximum with red followed by red + black, black but blue one ranked the last during 2001`and 2002 seasons.

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 concentration during two assigned seasons. So, protein concentration of different mulch treatment was higher when related to the control ones.

Table (27): Effect of polyethylene mulch surface color on minerals and crude protein concentration of tomato *(Lycopesicon esculentum, Mill.)* leaves at 45 days after transplanting during 2001 and 2002 seasons.

Chemical composition / Treatment	N mg/g dry weight		P mg/g dry weight		K mg/g dry weight		Ca mg/g dry weight		Mg mg/g dry weight		Total determined elements mg/g dry weight		Crude protein			
													mg/g dry weight		% relative to the control	
	Seasons		Seasons		Seasons		Seasons		Seasons		Seasons		Seasons		Seasons	
	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002
Black	41.64	46.86	4.50	5.02	42.34	43.42	37.06	37.73	5.09	5.11	130.63	138.14	260.25	292.88	108.61	117.56
Red	50.35	51.67	5.48	5.64	46.82	45.41	38.81	39.25	5.72	5.82	147.18	147.79	314.68	322.94	131.33	129.63
Red + Black	48.32	51.24	5.72	5.28	46.03	45.23	38.43	39.44	5.78	5.80	144.28	146.99	302.00	320.25	126.03	128.55
Blue	40.81	44.68	4.69	4.78	39.67	41.85	36.57	36.02	5.12	5.18	126.86	132.51	255.06	279.25	106.44	112.10
Control	38.34	39.86	4.18	4.34	37.08	39.44	30.64	31.84	4.05	4.28	114.29	119.76	239.62	249.12	100.00	100.00

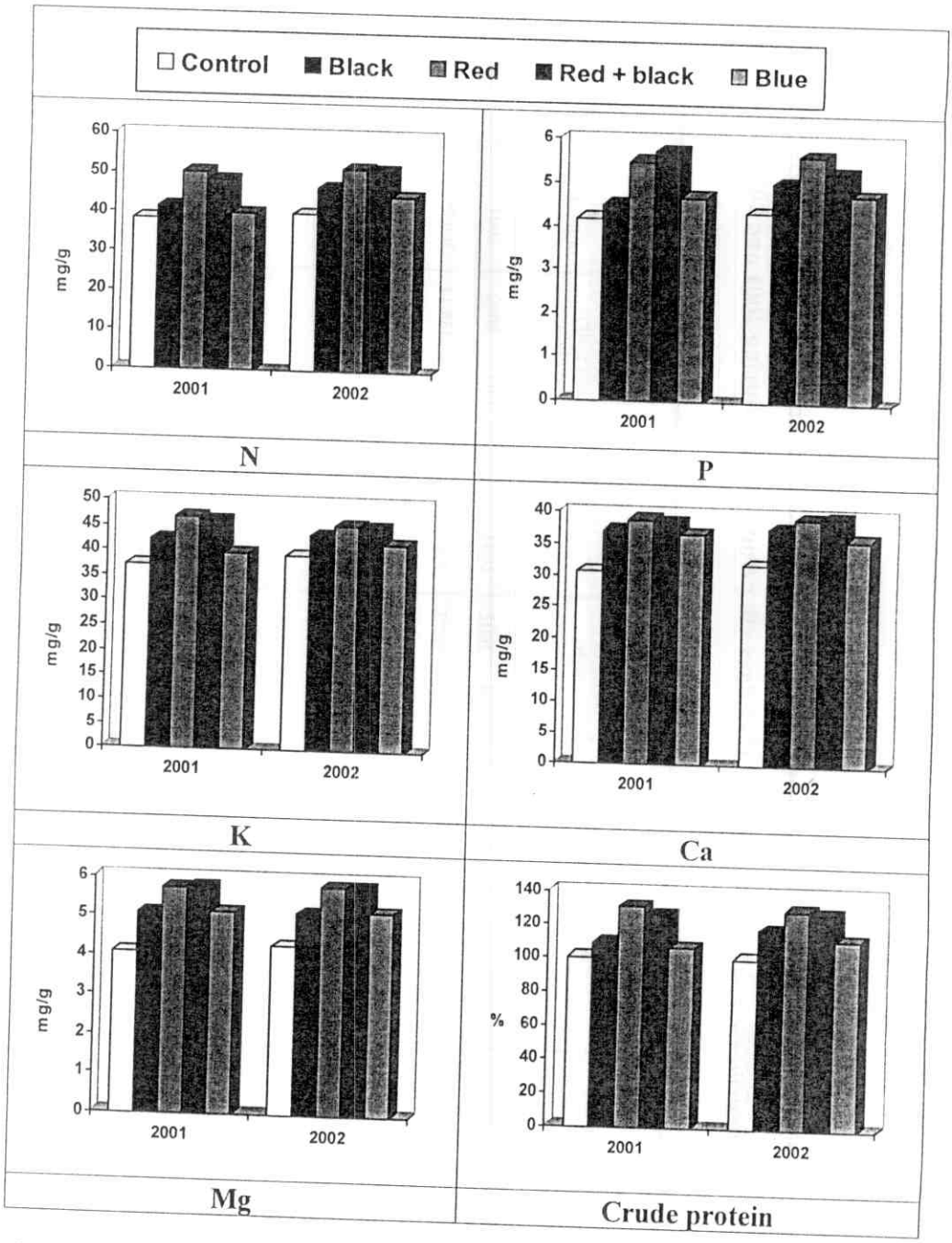


Fig. (33): Bar diagram indicating the effect of color mulches on minerals (mg/g dry weight) and crude protein (% relative to the control) of tomato (*Lycopersicon esculentum*, Mill.) leaves at 45 days after transplanting during 2001 and 2002 seasons.

III.1.1.2. At 60 days after transplanting:

Data in Table (28) and Fig. (34) clearly indicate that different minerals and crude protein in leaves of tomato plants grown above mulch colors at 60 days after transplanting behaved as the same as at 45 days during the two assigned seasons of the present study. Also red color showed the highest concentration of N, P, K elements and the crude protein during the two seasons. Meanwhile, red + black treatment gave the highest concentration of Ca and Mg also during the two assigned seasons.

In this respect, data in Tables (27 & 28) clearly indicate that color mulches increased the absorption of different elements by roots and also their translocation and accumulation in leaves. That was not only the case but also increased the crude protein concentration as one of the individual and principals bioconstituents.

On the other hand, some microelement concentration at 60 days after transplanting as shown in Table (29) and Fig. (35) it is more evident that various used mulch colors increased iron and manganese but decreased zinc concentrations in tomato leaves at 60 days after transplanting during 2002 season.

Also, it could be noticed that red mulch when used alone or above the black one was superior in this respect. Since iron concentration reached nearly the values of two times of that of control with red + black treatment. On the other hand, the highest reduction of zinc concentration existed with red mulch treatment. That could be mainly attributed to the fact that these elements being distributed into more plant material production.

Table (28): Effect of polyethylene mulch surface color on minerals and crude protein concentration of tomato *(Lycopesicon esculentum, Mill.)* leaves at 60 days after transplanting during 2001 and 2002 seasons.

Chemical composition / Treatment	N mg/g dry weight		P mg/g dry weight		K mg/g dry weight		Ca mg/g dry weight		Mg mg/g dry weight		Total determined elements mg/g dry weight		Crude protein			
													mg/g dry weight		% relative to the control	
	Seasons		Seasons		Seasons		Seasons		Seasons		Seasons		Seasons		Seasons	
	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002
Black	47.42	48.14	5.18	5.46	45.61	47.28	37.63	38.21	5.22	5.40	141.06	144.49	296.38	300.88	117.55	112.48
Red	51.77	52.86	6.04	6.20	48.23	49.44	39.05	39.46	5.84	5.96	150.93	153.92	323.56	330.38	128.33	123.51
Red + Black	49.34	50.78	5.78	6.12	47.82	48.63	39.27	39.64	5.92	5.98	148.13	151.15	308.38	317.38	122.31	118.65
Blue	45.73	47.82	4.96	5.34	45.16	45.86	37.29	35.05	5.32	5.58	138.46	139.65	285.81	298.87	113.36	111.73
Control	40.34	42.80	4.54	4.42	43.24	44.28	32.82	34.24	4.36	4.62	125.30	132.56	252.13	267.50	100.00	100.00

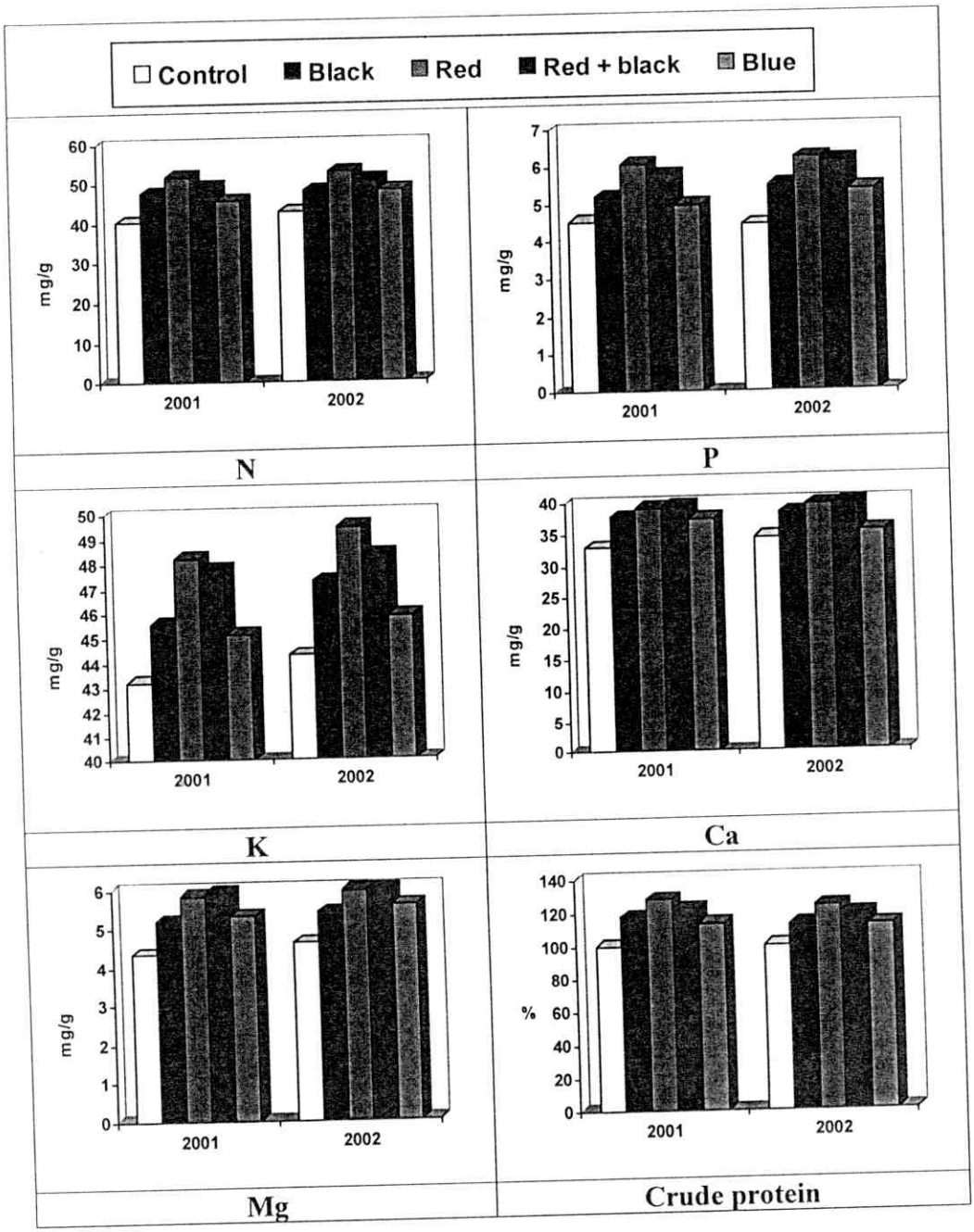


Fig. (34): Bar diagram indicating the effect of color mulches on minerals (mg/g dry weight) and crude protein (% relative to the control) of tomato (*Lycopersicon esculentum*, Mill.) leaves at 60 days after transplanting during 2001 and 2002 seasons.

Table (29): Effect of polyethylene mulch surface color on iron, zinc and manganese concentration of tomato (*Lycopersicon esculentum*, Mill.) plants at 60 days after transplanting during 2002 season.

Chemical composition / Treatment	Iron (Fe)			Zinc (Zn)			Manganese (Mn)		
	ppm	% relative to the control	% ±	ppm	% relative to the control	% ±	ppm	% relative to the control	% ±
Black	115.75	115.46	+ 15.46	71.00	90.16	-9.84	54.50	104.31	+4.31
Red	150.28	149.91	+49.91	57.78	73.37	-26.63	77.75	148.80	+48.80
Red + Black	211.75	211.22	+111.22	66.38	84.29	-15.71	80.50	154.07	+54.07
Blue	118.00	117.71	+17.71	76.50	97.14	-2.86	58.75	112.44	+12.44
Control	100.25	100.00	0.00	78.75	100.00	0.00	52.25	100.00	0.00

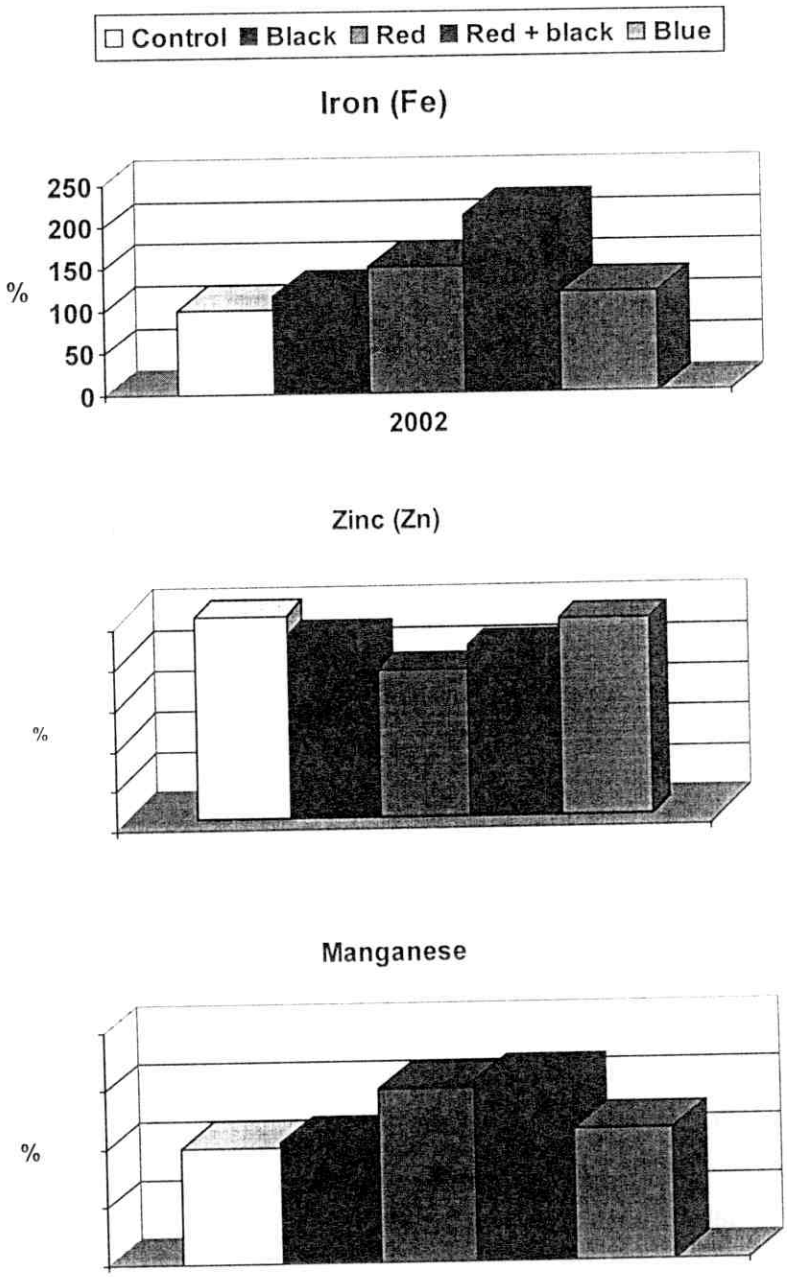


Fig. (35): Bar diagram indicating the effect of color mulches on iron, zinc and manganese concentration of tomato (*Lycopersicon esculentum*, Mill.) plants at 60 days after transplanting during 2002 seasons.

III.1.2. Sugars and carbohydrates concentration at 45 and 60 days after transplanting :

As shown in Tables (30 & 31) and Figs. (36 & 37) it could be clearly noticed that total carbohydrates in leaves (mg/dry weight) were increased with different used mulch colors during 2001 and 2002 seasons at the two time of determination, i.e. at 45 &60 days after transplanting.

Here, also, red mulch color when used above black mulch gave the highest of total carbohydrates concentration at 45 days during 2001 season, yet, red color alone showed maximum carbohydrates concentrations during 2002 season.

Also, black mulch followed the red one meanwhile blue mulch gave the lowest carbohydrates concentration. That was true at the two times of determination during the two assigned seasons.

In this respect, high concentration of total carbohydrates is a direct result for high rates of photosynthesis with great efficiency. That was preceded with large photosynthetic area (Tables, 10 & 18) and high concentration of photosynthetic pigments (Tables, 12 & 20) as well under the treatment of various mulch colors but it reached its maximum with red one.

So, red mulch being reflected more red and far-red light (Tables, 2, 3, 4 and 5) to again penetrate the photosynthetic area of growing tomato plants that is related with the alteration of R/FR ratio. Alterations of R/FR ratio has been recommended to increase photoassimilate accumulation in and translocation out, of the photosynthetic leaves **Kasperbauer (1987, 1988, 1992 and 2000), Kasperbauer and Hunt (1998) and Runkle and Heins (2001).**

Table (30): Effect of polyethylene mulch surface color on sugars and carbohydrates concentrations and contents of tomato *(Lycopersicon esculentum Mill.)* leaves at 45 days after trans planting during 2001 and 2002 seasons.

Chemical composition / Treatment	Total carbohydrates						Reducing sugars mg/g fresh weight		Non reducing sugars mg/g fresh weight		Total sugars					
	mg/g dry weight		(g) / Leaves		% relative to the control						mg/g fresh weight		(g) / Leaves		% relative to the control	
	Seasons		Seasons		Seasons		Seasons		Seasons		Seasons		Seasons		Seasons	
	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002
Black	422.92	418.09	4.04	3.55	234.88	381.72	17.95	18.24	8.45	8.88	26.40	27.12	1.41	1.31	276.47	262.00
Red	502.67	495.42	6.84	5.66	397.67	608.60	23.89	22.62	10.73	14.62	34.62	37.24	2.61	2.57	511.76	514.00
Red + Black	509.92	505.09	6.34	5.39	368.60	579.57	24.62	25.32	11.68	13.84	36.30	39.16	2.39	2.21	468.63	442.00
Blue	468.84	456.75	5.15	4.15	299.42	446.42	20.57	21.24	9.68	10.48	30.25	31.72	1.88	1.69	368.63	338.00
Control	416.88	403.59	1.72	0.93	100.00	100.00	13.59	15.60	6.69	8.78	20.28	24.38	0.51	0.50	100.00	100.00

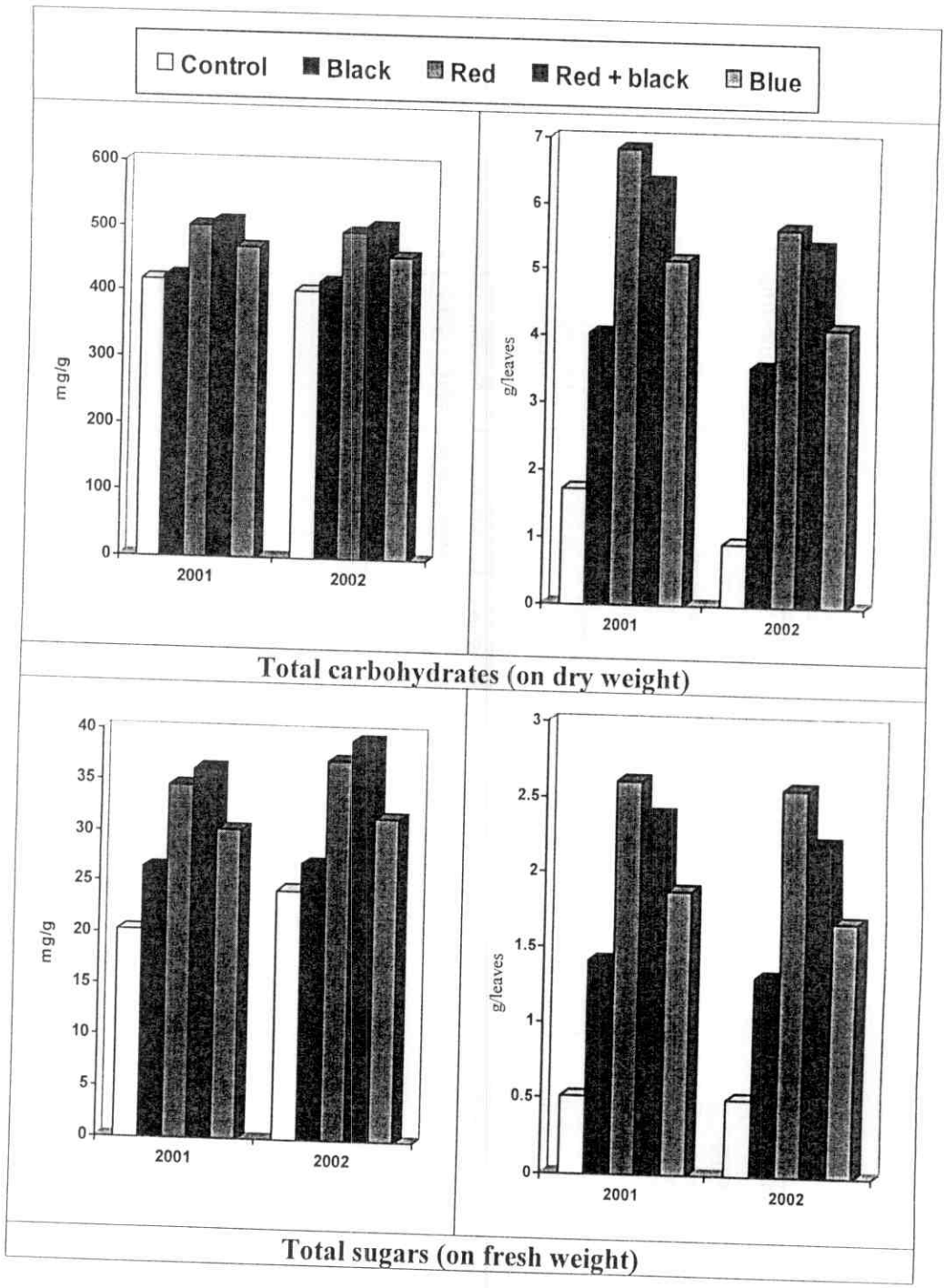


Fig. (36): Bar diagram indicating the effect of color mulches on sugars and carbohydrates concentration and content of tomato (*Lycopersicon esculentum*, Mill.) leaves at 45 days after transplanting during 2001 and 2002 seasons.

Table (31): Effect of polyethylene mulch surface color on sugars and carbohydrates concentration and content of tomato *(Lycopersicon esculentum Mill.)* leaves at 60 days after transplanting during 2001 and 2002 seasons.

Chemical composition / Treatment	Total carbohydrates						Reducing sugars mg/g fresh weight		Non reducing sugars mg/g fresh weight		Total sugars					
	mg/g dry weight		(g) / Leaves		% relative to the control						mg/g fresh weight		(g) / Leaves		% relative to the control	
	Seasons		Seasons		Seasons		Seasons		Seasons		Seasons		Seasons		Seasons	
	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002
Black	439.84	447.09	11.31	14.58	225.75	396.20	19.54	18.20	8.78	8.54	28.32	26.74	4.41	3.95	280.89	246.88
Red	506.29	511.13	17.02	21.34	339.72	579.89	25.32	22.94	11.38	10.88	36.70	33.82	7.07	6.64	450.32	415.00
Red + Black	507.50	508.72	24.24	20.03	483.83	544.29	26.80	24.72	13.38	13.64	40.18	38.36	11.53	9.36	734.39	585.00
Blue	473.67	478.50	11.04	11.72	220.36	318.48	18.92	22.54	13.70	12.08	32.62	34.62	4.48	4.69	285.35	293.13
Control	425.34	420.50	5.01	3.68	100.00	100.00	11.70	14.53	6.72	8.17	18.42	22.70	1.57	1.60	100.00	100.00

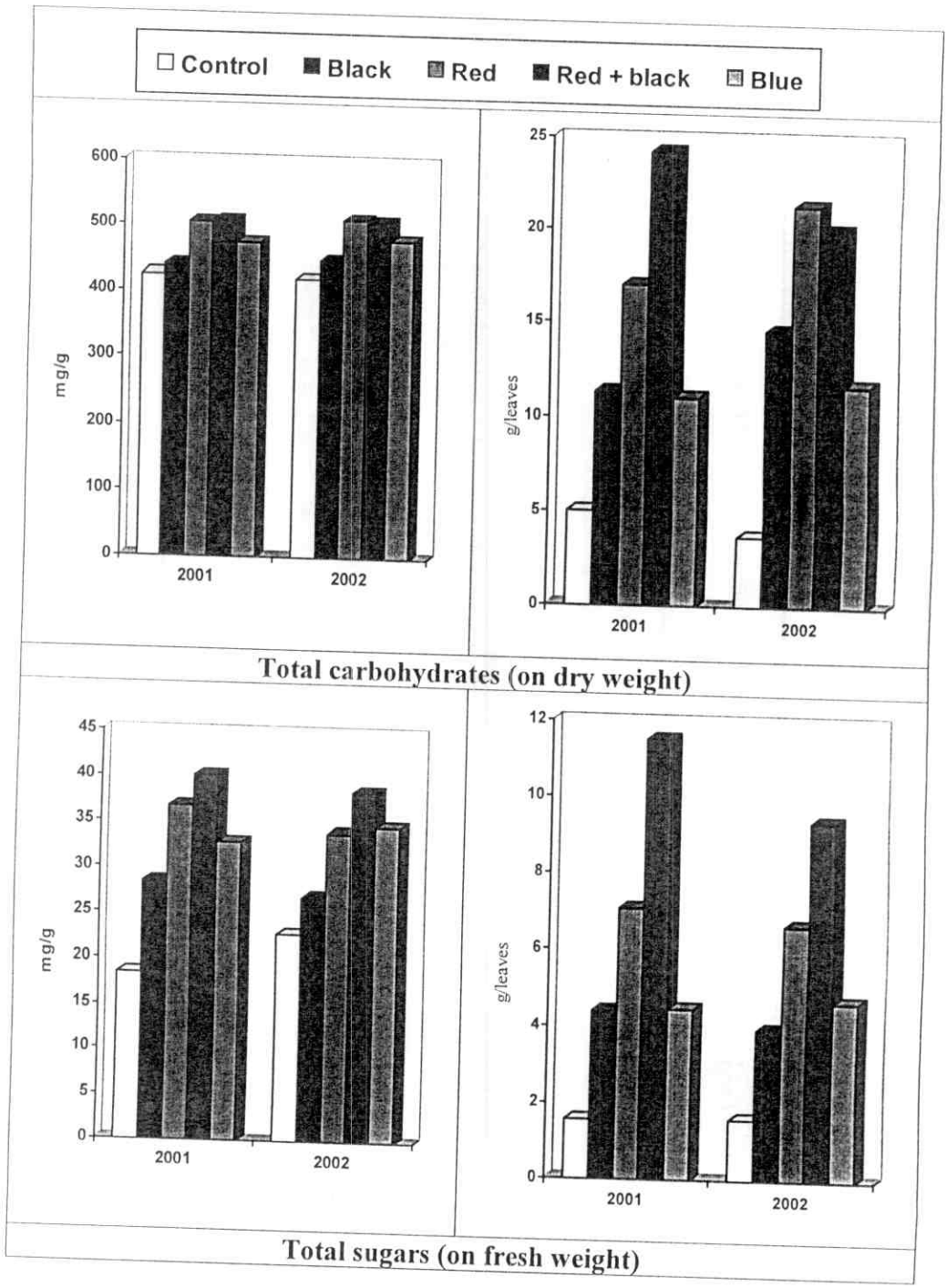


Fig. (37): Bar diagram indicating the effect of color mulches on sugars and carbohydrates concentration and content of tomato (*Lycopersicon esculentum*, Mill.) leaves at 60 days after transplanting during 2001 and 2002 seasons.

As for the total sugars and their fractions, data in Tables (30 & 31) exhibited their dominant increase not only at 45 &60 days after transplanting but also during the two assigned seasons, under different colors of used mulches.

Also, red +black treatment gave the highest of their concentration. Yet, it was followed by red, black and blue in descending order. That was true during the two times of determination and in the two years of the present study.

In addition, increment of sugars in tomato leaves with mulch treatment considered a direct result of vigorous growth that being accompanied with high efficiency of photosynthesis.

Thereby, plants with this case of vigorous growth and entire feeding system should fruited well with good quality and high weight as well.

IV.2. Sweet pepper plants:

IV.2.1. Minerals and crude protein concentration:

IV.2.1.1. At 45 days after transplanting:

Data in Table (32) and Fig. (38) indicate that all mulch colors increased N, P, K, Ca and Mg concentrations in leaves of sweet pepper plants at 45 days after transplanting during 2001 and 2002 seasons. Also, red mulch color gave the highest increase in N and K during the two assigned seasons and P only in the first season. Meanwhile, red + black treatment gave the highest increase in Ca & Mg during the two seasons and P only in the second season. Also, total elements was increased to reach its maximum with red color followed by red +black, blue and black one during the first season meanwhile followed by red + black, black and blue during the second season.

Table (32): Effect of polyethylene mulch surface color on minerals and crude protein concentration of sweet pepper *(Capsicum annuum L.)* leaves at 45 days after transplanting during 2001 and 2002 seasons.

Chemical composition / Treatment	N mg/g dry weight		P mg/g dry weight		K mg/g dry weight		Ca mg/g dry weight		Mg mg/g dry weight		Total determined elements mg/g dry weight		Crude protein			
													mg/g dry weight		% relative to the control	
	Seasons		Seasons		Seasons		Seasons		Seasons		Seasons		Seasons		Seasons	
	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002
Black	33.46	38.32	3.42	4.80	42.97	43.25	6.58	6.65	5.18	5.23	91.61	98.25	209.13	239.50	110.65	123.30
Red	42.48	43.38	4.98	5.16	45.15	45.72	6.79	6.82	5.74	5.82	105.14	106.90	265.50	271.13	140.48	139.58
Red + Black	40.42	42.36	4.84	5.40	45.09	45.64	6.84	6.90	5.80	5.86	102.99	106.16	252.63	264.75	133.67	136.29
Blue	38.46	32.36	4.08	4.28	42.49	43.09	6.62	6.68	5.24	5.40	96.89	91.81	240.38	202.25	127.19	104.19
Control	30.24	31.08	3.32	3.27	40.85	41.65	6.11	6.34	4.64	4.60	85.16	86.94	189.00	194.25	100.00	100.00

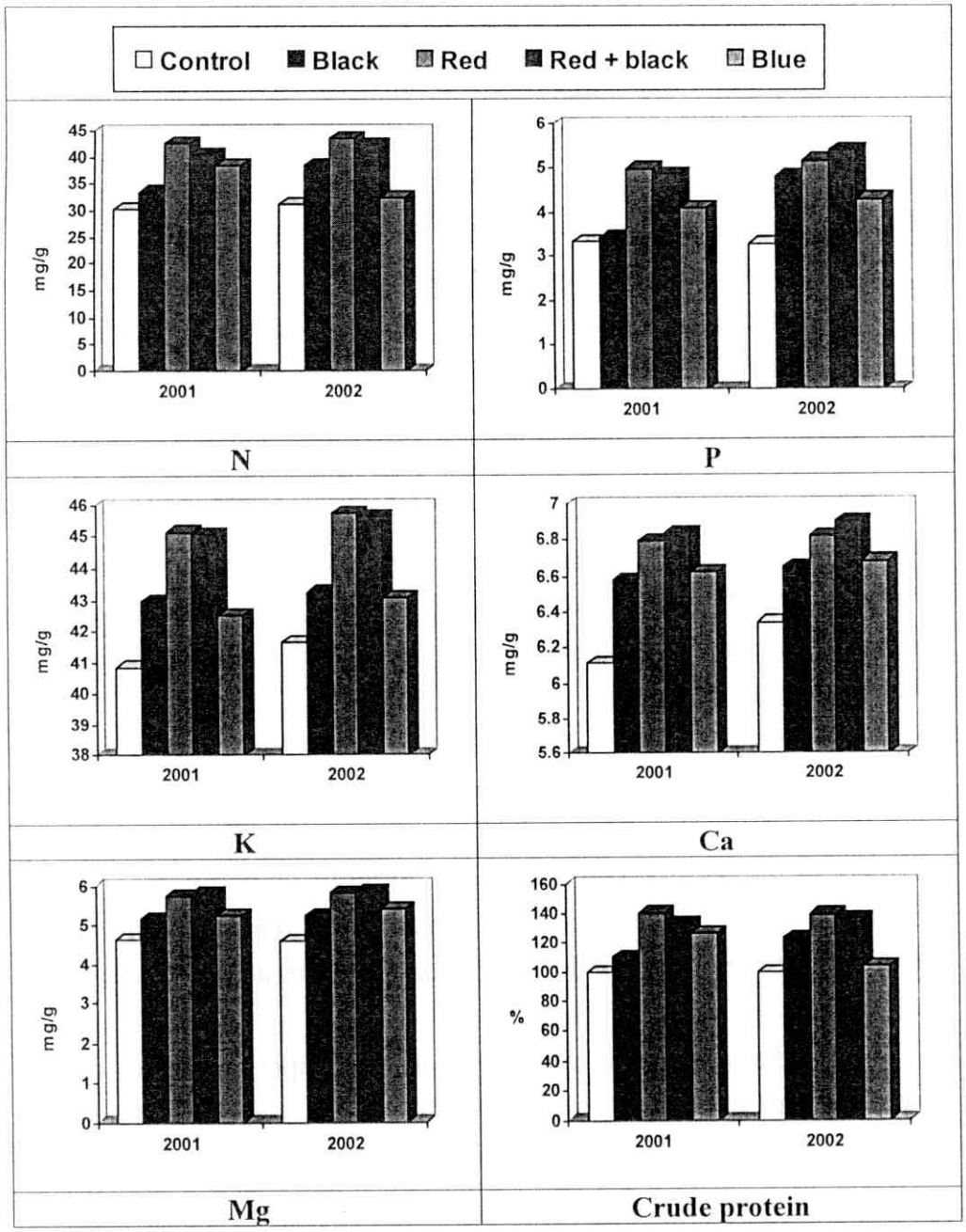


Fig. (38): Bar diagram indicating the effect of color mulches on minerals (mg/g dry weight) and crude protein (% relative to the control) of pepper (*Capsicum annuum* L.) leaves at 45 days after transplanting during 2001 and 2002 seasons.

With regard to the protein concentration, it could be noticed that red color mulch gave the highest increase in leaves of sweet pepper plants at 45 days after transplanting followed by red + black one during 2001 & 2002 seasons. In addition these data being more evident when related to the control ones.

IV.2.1.2. At 60 days after transplanting:

As shown in Tables (33 & 34) and Figs. (39 & 40) clearly indicate that all applied mluch colors increased minerals (i.e. N, P, K, Ca, and Mg) and crude protein concentration in leaves of sweet pepper plants during 2001 and 2002 seasons when compared with the control plants. Also, it could be noticed that the highest increase of any of these elements reached with red mulch only followed by red +black treatment. Also, red +black mulch color gave the highest increase of K, Ca, and Mg during the two assigned seasons.

Concerning the effect color mulches on some microelements (i.e. Fe, Zn, and Mn) in leaves all mulch colors increased iron concentration in leaves of sweet pepper plants. Also, red +black mulch color and red one gave the highest values in this respect. Since iron concentration reached to more than two times with red +black and red treatments when compared with bare soil plants.

On the other hand, zinc concentration (ppm) in leaves of sweet pepper plants was decreased with different applied mulch colors. Also, the highest reduction of zinc concentration existed with red mulch color.

Meanwhile, manganese concentration (ppm) in leaves of sweet pepper plant was increased to reach its maximum with red + black treatment followed by the red one. Also, these results are begin more evident when related to the control one.

Table (33): Effect of polyethylene mulch surface color on minerals and crude protein concentration of sweet pepper (*Capsicum annuum* L.) leaves at 60 days after transplanting during 2001 and 2002 seasons.

Character / Treatment	N mg/g dry weight		P mg/g dry weight		K mg/g dry weight		Ca mg/g dry weight		Mg mg/g dry weight		Total determined elements mg/g dry weight		Crude protein			
													mg/g dry weight		% relative to the control	
	Seasons		Seasons		Seasons		Seasons		Seasons		Seasons		Seasons		Seasons	
	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002
Black	39.42	38.64	4.94	4.66	43.82	44.65	6.72	6.78	5.18	5.23	100.08	99.96	246.38	241.50	123.81	117.59
Red	44.64	43.68	5.32	5.60	45.25	46.22	6.86	6.88	5.74	5.82	107.81	108.20	279.00	273.00	140.20	132.92
Red + Black	43.88	44.26	5.22	5.46	45.83	46.70	6.94	6.96	5.80	5.86	107.67	109.24	274.25	276.63	137.81	134.69
Blue	35.46	37.24	4.72	4.98	42.89	43.20	6.74	6.82	5.24	5.40	95.05	97.64	221.63	232.75	111.37	113.33
Control	31.84	32.86	4.56	4.40	41.84	42.18	6.56	6.42	4.64	4.60	89.44	90.46	199.00	205.38	100.00	100.00

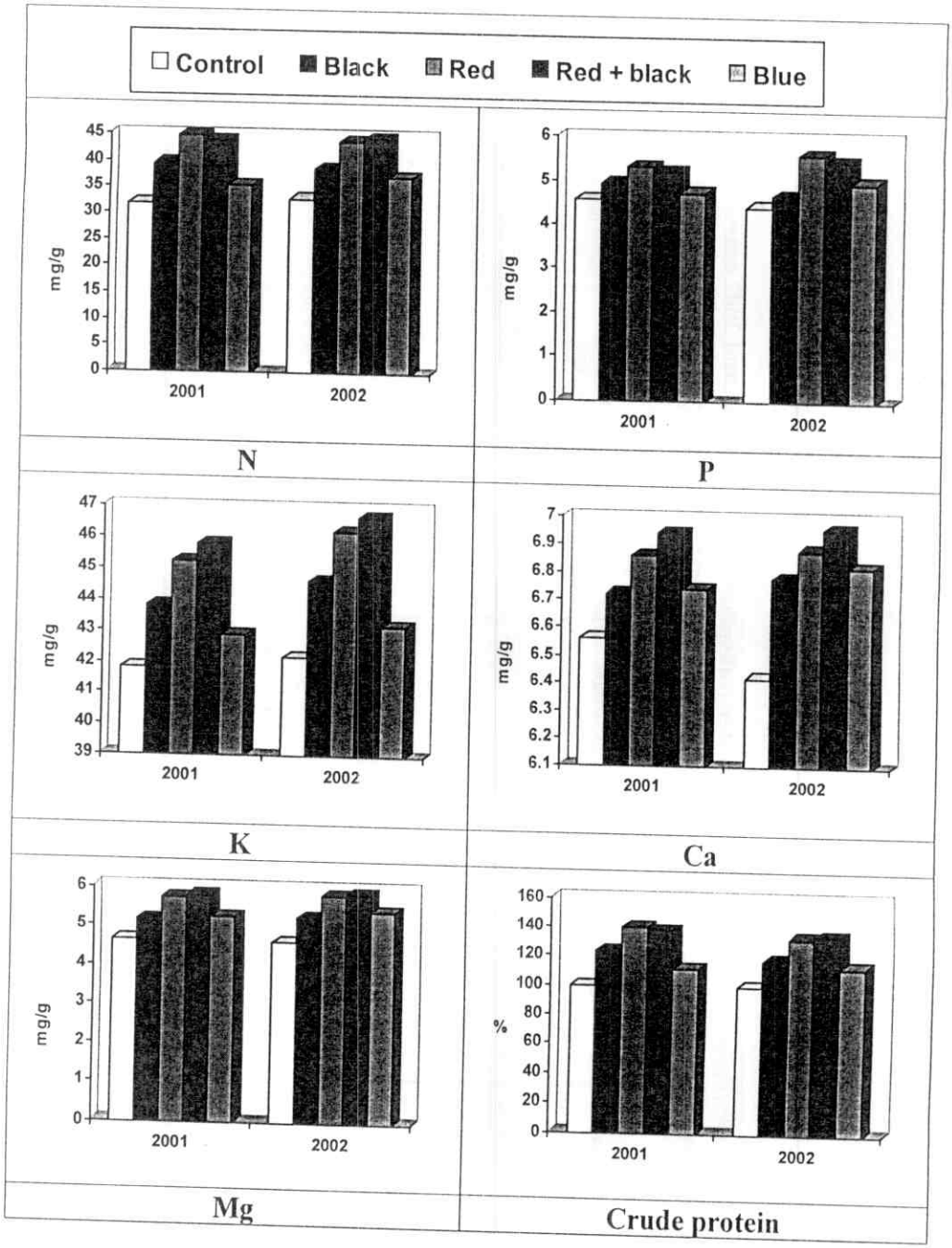


Fig. (39): Bar diagram indicating the effect of color mulches on minerals (mg/g dry weight) and crude protein (% relative to the control) of pepper (*Capsicum annuum* L.) leaves at 60 days after transplanting during 2001 and 2002 seasons.

Table (34): Effect of polyethylene mulch surface color on iron, zinc and manganese concentration of sweet pepper (*Capsicum annuum* L.) plants at 60 days after transplanting during 2002 season.

Chemical composition / Treatment	Iron (Fe)			Zinc (Zn)			Manganese (Mn)		
	ppm	% relative to the control	% ±	ppm	% relative to the control	% ±	ppm	% relative to the control	% ±
Black	85.23	110.40	+10.40	60.03	96.05	-3.95	52.25	103.98	+3.98
Red	168.75	218.59	+118.59	55.35	88.56	-11.44	74.50	148.26	+48.26
Red + Black	170.50	220.85	+120.85	60.73	97.17	-2.83	79.50	158.21	+58.21
Blue	97.70	126.55	+26.55	60.75	97.20	-2.80	65.25	129.85	+29.85
Control	77.20	100.00	0.00	62.50	100.00	0.00	50.25	100.00	0.00

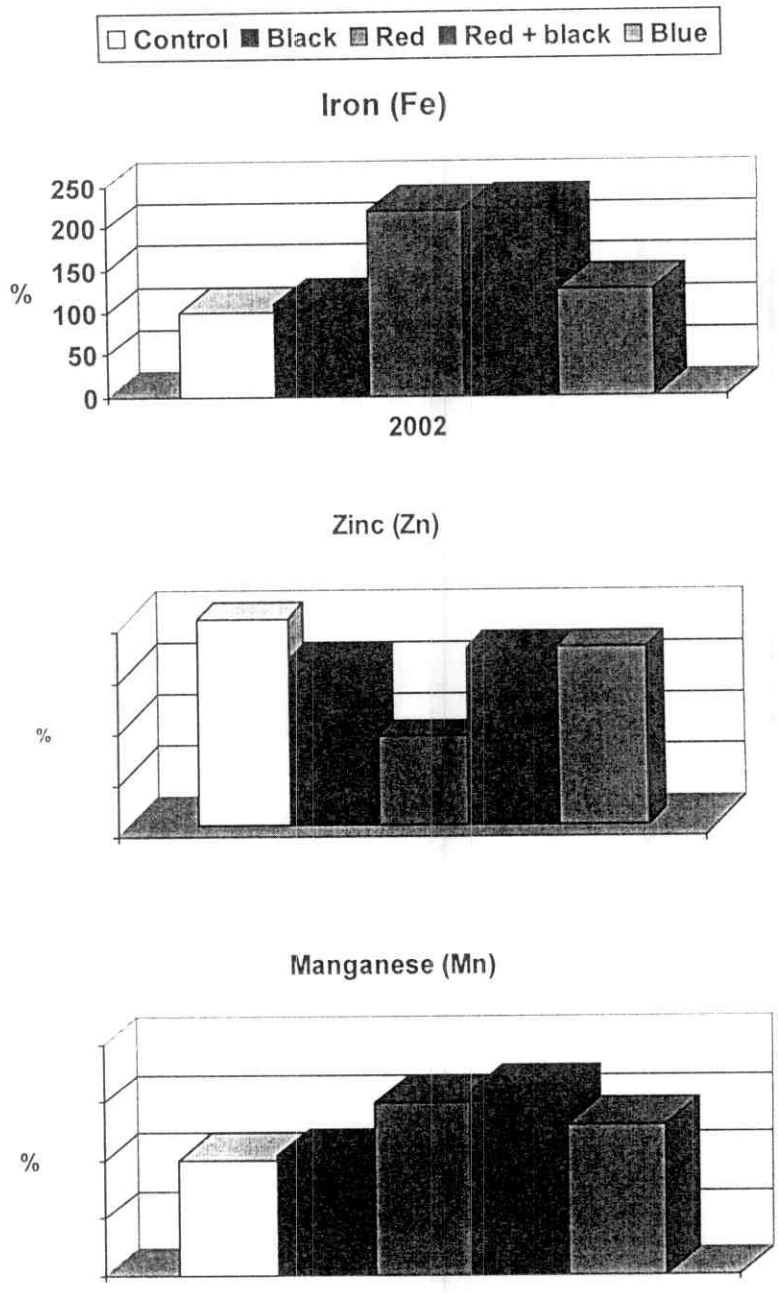


Fig. (40): Bar diagram indicating the effect of color mulches on iron, zinc and manganese % relative to the control of pepper (*Capsicum annuum* L.) plants at 60 days after transplanting during 2002 seasons.

III.2.2. Sugars and carbohydrates concentration at 45 and 50 days after transplanting:

Data in Tables (35 and 36) and Figs. (41 & 42) show the effect of various mulch colors on total carbohydrates and sugars and their fractions concentration in leaves of sweet pepper plants at 45 and 60 days after transplanting during 2001 and 2002 seasons.

As for total carbohydrates were increased with different applied mulch colors. Also, the red + black color gave the highest values followed by red, blue and black one during the two assigned seasons during the two times of determination.

Also, it could noticed that red + black and red treatments gave the highest concentration of total carbohydrates in leaves dry matter that reached to more than seven and fifth times during 2001 season meanwhile were more than seven and four times in 2002 season.

As for total sugars and their fractions, data in Tables (35 & 36) exhibited their dominant increase at 45 & 60 days after transplanting during the two assigned seasons with different used mulch colors.

Also, red + black gave the highest concentration of reducing, non-reducing and total sugars in leaves of sweet pepper plants either at 45 or 60 days after transplanting during 2001 and 2002 seasons, respectively.

Generally, tomato and sweet pepper plants under mulch color treatments gave not only the highest vigorous growth in the early stage but also increased early and total fruit yields as well as the improvement of fruit quality.

Table (35): Effect of polyethylene mulch surface color on sugars and carbohydrates concentration and content of sweet pepper *(Capsicum annuum L.)* leaves at 45 days after transplanting during 2001 and 2002 seasons.

Chemical composition / Treatment	Total carbohydrates						Reducing sugars mg/g fresh weight		Non reducing sugars mg/g fresh weight		Total sugars					
	mg/g dry weight		(g) / Leaves		% relative to the control						mg/g fresh weight		(g) / Leaves		% relative to the control	
	Seasons		Seasons		Seasons		Seasons		Seasons		Seasons		Seasons		Seasons	
	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002
Black	513.54	507.50	0.66	0.48	183.33	266.67	16.47	18.35	8.23	8.07	24.70	26.42	0.19	0.27	158.33	270.00
Red	582.42	599.34	1.35	1.47	375.00	816.67	22.85	25.15	9.59	11.07	32.44	36.22	0.56	0.64	466.67	640.00
Red + Black	606.59	623.50	1.26	1.37	350.00	761.11	26.33	27.17	10.79	12.23	37.12	39.40	0.51	0.63	425.00	630.00
Blue	543.75	577.59	1.04	0.83	288.89	461.11	21.03	22.66	9.25	9.52	30.28	32.18	0.44	0.49	366.67	460.00
Control	441.04	422.92	0.36	0.18	100.00	100.00	15.37	14.28	6.45	6.42	21.82	20.70	0.12	0.10	100.00	100.00

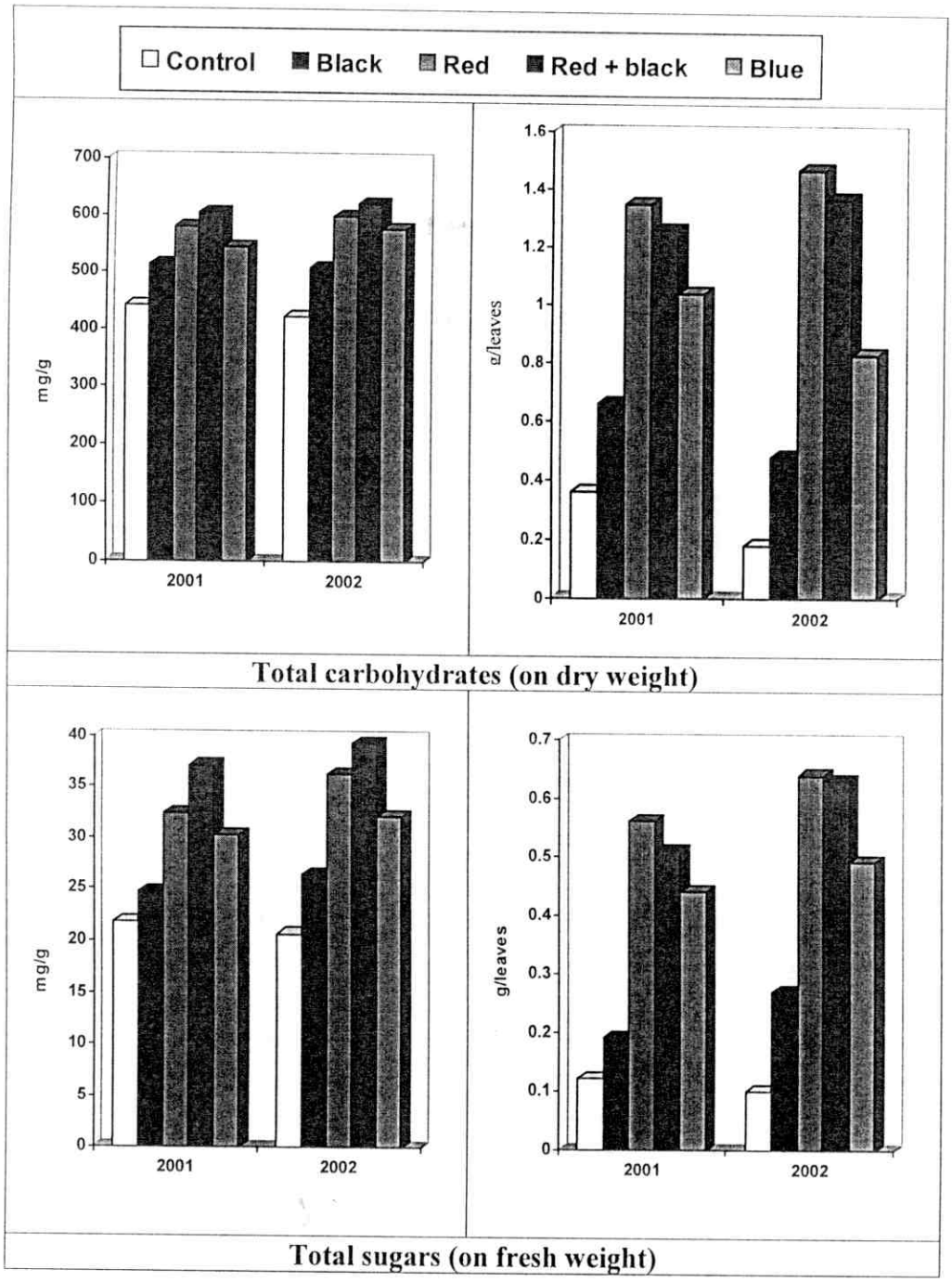


Fig. (41): Bar diagram indicating the effect of color mulches on sugars and carbohydrates concentration and content of sweet pepper (*Capsicum annuum* L.) leaves at 45 days after transplanting during 2001 and 2002 seasons.

Table (36): Effect of polyethylene mulch surface color on sugars and carbohydrates concentration and content of sweet pepper *(Copsicum annum L.)* leaves at 60 days after transplanting during 2001 and 2002 seasons.

Chemical composition / Treatment	Total carbohydrates						Reducing sugars mg/g fresh weight		Non reducing sugars mg/g fresh weight		Total sugars					
	mg/g dry weight		(g) / Leaves		% relative to the control						mg/g fresh weight		(g) / Leaves		% relative to the control	
	Seasons		Seasons		Seasons		Seasons		Seasons		Seasons		Seasons		Seasons	
	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002
Black	519.59	529.25	2.53	2.35	178.17	199.15	18.87	20.08	7.93	8.64	26.80	28.72	0.98	0.78	200.00	181.40
Red	589.67	600.54	7.28	5.79	512.68	490.68	24.15	25.89	10.62	11.65	34.77	37.54	2.37	2.03	483.67	472.09
Red + Black	601.75	609.00	10.13	8.54	713.38	723.73	26.75	27.50	11.77	12.38	38.52	39.88	3.59	2.86	732.65	665.12
Blue	555.84	549.79	4.70	4.06	330.99	344.07	20.16	21.40	9.28	9.97	29.44	31.37	1.55	1.44	316.33	334.88
Control	465.21	447.09	1.42	1.18	100.00	100.00	16.50	17.24	7.42	7.41	23.92	24.65	0.49	0.43	100.00	100.00

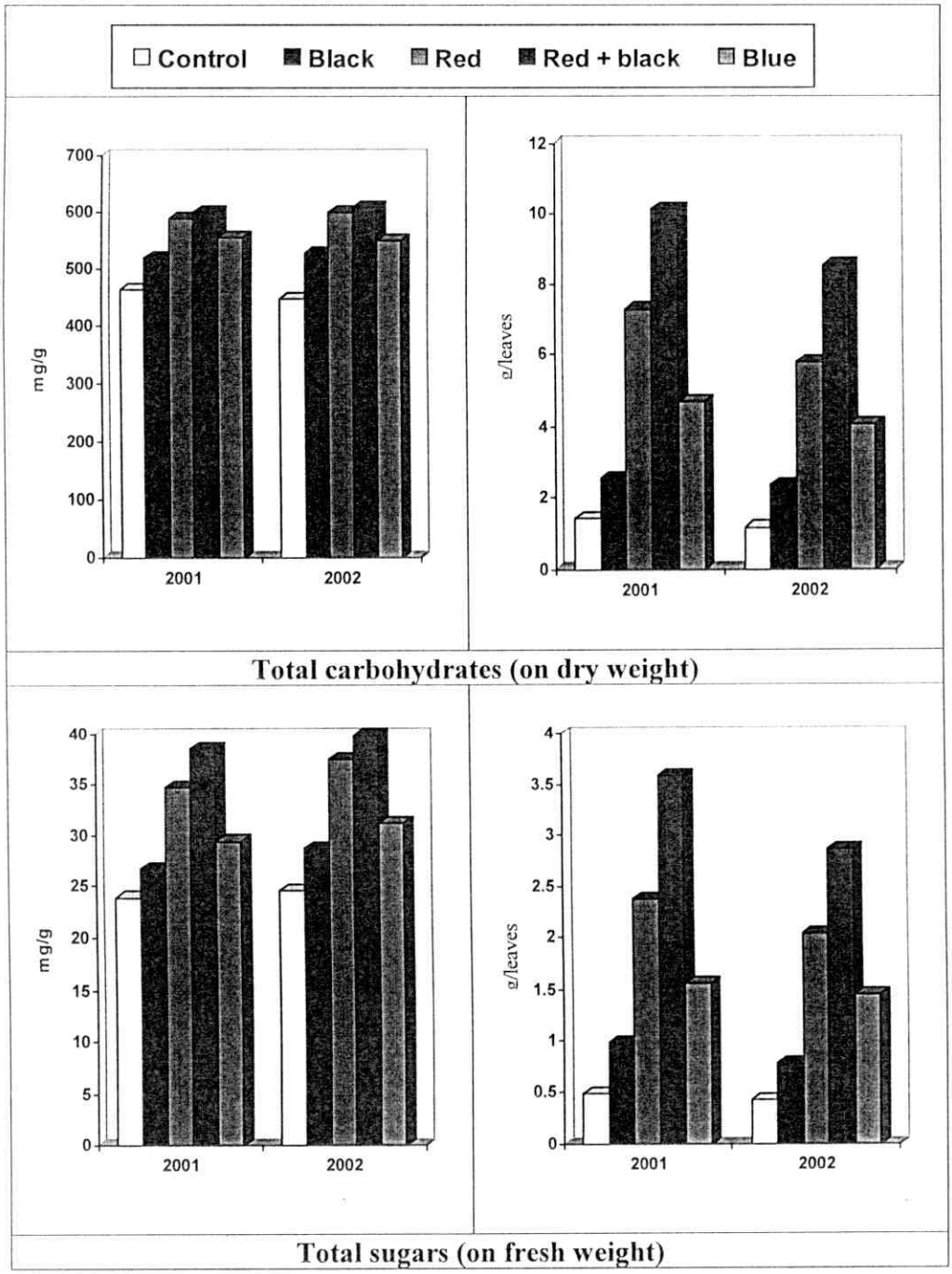


Fig. (42): Bar diagram indicating the effect of color mulches on sugars and carbohydrates concentration and content of sweet pepper (*Capsicum annuum* L.) leaves at 60 days after transplanting during 2001 and 2002 seasons.

Sugar plays a role as a signaling molecule that regulates a variety of genes **(Kock, 1996).** It probably affects various aspects of development in higher plants. For example, in Arabidopsis seedlings, accumulate high levels of sugar and light induced cotyledon opening **(Dijkwel *et al.*, 1997 and Jang *et al.*, 1997).** In addition to these developmental aspects that are affected by sugar, flowering also seems to be influenced by sugar. There has been a good amount of evidence suggesting that sucrose promotes flowering in most species that have been examined **(Bernier *et al.*, 1993).** After induction of flowering in a long-day plant, *Sinapis alba,* by either a single long day or by a displaced short day, the concentration of sucrose in the phloem reaching the shoot apex increases rapidly and transiently. This role of sucrose translocation precedes the increase in cell division that normally is observed in the shoot apical meristem during floral evocation **(Bernier *et al.*, 1993).**

IV- Reproductive growth:

In this part of the present study the effect of different mulch colors upon different flowering characteristics, i.e. the start of flowers anthesis and their earliness as well, number of flowers per plant and the fruits characteristics including fruit setting, abscission, early fruits, early yield as well as, the characteristics of total yielded fruits and each of economical and biological yields and the harvest index were investigated. Also, study prolonged to the fruits characteristics including size, fresh weight, dry weight, dimension and fruit shape as well as their concentration of some bioconstituents i.e. vitamin C, total

soluble solids and the titratable acidity. In addition, pollen grains fertility and sterility in yielded fruits were stimulated.

IV.1. Tomato plants:

IV.1.1. Flower characteristics:

As shown in Table (37) and Figs. (43, 44 & 45), it could be clearly noticed that; tomato plants grown above different used mulch colors opened their flowers earlier than control plants. The most effective, color in this respect was the red one followed by red + black, black and the blue one ranked the last. Here, days of earliness were 31.20, 28.60, 15.00 and 12.00 days for red, red + black, black and blue one during 2001 season, respectively, when compared with control. In other meaning plants grown above red, red + black and blue, their flowers were started anthesis at the age of 34.20, 36.80, 50.40 and 53.40 days during 2001 season, respectively, after transplanting comparing with 65.40 days that of control plants. These days of earliness e.g. with red color mulch reached to 47.71 and 47.90% less than control value during 2001 and 2002 seasons, respectively.

Also, it could be noticed that these days of earliness existed with different used colors reached to the high level of significance during the two seasons. These results could be considered as a pioneer of the present study. Since, earliness with 31 days could be followed by rapid development and growth of setted fruits their by earliness in repined tomato fruits being expected. The earliness of yielding fruits in tomato plant consider of great interest, because that will suit early marketing of such fruits. Moreover, also in this view only tomato fruits produced under tunnels being present in markets. So, the present

Table (37): Effect of polyethylene mulch surface color on flowering, fruit setting and abscission of tomato (*Lycopersicon esculentum*, Mill.) plants during 2001 and 2002 seasons.

Character / Treatment		Start of flower anthesis (days)		Earliness of flower anthesis (days)		Earliness of flower anthesis % relative to the control		No. of Flowers / plant		Total fruits (No. / plant)		Fruit setting (%)		Abscission (%)	
		Seasons		Seasons		Seasons		Seasons		Seasons		Seasons		Seasons	
		2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002
Black		50.40	53.20	15.00	8.60	22.94	13.92	58.80	60.60	29.80	27.20	50.68	44.88	49.32	55.12
Red		34.20	32.20	31.20	29.60	47.71	47.90	66.60	68.20	43.20	46.60	64.87	68.33	35.13	31.67
Red + Black		36.80	33.80	28.60	28.00	43.73	54.69	69.80	72.00	47.20	44.80	67.62	62.22	32.38	37.78
Blue		53.40	51.60	12.00	10.20	18.35	29.69	61.40	63.00	24.00	25.80	39.09	40.95	60.91	59.05
Control		65.40	61.80	0.00	0.00	0.00	0.00	51.40	54.00	19.80	21.20	38.52	39.26	61.48	60.74
L.S.D.	0.05	1.30	2.02	-	-	-	-	2.72	3.09	1.57	2.03	3.12	4.11	3.09	3.61
	0.01	1.79	2.78	-	-	-	-	3.75	4.26	2.17	2.80	4.31	5.56	4.26	4.98

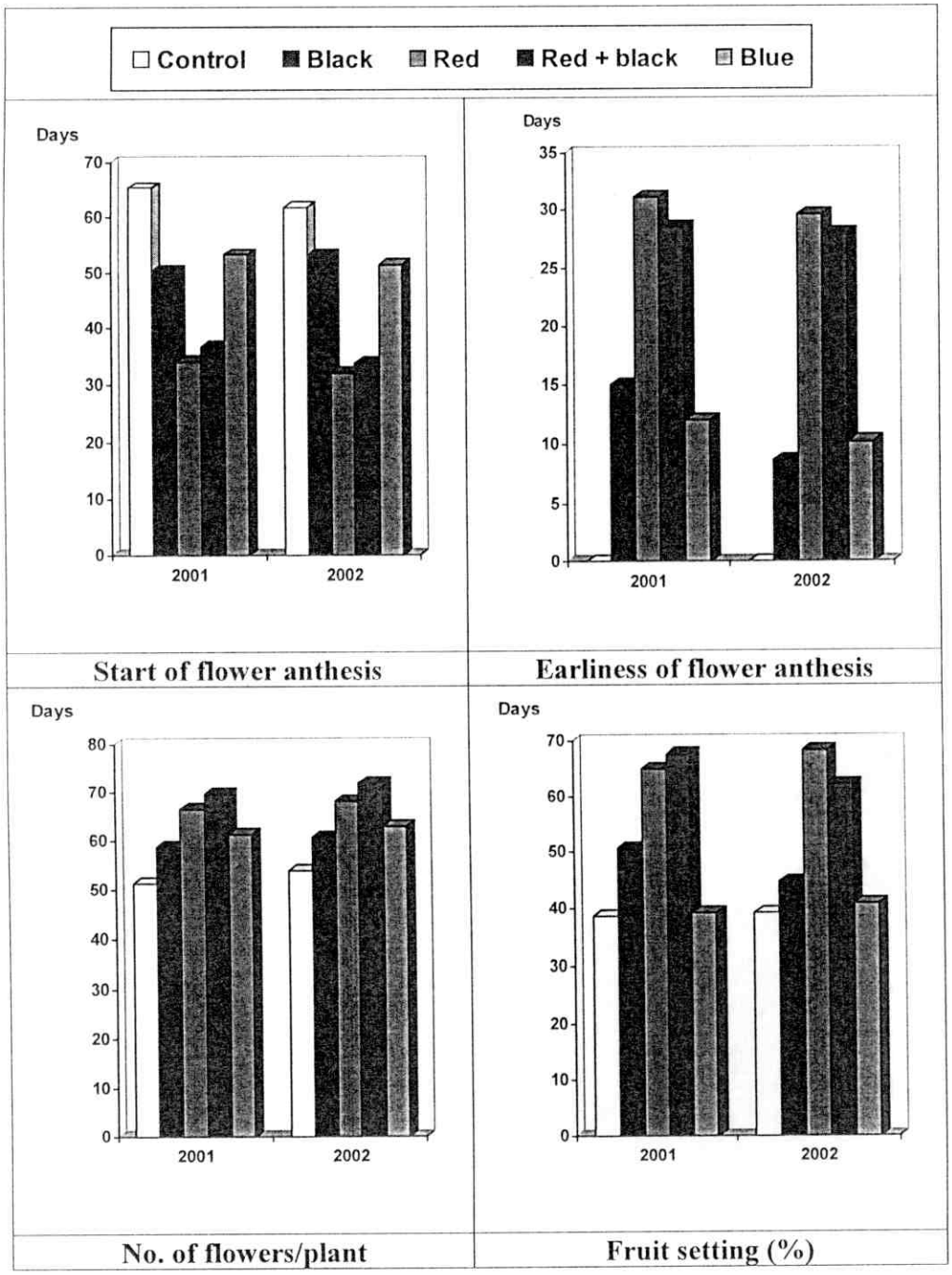


Fig. (43): Bar diagram indicating the effect of color mulches on flowering, fruit setting and abscission of tomato (*Lycopersicon esculentum*, Mill.) plants during 2001 and 2002 seasons.

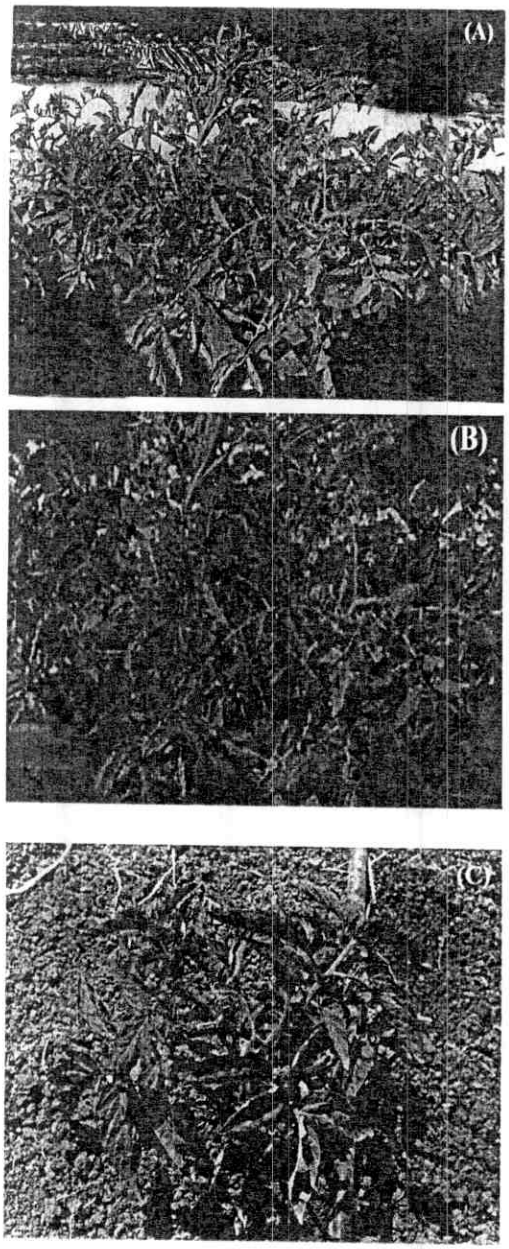


Fig . (44) : showing more flower anthesis at 60 days after transplanting, in case of (A) black and (B) blue comparing with less flower anthesis at the same age for (C) i.e. bare soil (control).

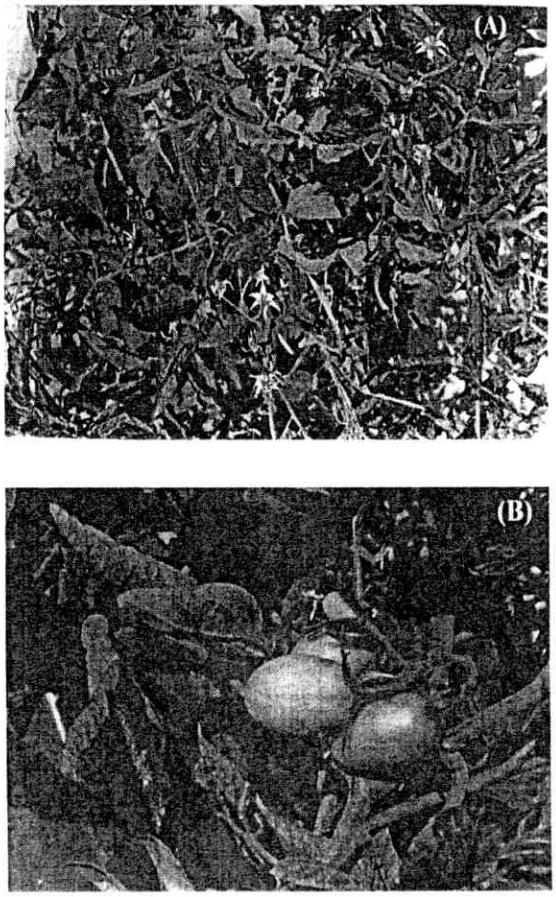


Fig.(45) : Indicating that more flower anthesis (A) and developing fruits (B) at 60 days after transplanting in case of red mulch.

study provide an alternative system for present repined tomato fruit during the time of spring and early summer, i.e. during last April and start of May.

Earliness of flowers anthesis under different used colors was preceded with vigorous growth of grown plants and high production of net assimilates in leaves of such plants (Tables 9, 10 & 11). Also, of interest to remember here that measurement of light reflection Tables (4 & 5) revealed that the red color mulch reflected (46.58 & 49.87 and 49.72 & 52.67%) of red and far-red light at mid-day of the April during 2001 and 2002 season, respectively, more red and far-red light comparing with all other mulch colors (Tables, 4 & 5). The role of red and far red light and percentage between them are great interest since the FR: R ratio plays a major role in promoting flowering during early stage of growth **(Koornneef *et al.*, 1998 and Levy and Dean, 1998).** The ratio acts through the phytochrome system to control flowering by floral evocation **(Bagnall *et al.*, 1995 and Carre, 1998).**

IV.1.2. Number of flowers:

Data in Table (37) and Fig. (43) also, indicate that high significant increase of flowers number was the dominantly existed with different used mulch colors during the two assigned seasons. Values were 69.80 & 72.00, 66.60 & 68.20, 61.40 & 63.00 and 58.80 & 60.60 in 2001 and 2002 season for red + black, red, blue and black colors, respectively. Meanwhile, values were 51.40 & 54.00 in the two seasons, for control plants.

The above mentioned high numbers of flowers existed with different mulch colors were followed also with increasing

of total fruits number. That means that was preceded with high percentages in setted fruits. That was the case, since as shown in Table (37) each of red and red + black colors gave the highest existed values for each of total fruit numbers and the percentages of fruit setting as well.

On the other hand, abortion of flowers was decreased. Since, percentage of abscission was decreased to reach the high level of significance with all used colors except only that insignificant decrease with blue color existed only during 2002 season. Also, it could be noticed that each of red and red + black were more pronounced in this respect. Since, values of abscission were 35.13 & 31.67 and 32.38 & 37.78% in 2001 and 2002 seasons, respectively, with red and red + black meanwhile values were 61.48 & 60.74 in the same two seasons for the control plants.

In this respect, other studies reported nearly similar effects of mulch colors treatment upon the earliness of tomato flowering **(Decoteau *et al.*, 1986 and Kasperbauer and Hunt, 1998).**

Recent molecular genetic studies of plant photoreceptors have demonstrated that the action of individual phytochromes and cryptochromes can either suppress or promote floral initiation, and that a photoreceptor may function within the nucleus to affect transcription of the flowering-time genes. It remains unclear how photoreceptors control photoperiodic flowering. A photoreceptor may regulate flowering time in response to different photoperiods *via* its regulation of the circadian clock. Alternatively, the direct effect of a photore-

ceptor on floral initiation may be gated by the circadian clock, resulting in different responses in different photoperiods. It is conceivable that the expression level or activity of a photoreceptor signaling molecule may oscillate with distinct cycling phases in different photo-periods, and as such may serve as the hypothesized gating factor that determines the signal transduction of a photoreceptor (and thus the flowering time) in different photoperiods. The identification of such factors and investigation of how the expression or activity of these factors affects the function of photoreceptors may shed light on the mechanism of photoreceptors in the control of flowering time **(Lin, 2000).**

IV.1.3. Pollen grains fertility:

As shown in Table (38) and Fig. (46) various used mulch colors increased the fertility of pollen grains in those plants grown above them. Also, it could be noticed that the red color gave the highest fertility but the black exhibited slight increase during 2001 season and decreased it during 2002 season.

These data being more evident when calculated on the control basis, since, e.g. red mulch gave increases values of +28.92 & + 20.61% more than the control or other treatments during 2001 & 2002 seasons, respectively. On the other hand, the only reduction existed was of –12.09% during 2002 season with the black mulch.

The above mentioned results could be directly reversed upon the high percentages of fruit setting as previously mentioned (Table, 37). Since red mulch, also gave the lowest percentages of aborted flowers (Table, 38). In addition, also in

Table (38): Effect of polyethylene mulch color on pollen grains fertility of tomato (*Lycopersicon esculentum*, Mill) plants during 2001 and 2002 seasons.

Character / Treatment	Fertility						Sterile				Sterility					
	%		% relative to the control				Morphol. normal %		Aborted %		%		% relative to the control			
	Seasons		Seasons				Seasons		Seasons		Seasons		Seasons			
	2001	2002	2001	% ±	2002	% ±	2001	2002	2001	2002	2001	2002	2001	% ±	2002	% ±
Black	61.88	56.26	102.10	+ 2.10	87.91	- 12.09	20.14	24.21	17.98	19.53	38.12	43.74	96.78	- 3.22	121.50	+21.50
Red	78.14	77.19	128.92	+28.92	120.61	+ 20.61	12.57	11.70	9.29	11.11	21.86	22.81	55.50	- 44.50	63.36	- 36.64
Red + Black	74.84	74.29	123.48	+23.48	116.08	+ 16.08	14.29	13.56	10.87	12.15	25.16	25.71	63.87	- 36.13	71.42	- 28.58
Blue	69.92	64.47	115.36	+15.36	100.73	+ 0.73	14.66	17.36	15.52	18.17	30.18	35.53	76.62	- 23.38	98.69	- 1.31
Control	60.61	64.00	100.00	0.00	100.00	0.00	21.21	19.20	18.18	16.80	39.39	36.00	100.00	0.00	100.00	0.00

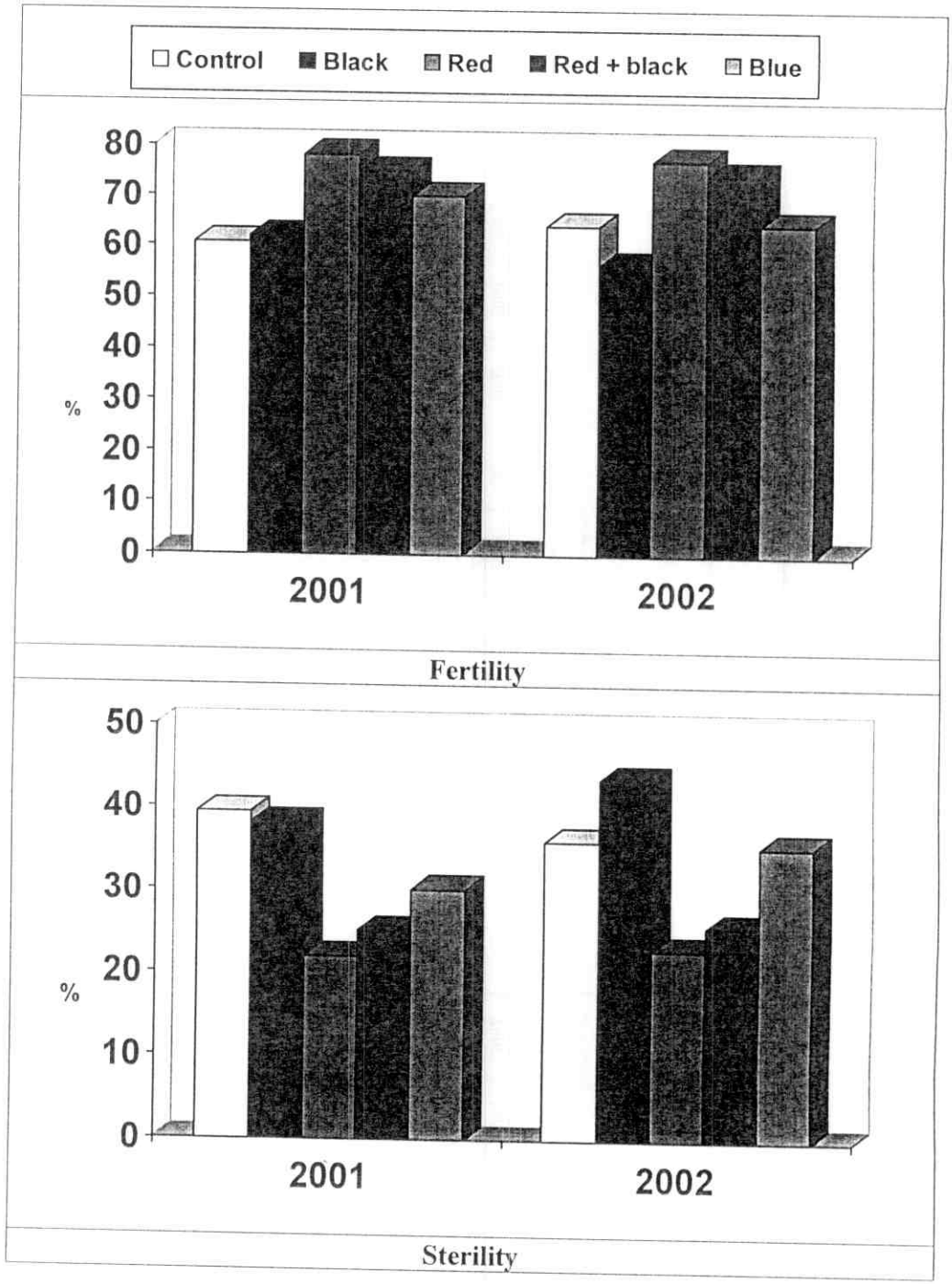


Fig. (46): Bar diagram indicating the effect of color mulches on pollen grains fertility of tomato (*Lycopersicon esculentum*, Mill.) plants during 2001 and 2002 seasons.

this respect, the red color gave the lowest percentages of sterility in the pollen grains in the two seasons those reached to 21.86 & 22.81%, yet, each of black and blue colors exhibited the highest percentages of sterility. These data being more evident when related to the control ones. Since, reduction reached to -44.50 & 36.64% less than that of control pollen sterility. Moreover, the above mentioned results are of great interest, since fruits setting, number, as well as early and total fruit yields are completely depending on them.

IV.1.4. Early fruits and early yield:

As shown in Table (39) and Fig. (47) the first four pickings were considered as early fruit yield. In this respect, different used mulch colors increased the number of early fruits to reach the high level of significance. Also, each of red and red + black gave the highest values of this number followed by the black and blue colors.

These results are also of great interest since these number rose from 6.00 & 7.20 fruits in 2001 season for control to 19.60 & 21.60 and 22.00 & 20.80 fruits during the two assigned seasons for red and red + black, respectively.

Also, the view will be more evident when these values related to the control one. Since, e.g. values reached to or even more three times of control with these two efficient treatments, i.e. red and red + black. Again, the important of such treatments being strongly supplemented for this system of cultivation. That because not only enables farmers to sol a large part of their tomato fruits with high prices but also they could minimize high costs of tomato production under protected conditions (i.e. tunnels or green houses).

Table (39): Effect of polyethylene mulch surface color on early fruits yield of tomato (*Lycopersicon esculentum*, Mill.) plants during 2001 and 2002 seasons.

Yield components / Treatment		Early fruits				Early yield*			
		(No. / plant)		% relative to the control		(g)/plant		% relative to the control	
		Seasons		Seasons		Seasons		Seasons	
		2001	2002	2001	2002	2001	2002	2001	2002
Black		11.00	12.20	183.33	169.44	898.90	1023.34	218.81	179.59
Red		19.60	21.60	326.67	300.00	1984.70	2460.78	483.12	431.85
Red + Black		22.00	20.80	366.67	288.89	2483.72	2386.34	604.59	418.78
Blue		10.80	12.20	180.00	169.44	894.39	1005.82	217.71	176.51
Control		6.00	7.20	100.00	100.00	410.81	569.83	100.00	100.00
L.S.D.	0.05	2.18	1.80	50.93	12.93	321.22	184.25	71.48	78.19
	0.01	3.00	2.48	70.24	17.84	443.02	254.11	98.59	107.84

* Early yield = Fruits of the first four pickings.

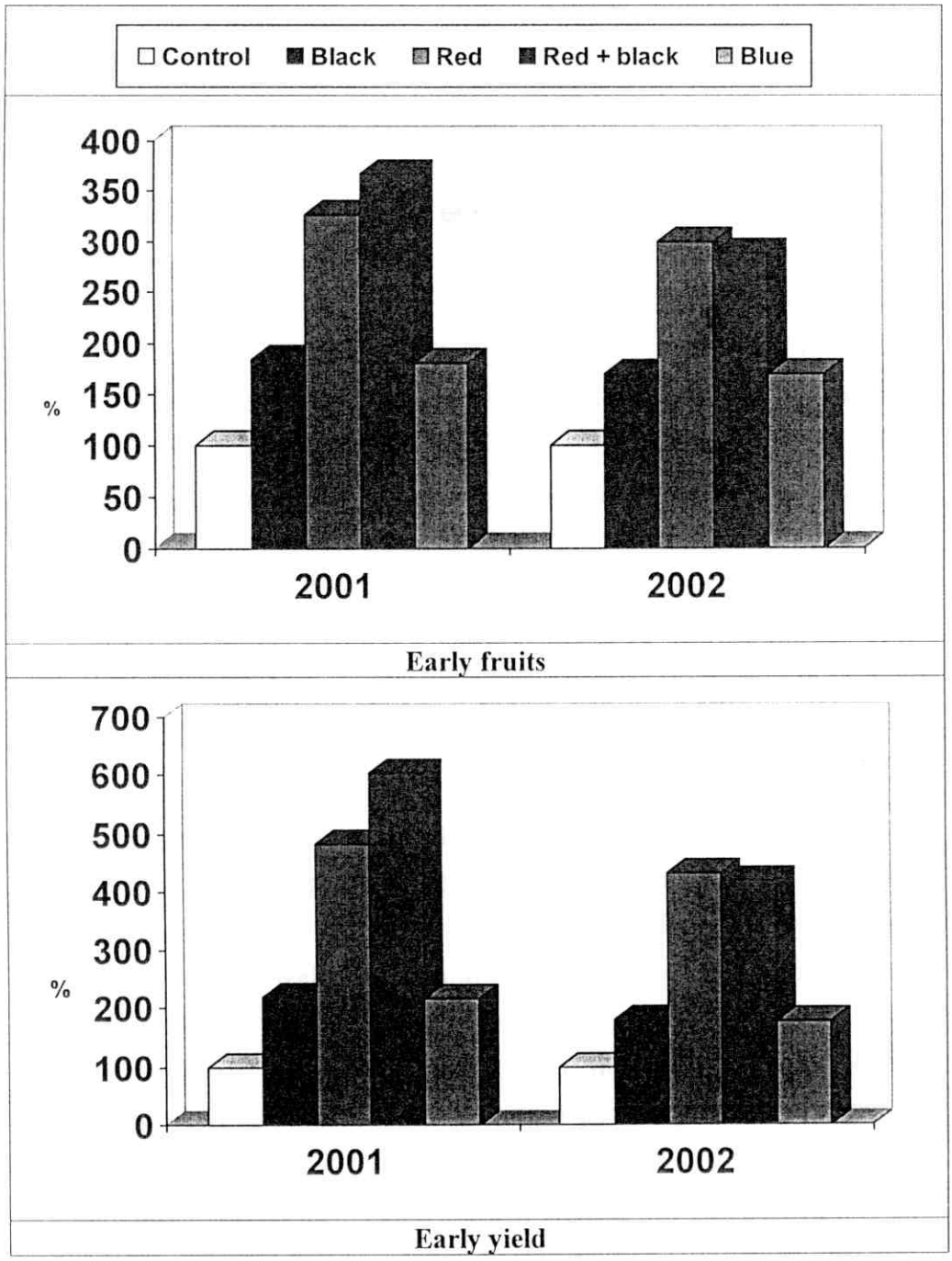


Fig. (47): Bar diagram indicating the effect of color mulches on early fruits yield percentage relative to the control of tomato (*Lycopersicon esculentum*, Mill.) plants during 2001 and 2002 seasons.

As for the weight of early yielded fruits, also high significant increase was existed with different used mulch colors. Here, data revealed that the treatment of red + black gave the highest weight (2483.72 gm) in 2001 season but the red mulch color gave the highest weight (2460.78 gm) during 2002 season. Here, again, the early yield of red + black exceeded the weight of control with more than six time and with more than four time by red colors during 2001 and 2002 seasons, respectively. Moreover, the lowest of the early weight that existed with black and blue colors (898.90 & 894.39 and 1023.34 & 1005.82, respectively) also exceeded the control with more than two times. In addition, these data being more evident when related to the control (Table 39).

IV.1.5- Total fruit yield:

Data shown in Table (40) and Fig. (48) reveal that high significant increase of the picked fruits during along harvest time dominantly existed with different used colors during the two assigned seasons. Also, of interest to note that the treatment of red + black and the red one gave the highest number of fruits during 2001 and 2002 seasons, respectively. Meanwhile black color ranked the second but blue one was the last in this respect. In addition, the two more efficient treatments, i.e. red and red + black increased this total fruits number more than two times but it was only more than one time with each of red and red + black treatments.

Moreover, the obtained high number of yielded ripened tomato fruits was also accompanied with high significant increase in their weight (kg/plant). In this respect, the red mulch

Table (40): Effect of polyethylene mulch surface color on total yield of tomato (*Lycopersicon esculentum*, Mill.) plants during 2001 and 2002 seasons.

Yield components / Treatment		Total fruits (No./plant)		% relative to the control		Total yield (kg/plant)		Relative total yield (%)		Early yield (kg/plant)		Early yield (%)	
		Seasons		Seasons		Seasons		Seasons		Seasons		Seasons	
		2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002
Black		29.80	27.20	150.51	128.30	2.41	2.28	165.07	137.35	0.90	1.02	37.34	44.74
Red		43.20	46.60	218.18	219.81	4.83	5.32	330.82	320.48	1.99	2.46	41.20	46.24
Red + Black		47.20	44.80	238.38	211.32	5.34	5.14	365.75	309.64	2.48	2.39	46.44	46.50
Blue		24.00	25.80	121.21	121.70	1.99	2.13	136.30	128.31	0.89	1.01	44.72	47.42
Control		19.80	21.20	100.00	100.00	1.46	1.66	100.00	100.00	0.41	0.57	28.08	34.34
L.S.D.	0.05	1.57	2.03	11.50	12.58	0.31	0.30	36.60	34.33	0.18	0.19	6.84	5.62
	0.01	2.17	2.80	15.86	17.35	0.43	0.41	50.48	47.35	0.25	0.26	9.44	7.75

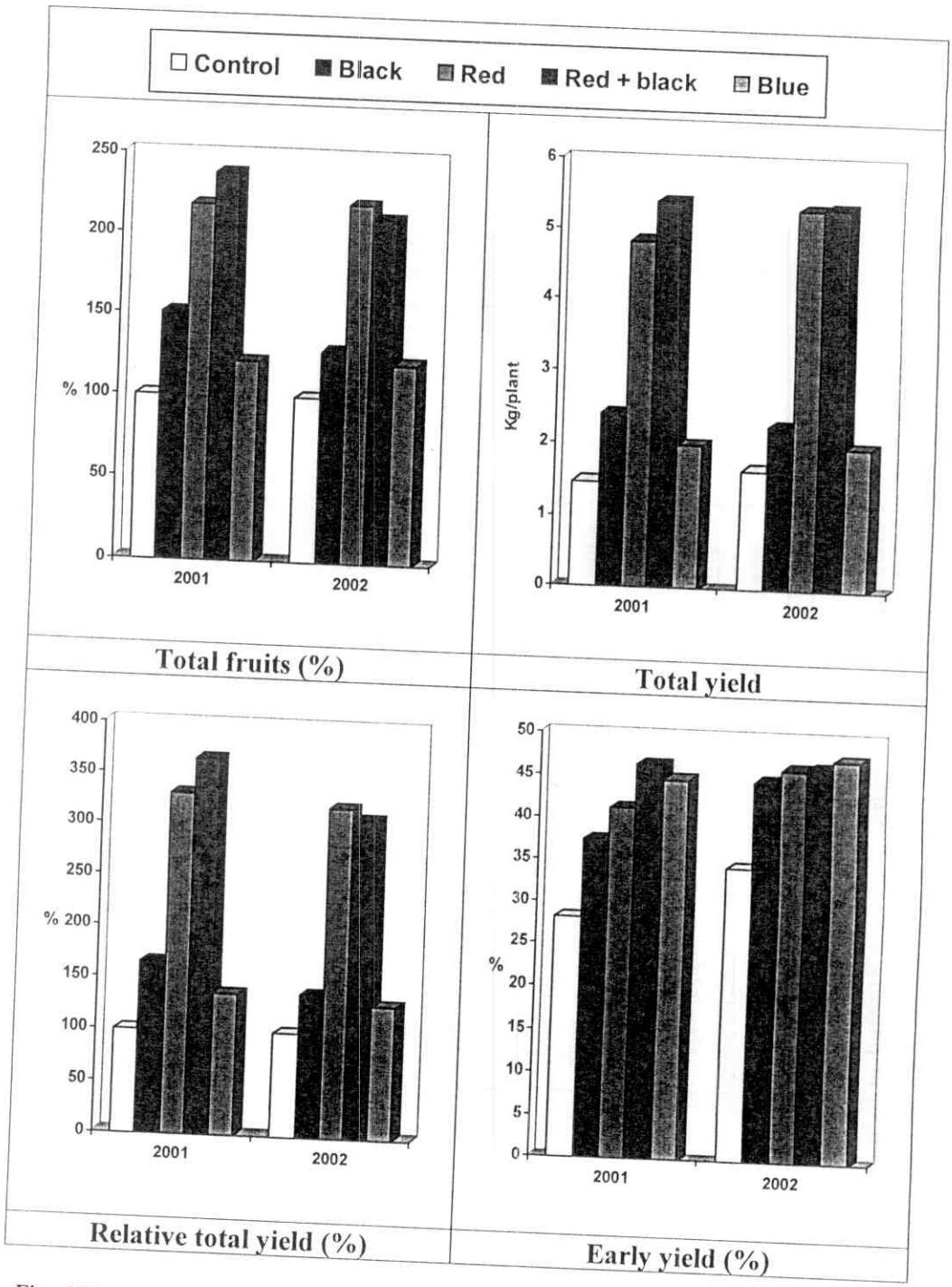


Fig. (48): Bar diagram indicating the effect of color mulches on total yield of tomato (*Lycopersicon esculentum*, Mill.) plants during 2001 and 2002 seasons.

color gave the highest total fruits weight (5.32 kg/plant) during 2002 season but red + black exhibited the highest (5.34 kg/plant) during 2001 season. These data being of great interest when compared with total fruits weight of control treatment that only weighted 1.46 & 1.66 kg/plant during the two assigned seasons. Also, that means that, mulch colors treatment gave not only highest increase of total fruits yield but also that part considered as early fruits yield. In addition these data being more evident when related them to the control ones.

Of interest also to note that the percentages of early fruits yield weight when related to the weight of total yielded fruits were increased to reach the high level of significance with all used colors except that its significant increase only at the 5% level of significance with black color during 2001 season.

This result summarize the bulk of interest of the present study, since the percentages of fruit yield weights e.g. reached to 47.24, 46.50, 46.25 and 44.74% during 2002 season with blue, red + black, red and black one, respectively. That means, nearly about half of the yielded fruits considered as early ones.

Furthermore, **Decoteau *et al.* (1989) and Kasperbauer and Hunt (1998)** concluded that mulch surface color can influence the plant microclimate sufficiently to affect the early and total yields of fresh-market tomatoes. Color of mulch affected both the plant light environment and soil temperatures. The beneficial effects of mulch color as compared to another are related to its effects on spectral distibution of upwardly reflected light as well as on soil temperature.

IV.1.6. Biological and economical yields:

As indicated in Table (41) and Fig. (49) the economic yield of tomato plant, i.e. dry weight of yielded fruits was increased to reach the high level of significance with different used mulch colors during 2001 and 2002 seasons.

Also, it could be noticed that each of red + black treatment during 2001 season and the red one during 2002 season gave the highest weights of economic yield that reached 236.28 and 234.98 gm/plant, respectively. Meanwhile, the black mulch ranked the second, yet, blue mulch gave the lowest increase in this respect.

Here, of interest to note that different mulch colors specially the red one significantly increased that part of assimilates being allocated to the economic part of tomato plant, i.e. fruits. These data being more evident also when related to the control, since during 2001 season dry matter accumulation in tomato fruits were more than the control values by three, six, six and two times with black, red, red + black and blue mulches, respectively.

On the other hand, the biological yield of tomato plants, i.e. total dry matter produced (including dry matter of shoots + fruits) were also exhibited high significant increase with different colors of used mulches.

These results are of great interest because they mean that color mulches not only increased dry matter accumulation in fruits but also that existed in shoots. That in other meaning strictly proved that the used mulch colors obviously increased the efficiency of photosynthesis in plants grown above them. In

addition, this stimulation of dry matter production considered as a direct result for that vigorous growth including the photosynthetic area and their concentrations of photosynthetic pigments (Tables, 12 and 20) in leaves of tomato plants during different stages of growth (Tables 10 and 18).

With regard to the harvest index, i.e. the dry matter of economic yield divided by the dry matter of biological yield; results obtained in the present study could be considered as a pioneer ones in this respect. Because, as shown in Table (41) only each of red and red + black mulches increased this index to reach the high level of significance during 2001 and 2002 seasons. Meanwhile, black color showed its insignificant increase only during 2001 season, yet, the rest of treatments insignificantly decreased it (i.e. black mulch during 2002 season and the blue mulch during the two assigned seasons).

Here, the obtained reduction of the harvest index under the black and blue mulches being in objection with the increase of the economic and biological yields with the same treatments. This objection could be interpreted on the basis that both treatments increased each of economical and biological yields but the proportion of biological yield increase was more greater than that of economical one. That means that a great part of photo-assimilates being directed to allocate in shoots under the treatments of these two color mulches.

Other studies, recently has been recommended the stimulative effect of red color mulches upon increasing of vegetative and reproductive growths of some vegetables **Fortnum *et al.* (1997); Wang *et al.* (1998); Loy *et al.* (1999) and Runkle and Heins (2001).**

IV.1.7. Fruit quality:

IV.1.7.1. Fruit characteristics:

Data in Table (42) and Fig. (50) clearly indicate that different mulches increased each of fruit size, fresh and dry weights of tomato fruits. These three characteristics of tomato fruits were increased to reach the high level of significance with red and red + black mulches but showed only insignificant increase with black and blue mulches.

The above mentioned data are of great interest, not only for increasing size of yielded fruits and their concentrations of bioconstituents but also, it must be mentioned that each red and red + black treatments reflected the greatest bulk of red and far red wavelengths during the growing season. So, improvement of fruits growth and development could be also attributed to the effect of this light spectra upon many physiological processes including photosynthetic pigments synthesis and photosynthesis process itself or enhancement of some phytohormones creation as well as other essential bioconstituents.

Here, again, it must be noticed that even at the one fruit basis; red mulch nearly duplicated the dry matter accumulation in fruits when compared with that in fruits of control plants. Moreover, these data were accompanied with great histological alterations in the internal structure in leaves of tomato plants as will mentioned later.

On the other hand, fruit dimensions, i.e. length and diameter were variously responded. In this respect, fruit length was significantly decreased at the level of 5% during 2001 season and reduction reached 1% level in 2002 season, with

black mulch. But, it was insignificantly decreased during the two assigned seasons with each of red and red + black treatments. Meanwhile, it was only increased but insignificantly with blue mulch color.

On the other hand, fruit diameter was increased with the three used mulch colors to reach the high level of significance with each of red and red + black treatments but insignificantly it was only increased with each of black and blue colors.

In this respect, it could be concluded that insignificant reduction of fruit length and high significant increase of its diameter being related with alterations in hormone profile. Since, red color increased cytokinins concentration in shoots of tomato plants as well mentioned later. Cytokinins has been reported not only to increase the wide growth on the account of longitudinal one but also to make fruits and other storage organs very active and strong sinks **(Hopkins, 1995).**

Therefore, fruit shape index, as shown in Table (42) considered as a light view for different effects of used treatments upon fruit characteristics.

IV.1.7.2. Effect of color mulches on minerals and crude protein concentrations in tomato fruits:

Data in Table (43) and Fig. (51) clearly show that various color of used mulches increased N, P, K, Ca and Mg concentration in the marketable stage of tomato fruits. In this respect, red color was more pronounced for increasing all these elements during the two assigned season. That was true even when used alone for N & P or above the black mulch (for K, Ca & Mg). Meanwhile, black and blue mulches ranked the second in this respect.

Table (43): Effect of polyethylene mulch surface color on minerals and crude protein concentration in ripened marketable tomato *(Lycopersicon esculentum, Mill.)* fruits *(i.e. Light red stage)* during 2001 and 2002 seasons.

Chemical composition / Treatment	N mg/g dry weight		P mg/g dry weight		K mg/g dry weight		Ca mg/g dry weight		Mg mg/g dry weight		Total determined elements mg/g dry weight		Crude protein			
													mg/g dry weight		% relative to the control	
	Seasons		Seasons		Seasons		Seasons		Seasons		Seasons		Seasons		Seasons	
	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002
Black	19.34	22.63	4.18	4.50	18.12	20.24	3.24	3.44	2.48	2.34	47.36	35.15	120.88	141.44	105.57	110.82
Red	27.18	24.48	4.90	4.94	24.70	26.42	3.80	3.86	2.50	2.42	63.08	62.12	169.88	153.00	148.37	119.88
Red + Black	21.28	23.64	4.75	4.72	26.40	26.80	3.82	3.94	2.62	2.70	58.87	61.80	133.00	147.75	116.16	115.76
Blue	19.70	23.25	3.48	3.56	22.72	24.12	3.62	3.50	2.46	2.50	51.98	56.93	123.13	145.32	107.54	113.86
Control	18.32	20.42	3.25	3.36	16.82	20.06	3.18	3.24	1.74	2.14	43.31	49.22	114.50	127.63	100.00	100.00

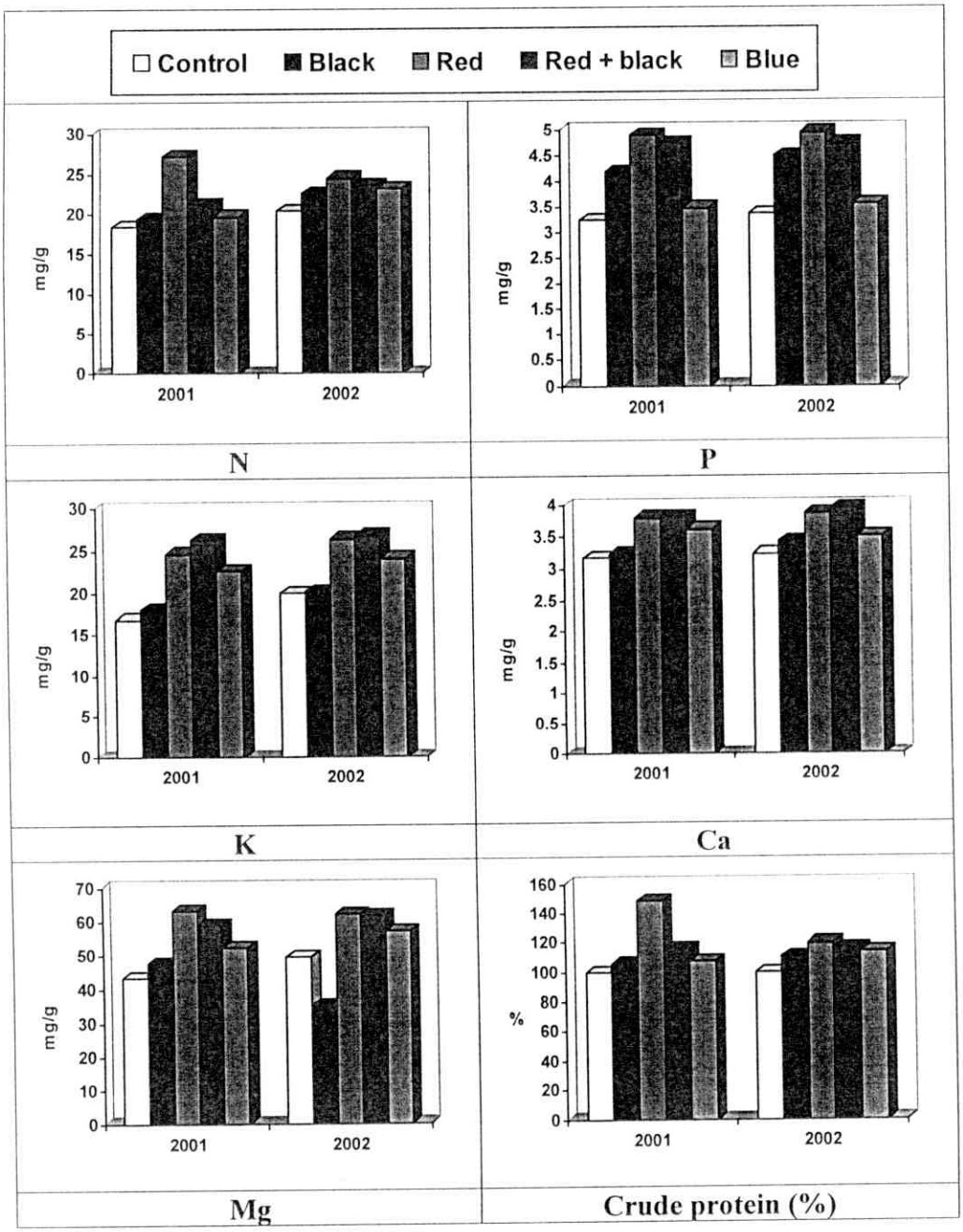


Fig. (51): Bar diagram indicating the effect of color mulches on minerals (mg/g dry weight) and crude protein (% relative to the control) of tomato (*Lycopersicon esculentum*, Mill.) fruits (i.e. light red stage) during 2001 and 2002 seasons.

As for the crude protein concentration clearly it could also be noticed that color mulch treatment increased its concentration in ripened tomato fruits during 2001 and 2002 seasons. Also, red mulch gave the highest concentration followed by red + black, blue and black in descending order.

The above mentioned results evidently indicated that mulch treatment increased the ability of tomato fruits as sink organs. So, absorption of these elements, their translocation into fruits being highly stimulated under such treatment. That is also true for the crude protein concentration as one of the essential bioconstituents.

Here, it must mentioned that mulch treatment make tomato fruits with high nutritive value, i.e. it increased their validity for human consumption.

Also, as previously mentioned, alteration of R/FR ratio by mulch treatment has been reported to increase the ability of sink organs to accumulate more assimilates **(Gan and Stobbe, 1996 and Niu *et al.*, 1998)**.

IV.1.7.3. Effect of mulch treatment on some bioconstituents in tomato fruits:

Data in Table (44) and Fig. (52) strongly recommend that positive and stimulative effects of mulch treatment specially that red one upon many bioconstituents production including vitamin C (Table, 45), crude protein (Table, 43) and here each of total carbohydrates and sugars.

Since, mulch treatment, obviously increased carbohydrates concentration and content special red alone or when used above the black one.

Table (44): Effect of polyethylene mulch surface color on sugars and carbohydrates concentration and content in ripened marketable tomato *(Lycopersicon esculentum Mill.)* fruits *(i.e., light red stage)* during 2001 and 2002 seasons.

Chemical composition / Treatment	Total carbohydrates						Reducing sugars mg/g fresh weight		Non reducing sugars mg/g fresh weight		Total sugars					
	mg/g dry weight		(g) / fruit		% relative to the control						mg/g fresh weight		(g) / fruit		% relative to the control	
	Seasons		Seasons		Seasons		Seasons		Seasons		Seasons		Seasons		Seasons	
	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002
Black	700.06	713.79	2.79	2.76	104.49	103.37	15.65	18.35	10.44	12.23	26.09	30.58	2.27	2.67	104.13	115.58
Red	735.75	741.24	3.96	4.08	148.31	152.81	21.85	26.15	14.57	17.43	36.42	43.58	4.42	5.43	202.75	235.07
Red + Black	743.99	749.48	4.06	4.13	152.06	154.68	22.18	23.95	14.79	15.96	36.97	39.91	4.56	4.98	209.17	215.58
Blue	716.53	727.52	3.00	3.11	112.36	116.48	17.92	17.74	10.99	13.16	28.91	30.90	2.79	3.18	127.98	137.66
Control	702.81	711.04	2.67	2.67	100.00	100.00	15.87	16.33	9.73	10.88	25.60	27.21	2.18	2.31	100.00	100.00

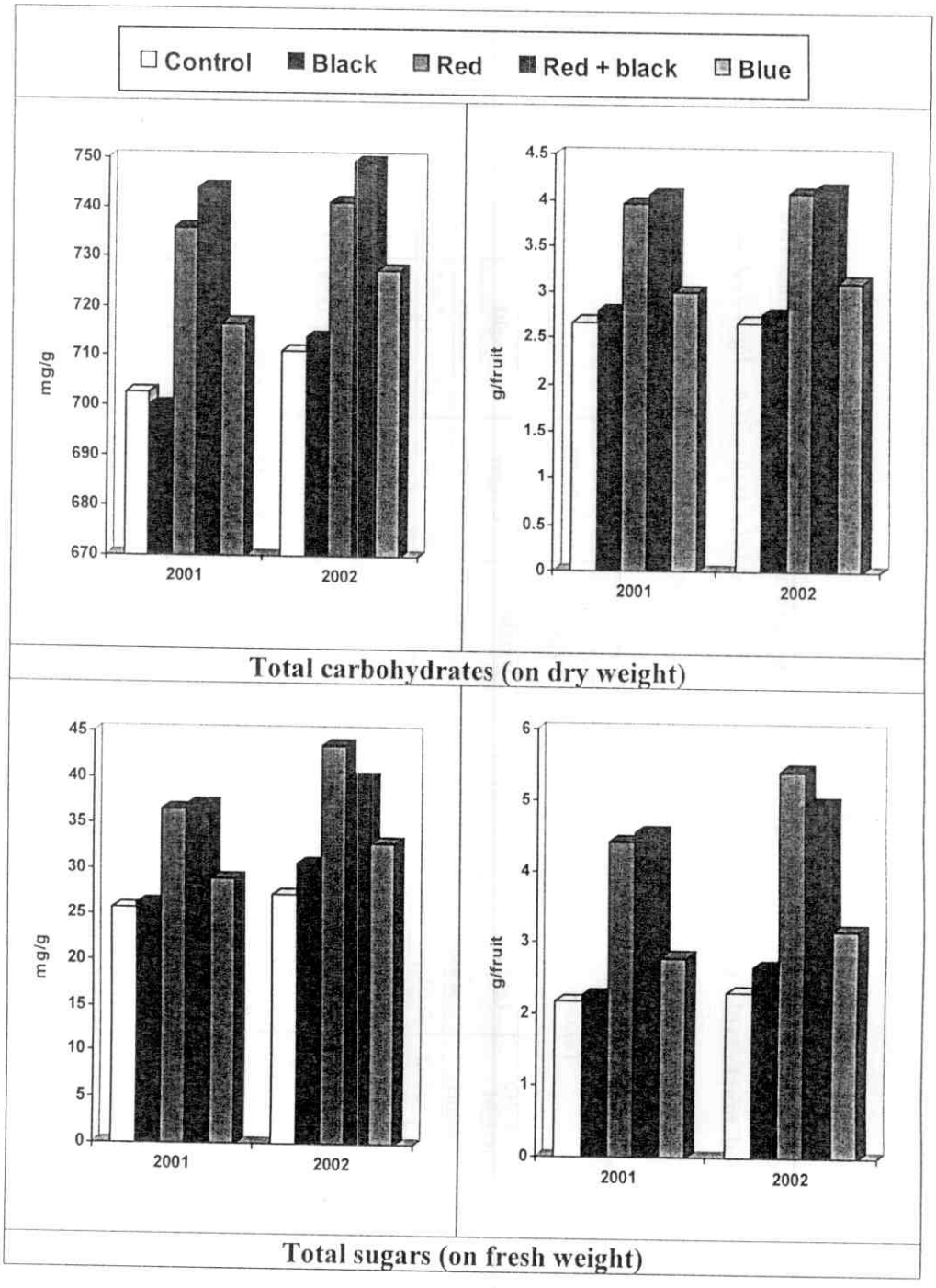


Fig. (52): Bar diagram indicating the effect of color mulches on sugars and carbohydrates concentration and content in ripened marketable tomato (*Lycopersicon esculentum*, Mill.) fruits (i.e., light red stage) during 2001 and 2002 seasons.

Also, total sugars (reducing and non-reducing) were increased with color mulch treatment to reach its maximum with red one and red + black followed by blue and black mulches.

IV.1.7.4. Effect of mulch treatment on some chemical constituents in tomato fruits:

As shown in Table (45) and Fig. (53) all used mulch colors, i.e. black, red and blue increased the amount of vitamin C in fruit during the two assigned seasons. Also, it could be noticed that the highest increase of this vitamin existed with the red mulch treatment that reached 26.88 and 28.93 mg/100 g fresh fruit during 2001 & 2002 seasons, respectively.

As for the total soluble solids, it could also be noticed that its percentage increased with different mulch colors to reach its maximum during 2001 season with red + black treatment and with red one during 2002 season.

With regard to the titratable acidity percentage, results as shown in Table (45) also indicate its increase with different mulch colors. These results being important from the view of fruit quality. Since, shelf time of such fruits being increased in case of mulch colors treatment specially that of red one.

In this respect, **Wang *et al.* (1998)** has been reported such improvement of tomato fruits quality by increasing its concentrations of total soluble solids and the titratable acidity, as well.

Table (45): Effect of polyethylene mulch surface color on some chemical constituents of tomato (*Lycopersicon esculentum*, Mill.) fruits during 2001 and 2002 seasons.

Fruit quality / Treatment	Vitamin C (mg/100g fresh fruit)		Total soluble solids (%)		Titratable acidity (%)	
	Seasons		Seasons		Seasons	
	2001	2002	2001	2002	2001	2002
Black	21.18	22.67	4.84	5.12	0.524	0.580
Red	26.88	28.93	6.29	6.79	0.752	0.695
Red + Black	27.64	28.04	6.80	6.59	0.689	0.651
Blue	23.42	25.17	5.43	5.98	0.634	0.541
Control	20.44	21.05	4.12	5.04	0.512	0.510

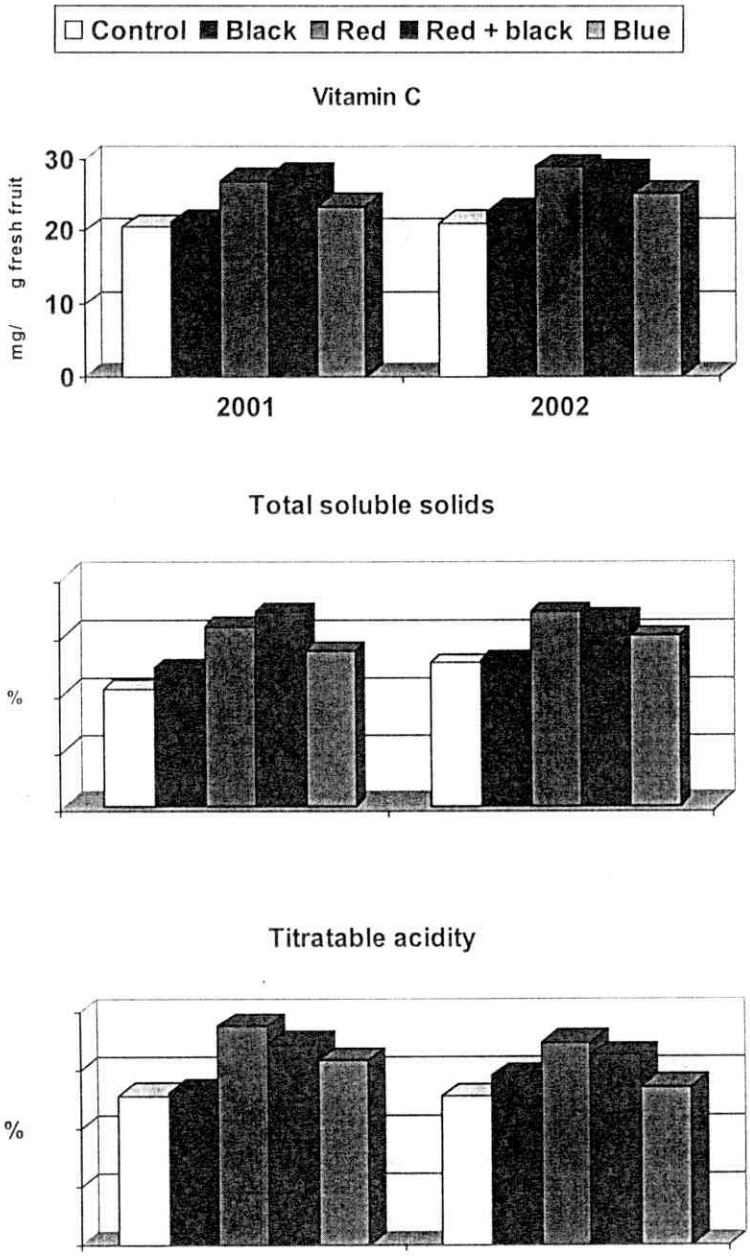


Fig. (53): Bar diagram indicating the effect of color mulches on some chemical constituents of tomato (*Lycopersicon esculentum,* Mill.) fruits during 2001 and 2002 seasons.

IV.2. Sweet pepper plants:

IV.2.1. Flower characteristics:

In this respect, it could be noticed that red and red + black mulch colors gave the highest value in earliness of flower anthesis (Table, 46) and Fig. (54). Earliness days were 27.80, 26.20, 17.00 and 16.40 days for red + black, red, black and blue during 2001 season, respectively. In other meaning, after transplanting plants grown above red + black, red, black and blue mulch treatments, their flowering buds started stored anthesis at the age of 41.40, 43.00, 52.20 and 52.80 days during 2001 season, respectively comparing with 69.2 days for bare soil.

These days of earliness reached to 40.17, 37.86, 24.57 and 17.34% with red + black, red, black and blue mulch colors less than control value during 2001 season, respectively.

In this respect, **Thomas and Vince-Prue (1997)** reported that the photoperiodic control of flowering is brought about by the interaction of genes involved in the developmental control of floral initiation, the regulation of the circadian clock and the signal transduction of photoreceptors.

IV.2.2. Number of flowers:

As shown in Table (46) and Fig. (54) different mulch colors, highly significantly increased number of flowers per plant during the two assigned seasons. Values were 102.00 & 113.60, 97.40 & 104.80, 82.40 & 88.40 and 75.00 & 79.20 flowers in 2001 and 2002 seasons for red + black, red, blue and black mulch colors, respectively. Meanwhile, values were 65.20 & 70.40 flowers in the 2001 and 2002 seasons, for control plants.

Table (46): Effect of polyethylene mulch surface color on flowering, fruit settings and abscission of sweet pepper (*Capsicum annuum* L.) plants during 2001 and 2002 seasons.

Character / Treatment		Start of flower anthesis (days)		Earliness of flower anthesis (days)		Earliness of flower anthesis % relative to the control		No. of Flowers / plant		Total fruits (No. / plant)		Fruit setting (%)		Abscission (%)	
		Seasons		Seasons		Seasons		Seasons		Seasons		Seasons		Seasons	
		2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002
Black		52.20	50.60	17.00	16.20	24.57	24.25	75.00	79.20	25.20	27.20	33.60	34.34	66.40	65.66
Red		43.00	40.80	26.20	26.00	37.86	38.92	97.40	104.80	47.00	50.20	48.25	47.90	51.75	52.10
Red + Black		41.40	43.20	27.80	23.60	40.17	35.33	102.00	113.60	50.60	54.40	49.61	47.89	50.39	52.11
Blue		52.80	54.80	16.40	12.00	17.34	17.96	82.40	88.40	26.00	29.60	31.55	33.48	68.45	66.52
Control		69.20	66.80	0.00	0.00	0.00	0.00	65.20	70.40	20.40	23.20	31.29	32.95	68.71	67.05
L.S.D.	0.05	1.43	1.38	-	-	-	-	2.98	2.74	1.54	2.71	2.35	2.88	2.15	2.84
	0.01	1.99	1.96	-	-	-	-	4.11	3.78	2.12	3.75	3.11	4.02	2.97	3.96

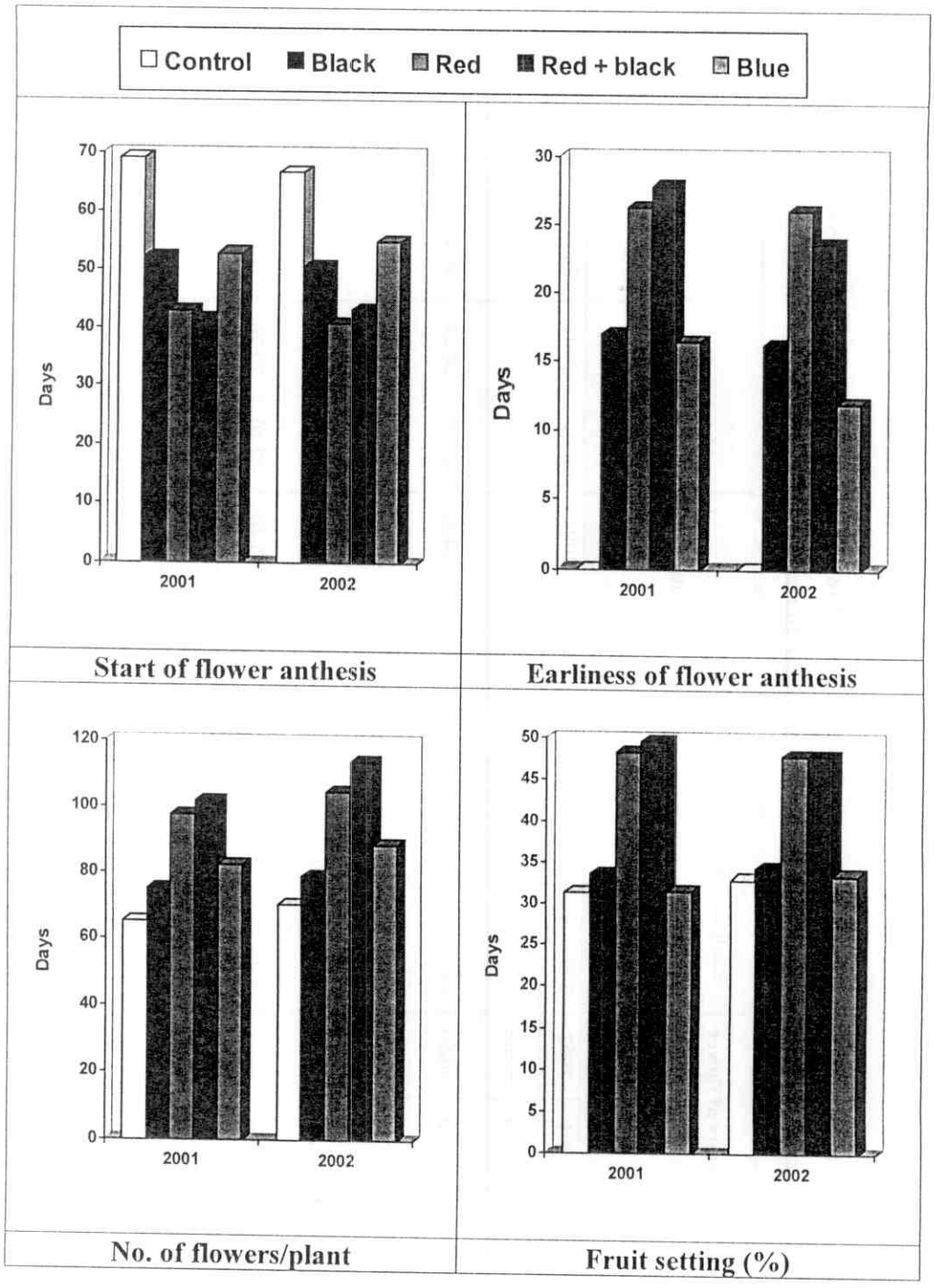


Fig. (54): Bar diagram indicating the effect of color mulches on flowering, fruit settings and abseission of pepper (*Capsicum annuum*, L.) plants during 2001 and 2002 seasons.

On the other hand, the percentage of abscission was decreased to reach the high level of significance with red and red + black mulch colors during the two seasons. But significantly was decreased at 5% level with black one during 2001 season and insignificantly decreased with black and blue colors in 2002 season. Also, it could be noticed that each of red + black and red treatments were more pronounced in this respect. These results are in agreement with those obtained by **Hunt *et al.* (1990) and Mozley and Thomas (1995).**

IV.2.3. Pollen grains fertility:

As in case of tomato plant different applied mulch colors increased the fertility of pollen grains in sweet pepper plants (Table, 47 and Fig., 55). The exception was only that reduction of pollen grains fertility in case of black mulch surface color during 2002 season. Also, it could be noticed that the red mulch color gave the highest fertility followed by red + black, blue and black ones during two seasons.

These data being more evident when related to the control values since the 100 percentage of control rose to 148.08 & 130.39 and 138.37 & 122.05% with red and red + black colors during 2001 and 2002, respectively. On the other hand, the only reduction existed was of 90.91% during 2002 season with the black mulch color.

In addition, red mulch color gave the lowest percentages of sterility in the pollen grains that reached to 18.69 & 23.08% meanwhile, each of black and blue mulch colors exhibited the highest percentages of sterility that reached to 44.21 & 46.37 and 42.12 & 37.57% during 2001 and 2002, respectively.

Table (47): Effect of polyethylene mulch color on pollen grains fertility of sweet pepper (*Capsicum annuum* L.) plants during 2001 and 2002 seasons.

Character / Treatment	Fertility						Sterile				Sterility					
	%		% relative to the control				Morphol. normal %		Aborted %		%		% relative to the control			
	Seasons		Seasons				Seasons		Seasons		Seasons		Seasons			
	2001	2002	2001	% ±	2002	% ±	2001	2002	2001	2002	2001	2002	2001	% ±	2002	% ±
Black	55.79	53.63	101.60	+1.60	90.91	-9.09	23.13	26.09	21.08	20.28	44.21	46.37	98.05	-1.95	113.07	+13.07
Red	81..31	76..92	148.08	+48.08	130.39	+30.39	11.62	14.35	7.07	8.73	18.69	23.08	41.15	-58.85	56.28	-43.72
Red + Black	75.98	72.00	138.37	+38.37	122.05	+22.05	15.09	17.14	8.93	10.86	24.02	28.00	53.27	-46.73	68.28	-31.72
Blue	57.88	62.43	105.41	+5.41	105.83	+5.83	25.15	23.56	16.97	14.01	42.12	37.57	93.41	-6.59	91.61	-8.39
Control	54.91	58.99	100.00	0.00	100.00	0.00	24.50	23.01	20.59	18.00	45.09	41.01	100.00	0.00	100.00	0.00

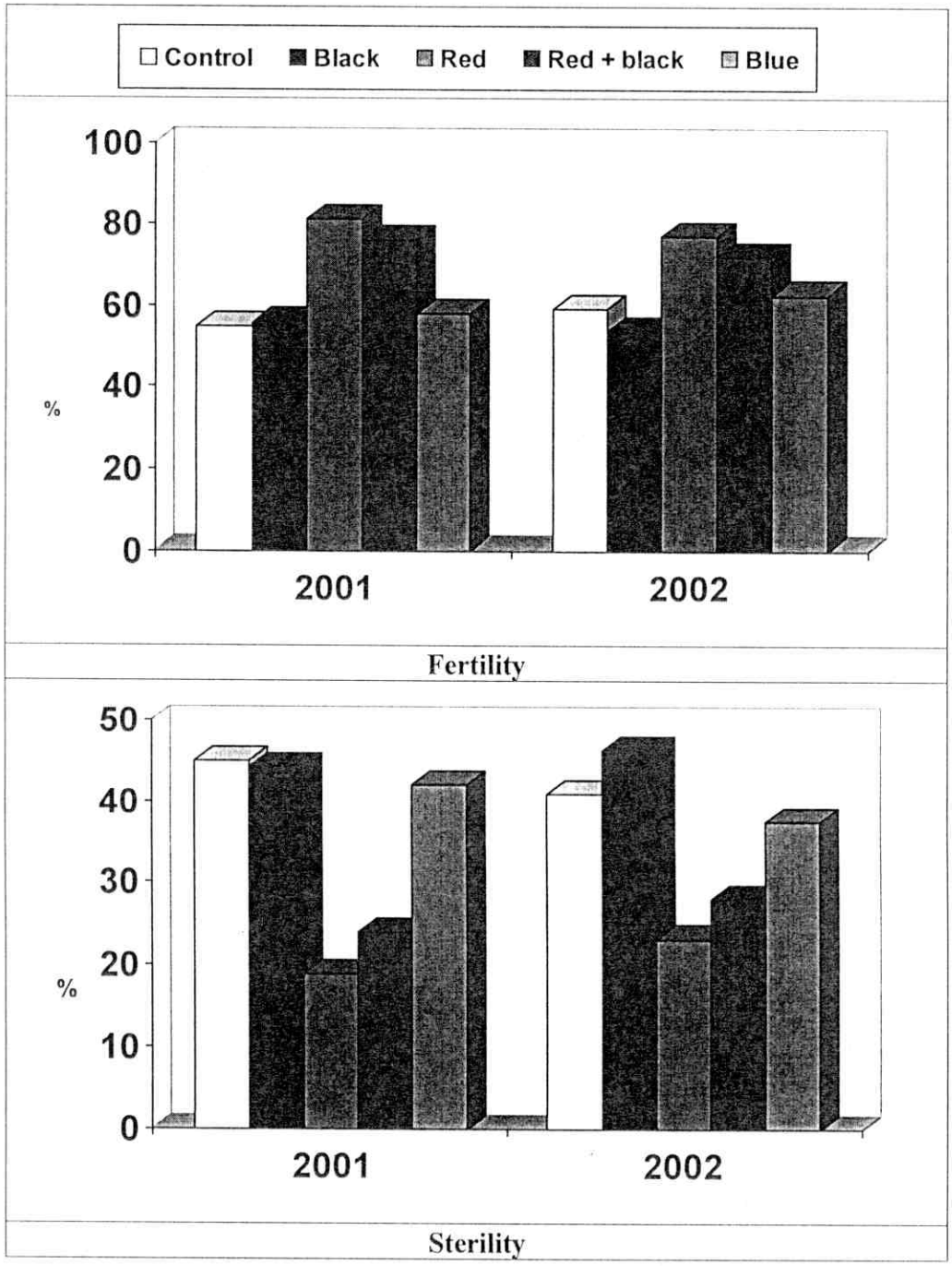


Fig. (55): Bar diagram indicating the effect of color mulches on pollen grains fertility of pepper (*Capsicum annuum* L.) plants during 2001 and 2002 seasons.

IV.2.4. Early fruits and yield:

As shown in Table (48) and Figs. (56 & 57) high significant increase in the number of early sweet pepper fruits was existed with different applied mulch colors during 2001 and 2002 seasons. Also, the red + black mulch color ranked the first in this respect followed by red, blue and black ones.

Moreover, red + black and red treatments gave the highest values when compared to the control. Values were 26.20 & 24.40 and 21.20 & 22.40 fruit per plant with red + black and red colors during 2001 and 2002, respectively, meanwhile values were 4.80 & 6.40 in the control plants.

Also, these data being more evident when related to the control value. These values reached more than four and fifth times in 2001 season with red and red + black, respectively.

With regard to the weight of early yielded fruits per plant, it was positively responded as in case of tomato plants.

IV.2.5. Total fruit yield:

As shown in Table (49) and Fig. (58), all used mulch colors exhibited high significant increase of total fruits number per plant. Also, of interest to note that the treatment of red + black and red one gave the highest values in this respect. Values were 50.60 & 54.40 and 47.00 & 50.20 fruits with red + black and red colors during 2001 and 2002 seasons, but were 20.40 & 23.20 with control plants.

As for weight of total yielded fruits (kg/plant), its high significant increase existed with red and red + black mulch colors meanwhile insignificant increase with blue and black

Table (48): Effect of polyethylene mulch surface color on early fruits yield of sweet pepper (*Capsicum annuum* L.) plants during 2001 and 2002 seasons.

Yield components / Treatment		Early fruits				Early yield*			
		(No. / plant)		% relative to the control		(g)/plant		% relative to the control	
		Seasons		Seasons		Seasons		Seasons	
		2001	2002	2001	2002	2001	2002	2001	2002
Black		10.20	12.80	212.50	200.00	268.45	352.08	217.32	203.96
Red		21.20	22.40	441.67	350.00	991.45	1112.52	802.60	644.49
Red + Black		26.20	24.40	545.83	381.25	1220.84	1175.23	988.29	680.82
Blue		10.60	13.20	220.83	206.25	301.26	405.27	243.88	234.78
Control		4.80	6.40	100.00	100.00	123.53	172.62	100.00	100.00
L.S.D.	0.05	1.72	1.40	112.35	41.74	175.64	111.96	305.59	197.06
	0.01	2.37	1.93	154.95	57.56	242.24	154.42	421.47	271.79

* Early yield = Fruits of the first four pickings.

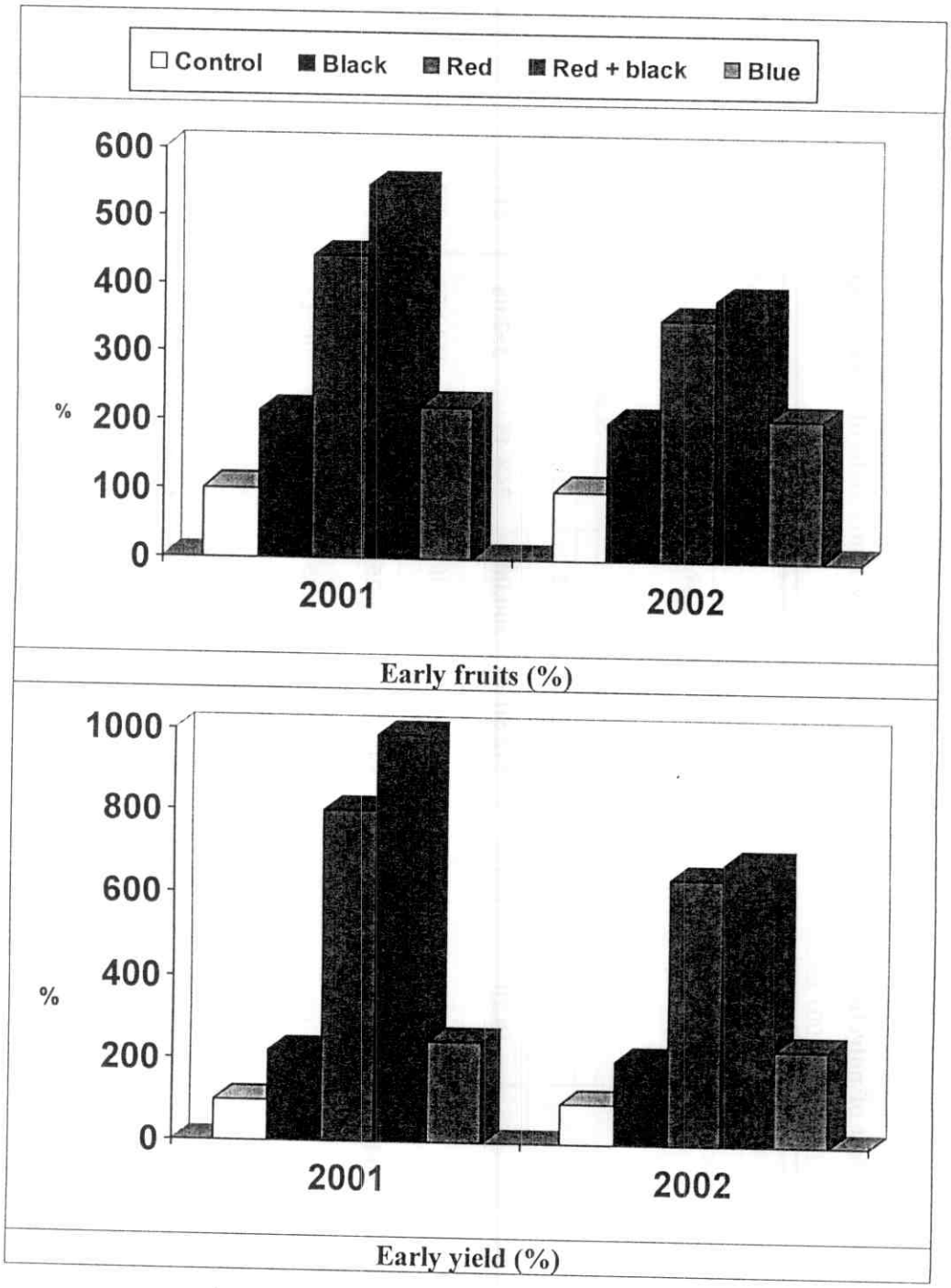


Fig. (56): Bar diagram indicating the effect of color mulches on early fruits yield of pepper (*Capsicum annuum* L.) plants during 2001 and 2002 seasons.

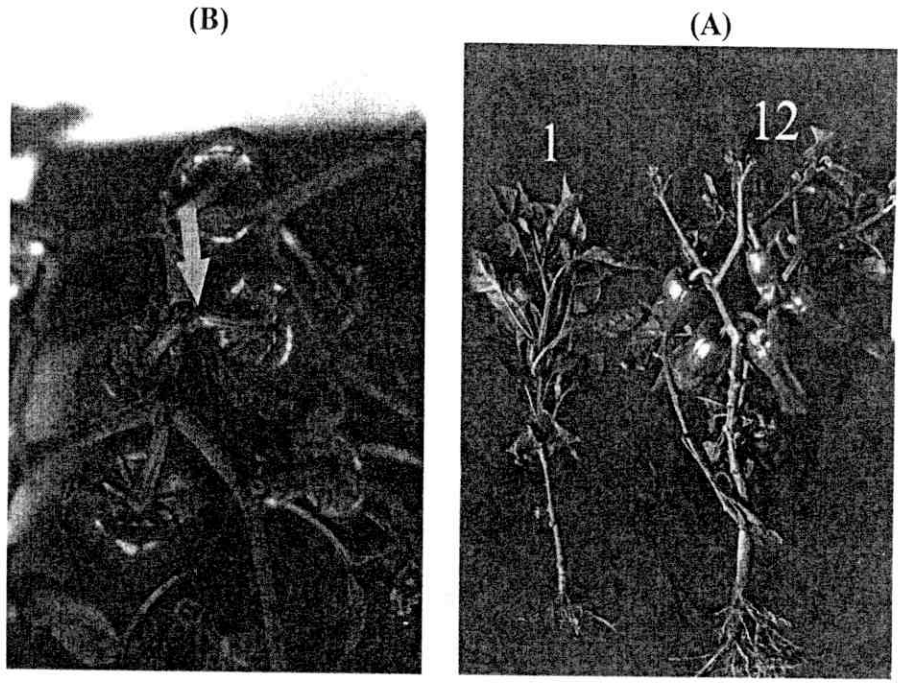


Fig.(57): Red treatnent ; indicating early fruit yield (A-12) and more than one developing fruit were formed on the same node (B) and in comparisonwith the control (A-1) .

Table (49): Effect of polyethylene mulch surface color on total yield of sweet pepper (*Capsicum annuum* L.) plants during 2001 and 2002 seasons.

Yield components / Treatment		Total fruits (No./plant)		% relative to the control		Total yield (kg/plant)		Relative total yield (%)		Early yield (kg/plant)		Early yield (%)	
		Seasons		Seasons		Seasons		Seasons		Seasons		Seasons	
		2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002
Black		25.20	27.20	123.53	117.24	0.66	0.74	124.53	119.36	0.27	0.35	40.91	47.30
Red		47.00	50.20	230.39	216.38	2.20	2.49	415.09	401.61	0.99	1.11	45.00	44.58
Red + Black		50.60	54.40	248.04	234.48	2.64	2.85	498.11	459.68	1.37	1.28	51.89	44.91
Blue		26.00	29.60	127.45	127.59	0.73	0.91	137.74	146.77	0.30	0.41	41.10	45.05
Control		20.40	23.20	100.00	100.00	0.53	0.62	100.00	100.00	0.12	0.17	22.64	27.42
L.S.D.	0.05	1.54	2.71	10.11	13.18	0.32	0.29	79.97	63.53	0.73	0.11	10.37	6.27
	0.01	2.12	3.75	13.94	18.18	0.44	0.39	110.30	87.25	1.00	0.15	14.31	8.64

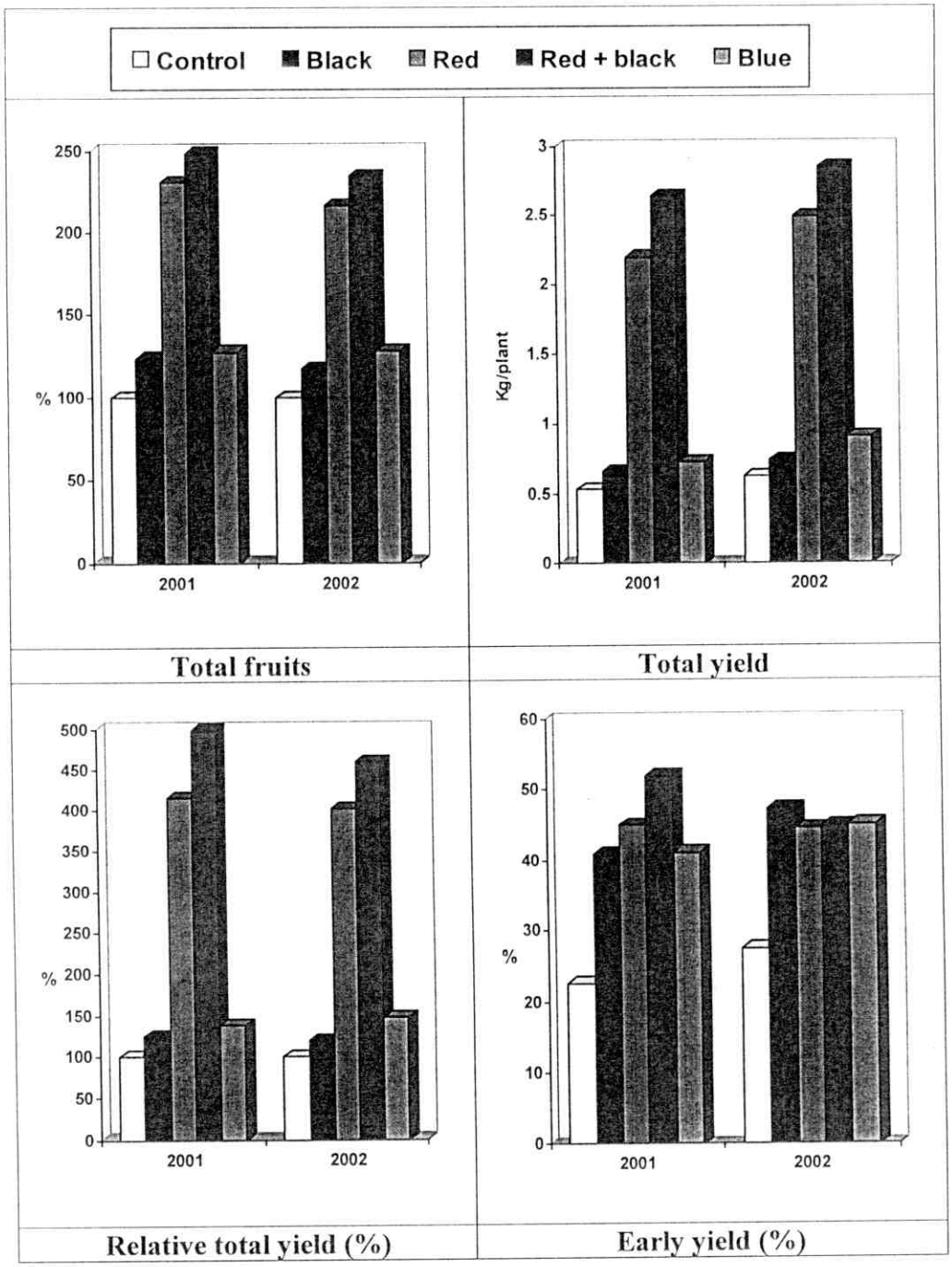


Fig. (58): Bar diagram indicating the effect of color mulches on total yield of sweet pepper (*Capsicum annuum* L.) plants during 2001 and 2002 seasons.

colors were obtained during 2001 and 2002 seasons. In this respect, the red + black and red treatments gave the highest weights (2.64 & 2.85 and 2.20 & 2.49 kg/plant during 2001 and 2002 seasons, respectively), meanwhile values were 0.53 & 0.62 kg/plant with control plants during the two seasons.

As for the percentage of early yield weight when related to the weight of total yielded fruits were increased to reach the high level of significance with all applied mulch colors during the two assigned seasons.

Other studies reported similar results of mulch colors treatment upon early and total yields of sweet pepper **(Decoteau *et al.*, 1990 and Flores and Ibarra, 1998).**

IV.2.6. Biological and economical yields:

Data in Table (50) and Fig. (59) clearly indicate that these two parameters in case of sweet pepper plant were behaved as the same as in case of tomato plant.

Also, it could be noticed that red + black and red treatments gave the highest values followed by blue and black ones. Values were 70.65 & 73.19 and 56.21 & 67.56 (gm) / plant with red + black and red mulch colors during 2001 and 2002 seasons, respectively.

In addition, of interest to note that various mulch colors specially the red one significantly increased that part of assimilates being allocated to the economic part of sweet pepper plant, i.e. fruits. These results being more evident when related to the control values.

Table (50): Effect of polyethylene mulch surface color on biological and economical yields as well as the harvest index of sweet pepper (*Capsicum annuum* L.) plants during 2001 and 2002 seasons.

Yield components / Treatment		Economical yield				Biological yield *				Harvest index (%)	
		(g)/plant		% relative to the control		(g)/plant		% relative to the control			
		Seasons		Seasons		Seasons		Seasons		Seasons	
		2001	2002	2001	2002	2001	2002	2001	2002	2001	2002
Black		17.82	20.21	125.94	119.80	84.77	94.74	145.88	142.83	21.02	21.33
Red		56.21	67.56	397.24	400.47	133.25	148.90	229.31	224.48	42.18	45.37
Red + Black		70.65	73.19	499.29	433.85	159.26	171.35	274.07	258.33	44.36	42.71
Blue		20.02	24.88	141.48	147.48	83.52	95.29	143.73	143.66	23.97	26.11
Control		14.15	16.87	100.00	100.00	58.11	66.33	100.00	100.00	24.35	25.43
L.S.D.	0.05	9.21	6.13	85.37	42.42	18.58	14.89	35.05	24.91	6.42	5.00
	0.01	12.70	8.45	117.74	58.51	25.62	20.54	48.35	34.35	8.86	6.90

* The biological yield calculated without dry weight of root system.

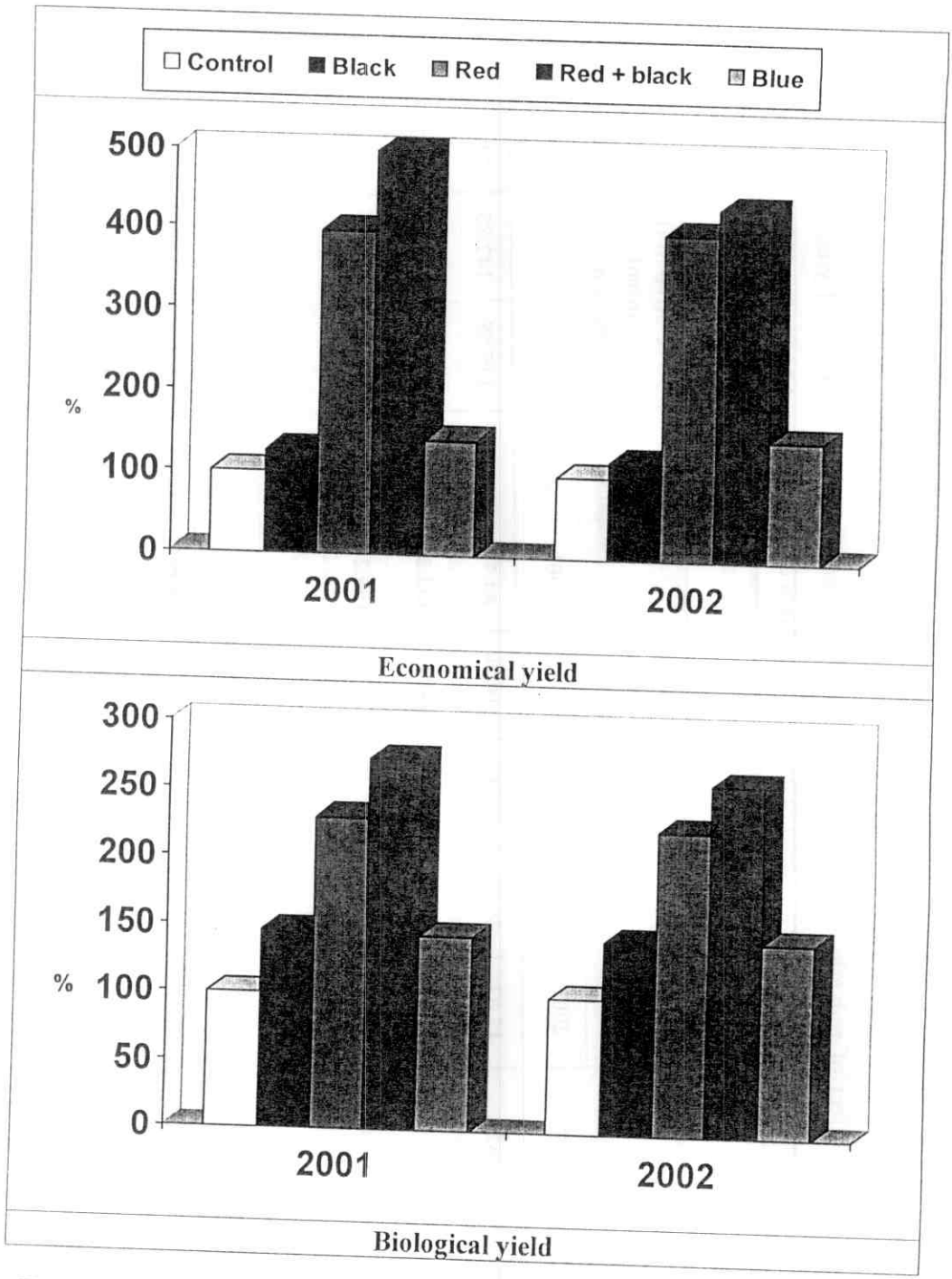


Fig. (59): Bar diagram indicating the effect of color mulches on total yield of sweet pepper (*Capsicum annuum* L.) plants during 2001 and 2002 seasons.

Regarding, the biological yield of sweet pepper plants, i.e. total dry matter of shoots and fruits were also exhibited high significant increase with various applied mulch colors except that significant increase at 5% level of significance with blue color in the first season. Also, in this respect red + black and red color mulches gave the highest values when compared with the bare soil (control).

Concerning the harvest index (i.e. the dry matter of economical yield divided by the dry matter of biological one), Table (50) indicate that only red + black and red mulch colors increased this index to reach the high level of significance during 2001 and 2002 seasons. Meanwhile, blue color mulch showed insignificant increase during second season, yet, the rest of treatment insignificantly decreased it.

IV.2.7. Fruit quality:

IV.2.7.1. Fruit characteristics:

Data presented in Table (51) and Fig. (60) clearly indicate that different applied mulch colors increased each of fruit size, fresh and dry weights of sweet pepper fruits during two seasons. Also, red, red + black and blue increased these characteristics of sweet pepper fruits to reach the high level of significance during the two seasons except blue one that gave only significant increase at 5% level in 2002 season. Meanwhile, black treatment gave insignificant increase of these characteristics but this increase reached to 5% level in fruit fresh and dry weights during 2002 season.

The above mentioned results are of great interest, because red and red + black treatments being reflected the greatest bulk

Table (51): Effect of polyethylene mulch surface color on fruit characteristics of sweet pepper (*Capsicum annunm* L.) plants during 2001 and 2002 seasons.

Fruit quality / Treatment		Fruit size (cm^3)		Fruit fresh weight (g)/fruit		Fruit dry weight (g)/fruit		Fruit dimensions				Fruit shape index (L/D)*	
								Length (cm)		Diameter (cm)			
		Seasons		Seasons		Seasons		Seasons		Seasons		Seasons	
		2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002
Black		59.50	61.00	25.47	29.40	0.71	0.80	7.73	7.12	4.03	3.92	1.92	1.82
Red		98.50	100.50	41.83	44.46	1.13	1.21	8.74	8.61	5.09	5.41	1.72	1.59
Red + Black		107.00	108.00	45.96	47.42	1.23	1.32	8.93	8.31	5.21	5.37	1.71	1.55
Blue		79.00	73.00	29.66	31.56	0.80	0.85	8.69	7.83	4.25	4.12	2.05	1.90
Control		53.50	56.00	21.99	23.62	0.59	0.64	7.24	7.17	3.98	4.25	1.82	1.69
L.S.D.	0.05	13.03	11.60	5.53	5.70	0.15	0.17	0.90	0.62	0.45	0.37	0.24	0.21
	0.01	17.47	15.56	7.41	7.65	0.21	0.23	1.21	0.82	0.61	0.50	0.32	0.27

* L = Length

D = Diameter

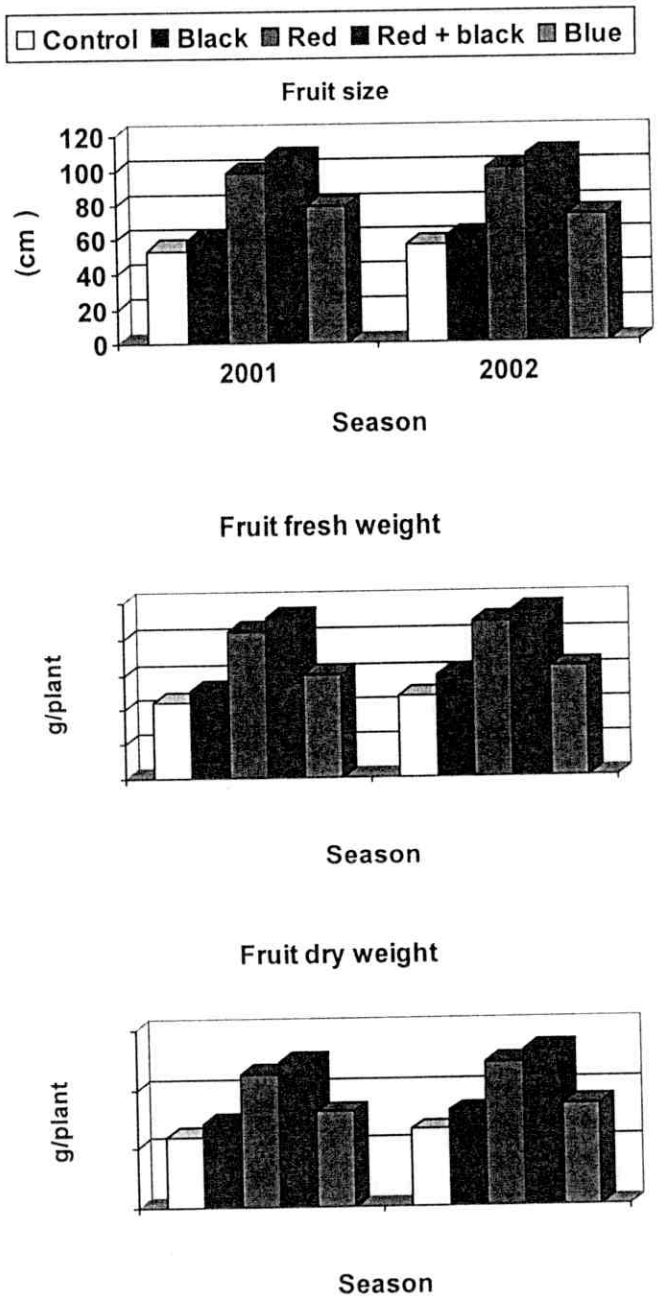


Fig. (60): Bar diagram indicating the effect of color mulches on fruit characteristics of sweet pepper (*Capsicum annuum* L.) plants during 2001 and 2002 seasons.

of red and far-red wavelengths during the growing season (Tables, 2, 3, 4 & 5). So, improvement of fruits growth and development could be also attributed to the effect of reflection of this light spectra upon many physiological orders.

On the other hand, fruit dimensions, were increased to reach the high level of significance with red and red + black treatments during 2001 and 2002 seasons and with blue one in 2001 season, as well. Also, black mulch color insignificantly increased it in 2001 season but insignificantly was decreased it in 2002 season.

Moreover, fruit shape index, as presented in Table (51) considered as a light view for different effects of applied treatments upon fruit characteristics.

IV.2.7.2. Effect of color mulches on minerals and crude protein concentrations in sweet pepper fruits:

Data in Table (52) and Fig. (61) clearly show that different used color mulches increased N, P, K, Ca and Mg concentration in marketable stage of sweet pepper fruits. Also, it could be noticed that red mulch color ranked the first followed by red + black, blue and the black one during the two assigned seasons.

As for the crude protein concentration, it was increased with different applied mulch colors. Also, the red treatment gave the highest concentration of crude protein in ripened sweet pepper fruits followed by red + black, blue while black ranked the last one in this respect.

Table (52): Effect of polyethylene mulch surface color on minerals and crude protein concentration in ripened marketable sweet pepper *(Capsicum annuum L.)* fruit *(i.e. Light green stage)* during 2001 and 2002 seasons.

Chemical composition / Treatment	N mg/g dry weight		P mg/g dry weight		K mg/g dry weight		Ca mg/g dry weight		Mg mg/g dry weight		Total determined elements mg/g dry weight		Crude protein			
													mg/g dry weight		% relative to the control	
	Seasons		Seasons		Seasons		Seasons		Seasons		Seasons		Seasons		Seasons	
	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002
Black	22.56	23.32	3.38	3.42	20.18	20.82	2.24	2.32	1.72	1.88	50.08	51.76	141.00	145.75	117.26	113.97
Red	28.36	26.76	4.17	3.98	22.70	24.14	3.16	3.04	2.60	2.55	60.99	60.47	177.25	167.25	147.40	130.79
Red + Black	25.42	24.80	3.86	3.92	21.84	22.62	2.60	2.68	1.98	2.08	55.70	56.10	158.88	155.00	132.12	121.21
Blue	24.82	24.62	3.54	3.62	20.64	20.96	2.38	2.52	1.84	1.92	53.22	53.64	155.13	153.88	129.01	120.33
Control	19.24	20.46	3.12	3.26	15.52	18.60	2.16	2.20	1.40	1.52	41.44	46.04	120.25	127.88	100.00	100.00

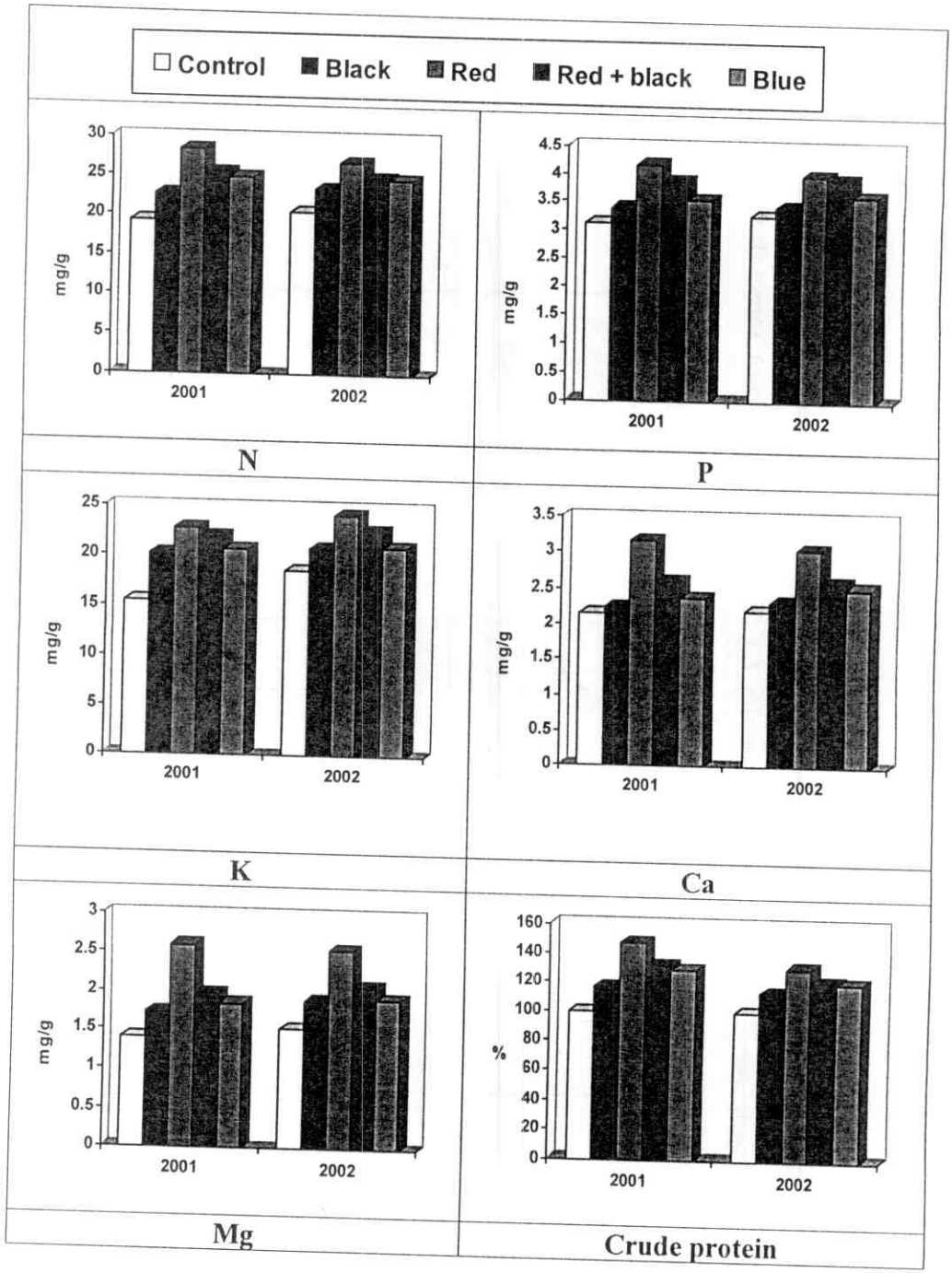


Fig. (61): Bar diagram indicating the effect of color mulches on minerals (mg/g dry weight) and crude protein (% relative to the control) of pepper (*Capsicum annuum* L.) fruits (i.e. light red stage) during 2001 and 2002 seasons.

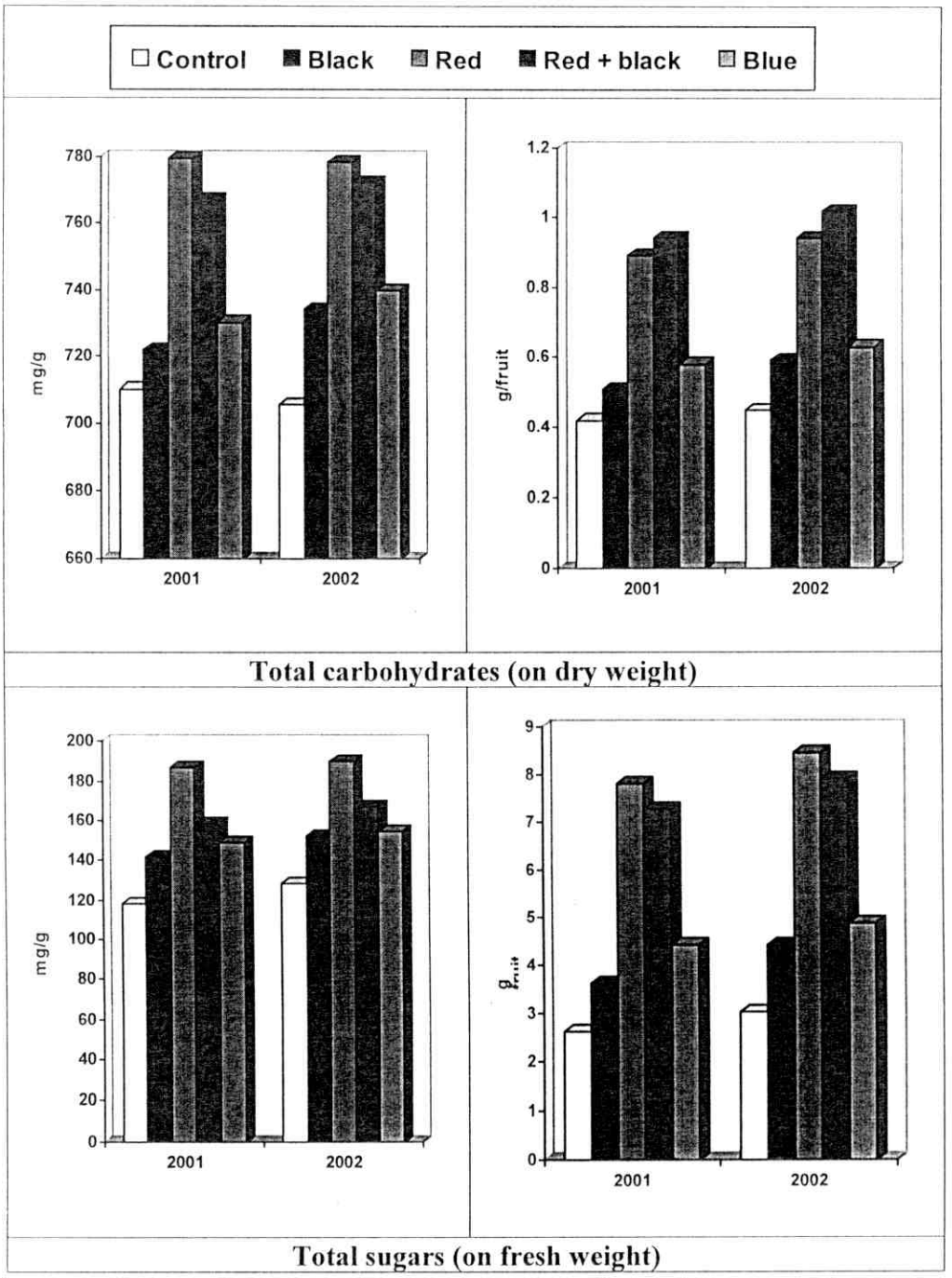


Fig. (62): Bar diagram indicating the effect of color mulches on sugars and carbohydrates concentration and content in ripened marketable sweet pepper (*Capsicum annuum*, L.) fruits (i.e., light green stage) during 2001 and 2002 seasons.

Table (54): Effect of polyethylene mulch surface color on some chemical constituents of sweet pepper (*Capsicum annuum* L.) fruits during 2001 and 2002 seasons.

Fruit quality / Treatment	Vitamin C (mg/100g fresh fruit)		Total soluble solids (%)		Titratable acidity (%)	
	Seasons		Seasons		Seasons	
	2001	2002	2001	2002	2001	2002
Black	127.80	125.73	4.07	3.98	0.312	0.343
Red	130.17	131.40	5.17	5.45	0.415	0.470
Red + Black	131.73	133.58	4.82	5.02	0.407	0.480
Blue	128.14	126.44	3.73	4.34	0.328	0.314
Control	124.50	121.18	3.18	3.34	0.298	0.302

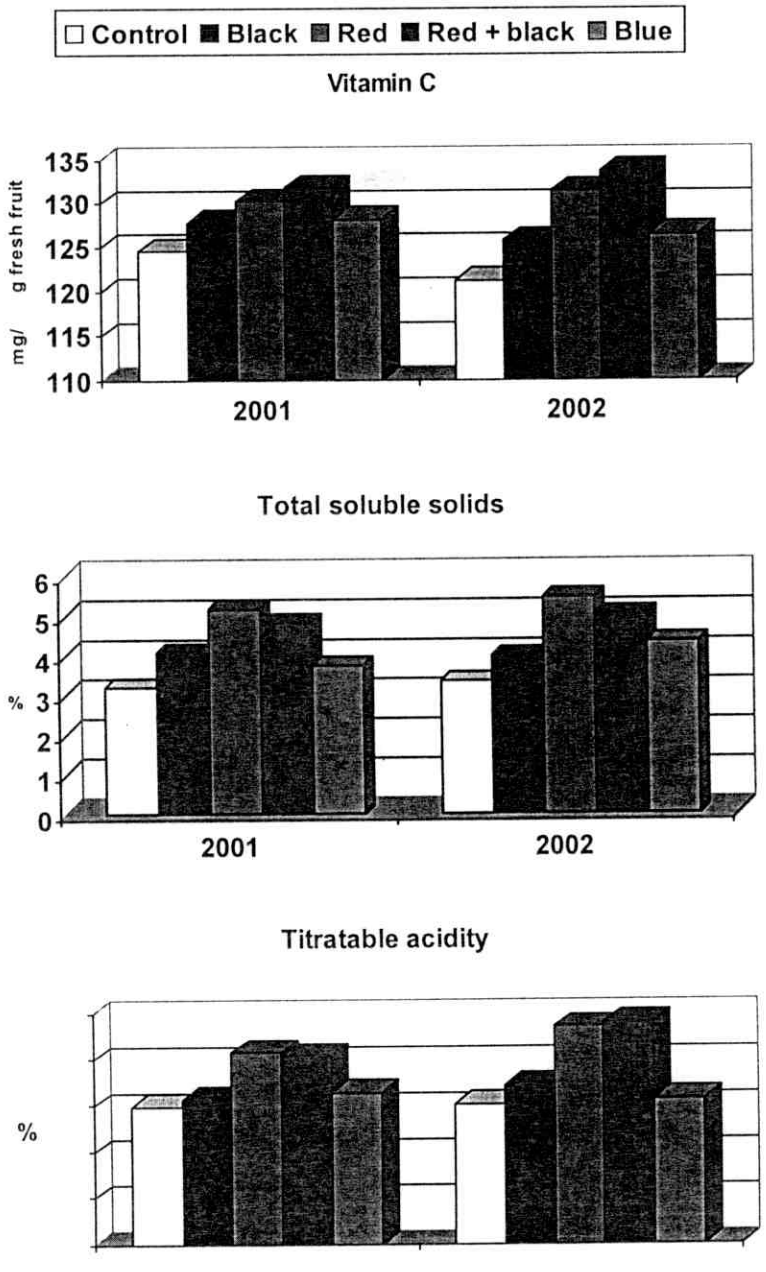


Fig. (63): Bar diagram indicating the effect of color mulches on some chemical constituents of sweet pepper (*Capsicum annuum* L.) fruits during 2001 and 2002 seasons.

V- Endogenous phytohormones:

V.1. Effect of color mulches on phytohormones profile in tomato shoots at 60 days after transplanting:

Data in Table (55) and Fig. (64) clearly indicate that different used color mulches decreased the level of endogenous gibberellins (GA_3) in tomato shoots at 60 days after transplanting. Exception was only that obvious increase (644.08 µg/g f.w.) in this level existed with red + black treatment. Also, it could be noticed that reduction of gibberellins level ranged –35.35, -36.20 and –47.02% of the control value for black, red and blue color, respectively.

As for auxins (IAA), its level 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 colors.

With regard to, cytokinins level, data in Table (55) also clearly show that red, red + black and blue colors increased it and red + black one was more pronounced in this respect. Meanwhile, black mulch decreased this level by 15.92%.

In general, total phytohormones those promote growth aspects (i.e. growth promoters, auxin, gibberellin and cytokinin) only increased in case of red + black treatment by 121.91% more than the control, in other meaning more than two times of control.

Table (55): Effect of polyethylene mulch surface color on endogenous phytohormones of tomato (*Lycopersicon esculentum*, Mill.) shoots at 60 days after transplanting during 2002 season.

Plant hormones / 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	% ±
Black	190.781	64.65	-35.35	2.548	29.66	-70.34	4.110	84.08	-15.92	197.44	58.15	-41.85	0.337	21.01	-78.99
Red	188.293	63.80	-36.20	3.178	37.00	-63.00	10.725	219.42	+119.42	202.20	65.52	-34.48	0.775	48.32	-51.68
Red + Black	644.080	218.25	+118.25	27.726	322.77	+222.77	12.987	265.69	+165.69	684.79	211.91	+121.91	0.121	7.54	-92.46
Blue	156.362	52.98	-47.02	7.831	91.16	-8.84	5.931	121.34	+21.34	170.12	55.13	-44.87	0.128	7.98	-92.02
Control	295.113	100.00	0.00	8.590	100.00	0.00	4.888	100.00	0.00	308.59	100.00	0.00	1.604	100.00	0.00

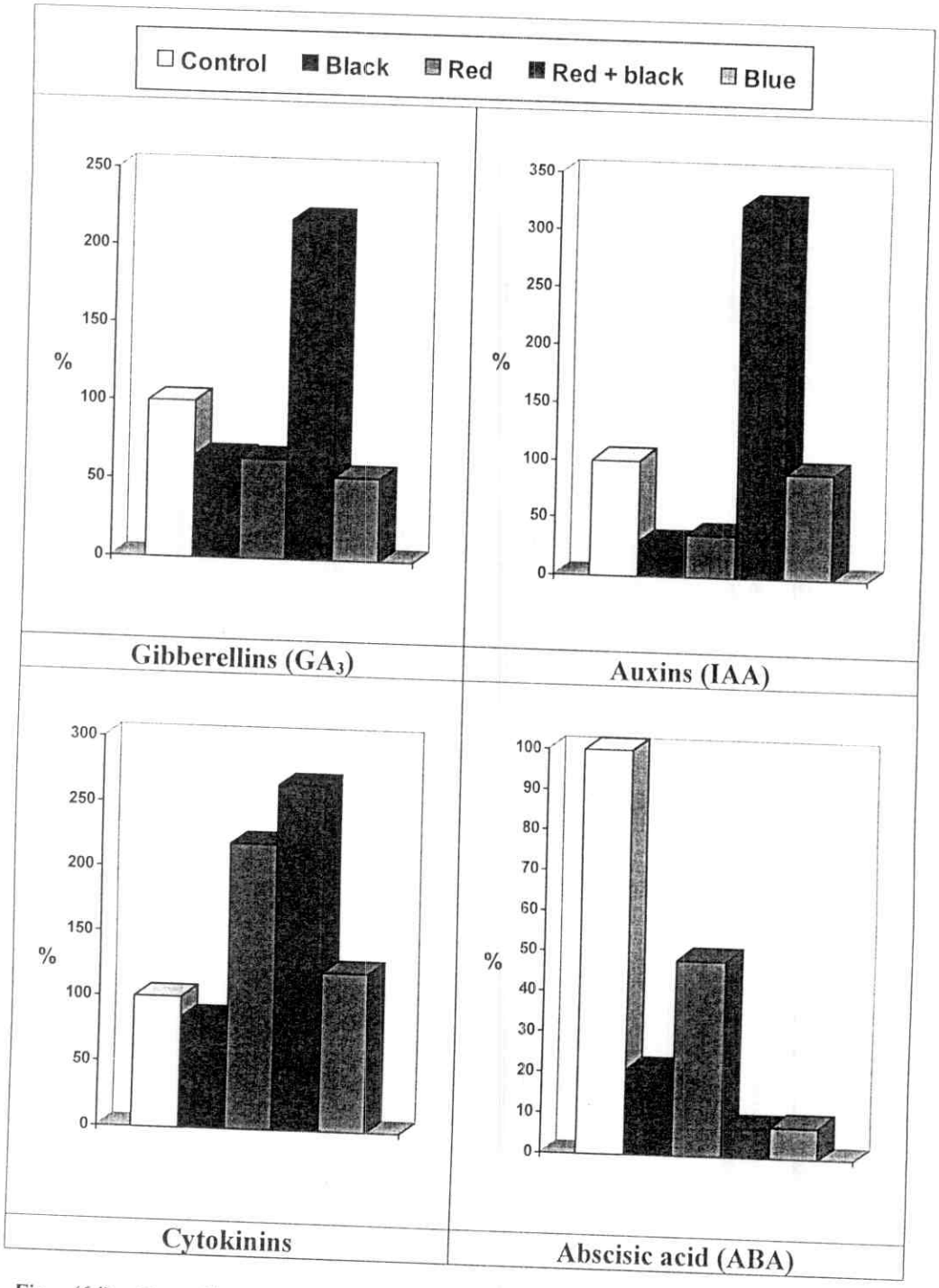


Fig. (64): Bar diagram indicating the effect of color mulches on endogenous phytohormones of tomato (*Lycopersicon esculentum*, Mill.) shoots at 60 days after transplanting during 2002 season.

On the other hand, the growth inhibitor; abscisic acid it 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 addition, as shown in Table (56) cytokinins fractions (i.e. zeatin, kinetin and benzyl adenine) were variously affected with different colors of used mulches. Since, zeatin only increased with red and red + black mulch color, meanwhile kinetin was increased with black, red and red + black mulches, yet, benzyl adenine was increased with each of red, red + black and blue mulches. 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 plant. Also, a certain level of any of these fractions accompanied with any of those alterations existed in either other promoters (IAA & GA_3) or even the common inhibitor (i.e. abscisic acid) could be reversed upon growth or reproductive traits into stimulation or inhibition of some or all of them.

Moreover, the proportions of total promoters to the inhibitor abscisic acid (Table, 57) was increased with various used color mulches meanwhile the proportion of auxin to

Table (56): Effect of polyethylene mulch surface color on endogenous cytokinins (i.e. cytokinin fractions) in tomato (*Lycopersicon esculentum*, Mill.) shoots at 60 days after transplanting during 2002 season.

cytokinins / plant hormones / Treatment	Zeatin			Kinetin			Benzyl adenine			Total determined 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	% ±
Black	0.56911	84.79	- 15.12	0.80753	296.29	+196.29	2.733	69.30	- 30.70	4.110	84.08	-15.92
Red	1.52023	226.50	+126.5	1.35522	497.24	+397.24	8.120	205.88	+105.88	10.725	219.42	+119.42
Red + Black	1.28162	190.95	+90.95	1.44963	531.88	+431.88	10.256	260.04	+160.04	12.987	265.69	+165.69
Blue	0.57603	85.82	- 14.18	0.2298	84.31	-15.69	5.125	129.94	+29.94	5.931	121.34	+21.34
Control	0.67118	100.00	0.00	0.27255	100.00	0.00	3.944	100.00	0.00	4.888	100.00	0.00

Table (57): Endogenous phytohormones (promoters and inhibitors) proportions in tomato (*Lycopersicon esculentum*, Mill.) shoots at 60 days after transplanting during 2002 season.

Plant hormones / Treatment	Promoters / inhibitor	% relative to the control	% ±	P : I	IAA / cytokinins	% relative to the control	% ±	I : C	IAA + Cytokinins / GA_3	% relative to the control	% ±	I+C: G
Black	585.88	304.53	+204.53	585.88:1	0.620	35.27	-64.73	0.620:1	0.035	76.09	-23.91	0.035:1
Red	260.90	135.61	+35.61	260.90:1	0.296	16.84	-83.16	0.296:1	0.074	160.87	+60.87	0.074:1
Red + Black	5659.42	2941.64	+2841.64	5659.42:1	2.135	+121.44	21.44	2.135:1	0.063	136.96	+36.96	0.063:1
Blue	1329.06	690.82	+590.82	1329.06:1	1.320	75.09	-24.91	1.32:1	0.088	191.30	+91.30	0.088:1
Control	192.39	100.00	0.00	192.39:1	1.758	100.00	0.00	1.758:1	0.046	100.00	0.00	0.046:1

cytokinins was dominantly decreased, yet, auxin + cytokinins / gibberellin was only decreased with black mulch but increased with the rest of used colors.

These data, could also be of great influence upon different vegetative and reproductive characteristics of tomato plant. For example, increasing cytokinin level on the account of auxin could be in favor of increasing the number of formed branches and that could also increased transverse growth on the account of longitudinal one as well as increasing of sink organs (i.e. fruits) ability to accumulate and storage more assimilates.

V.2- In sweet pepper shoots at 60 days after transplanting:

Data in Table (58) and Fig. (65) indicate the effect of color mulches on the endogenous level of the growth promoters gibberellin (GA_3), auxin (IAA), cytokinins (cyt.) and the growth inhibitors (ABA).

As for the endogenous gibberellin, it is obvious that black, red and red + black mulches increased its level by +413.78, +279.91 and +476.12% more than the control, respectively.

With regard to the endogenous auxin, reduction of its level resulted in case of various colors of used mulches. Also, the highest reduction (90.22% less than the control) reached by the red mulch.

Meanwhile, cytokinins was dominantly increased with various color mulches and reached its maximum (1555.44% 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 sixteen times of the

Table (58): Effect of polyethylene mulch surface color on endogenous phytohormones of sweet pepper (*Capsicum annuum* L.) shoots at 60 days after transplanting during 2002 season.

plant hormones / 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	% ±
Black	109.173	513.78	+413.78	74.661	17.17	-82.83	170.883	1404.25	+1304.25	354.72	77.59	-22.41	0.334	19.48	-80.52
Red	80.727	379.91	+279.91	42.530	9.78	-90.22	187.638	1541.93	+1441.93	310.90	68.00	-32.00	0.658	38.37	-61.63
Red + Black	122.419	576.12	+476.12	149.418	34.37	-65.63	201.451	1655.44	+1555.44	473.29	103.52	+3.52	0.042	2.45	-97.55
Blue	16.927	79.66	- 20.34	143.617	33.03	-66.97	185.883	1527.51	+1427.51	346.43	75.77	-24.23	0.575	33.53	-66.47
Control	21.249	100.00	0.00	434.779	100.00	0.00	12.169	100.00	0.00	457.20	100.00	0.00	1.715	100.00	0.00

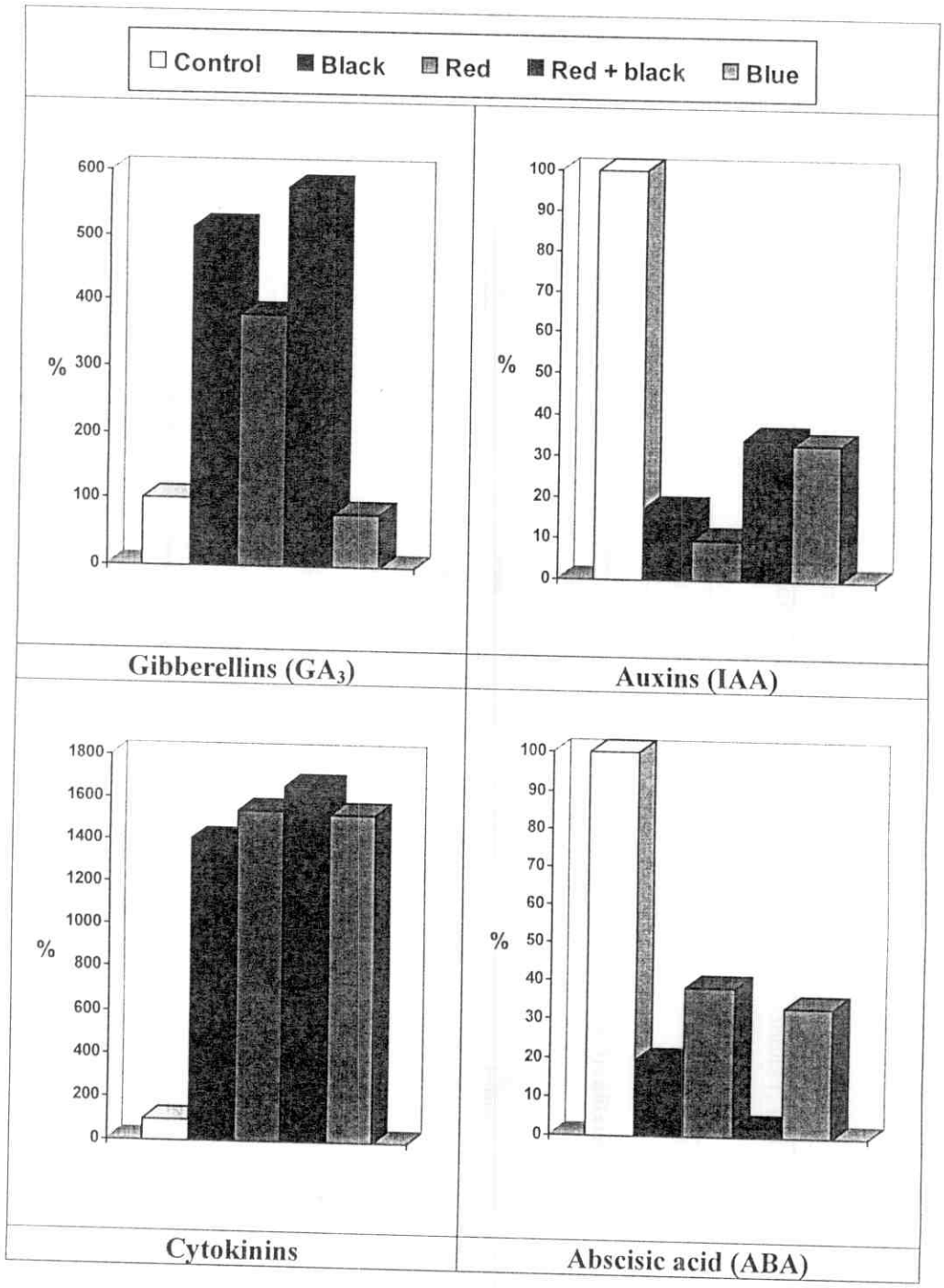


Fig. (65): Bar diagram indicating the effect of color mulches on endogenous phytohormones of sweet pepper (*Capsicum annuum*, L.) shoots at 60 days after transplanting during 2002 season.

control value and with red mulch by more than eleven times. So, this obvious increase of cytokinin level being directly related with high fruit yield as well as with that pioneer results that more one fruit formed on the same node as shown in Fig. (81).

On the other hand, abscisic acid, i.e. the growth inhibitor its level was decreased with various colors of used mulches. Also, it could be noticed that 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.

In addition, for cytokinin fractions as shown in Table (59), increases of different estimated fractions, i.e. zeatin, kinetin and benzyl adenine were dominantly existed with various colors of used mulches. Here, also it could be noticed that red + black mulch was more pronounced in this respect.

Moreover, proportions between the promoters and between promoters and inhibitor abscisic acid were also variously affected with different applied treatments (Table, 60).

In this respect, the proportion of promoters / inhibitor was increased with different colors of used mulches to reach its maximum with the red + black one. Also, IAA/Cyto. was dominantly decreased. These results being of great interest for interpreating each of the obtained vigorous growth and the great fruit yield of sweet pepper those reached in the present study.

Light and phytohormones control many aspects of plant development. Depending on the species considered and the experimental conditions, all kinds of interactions (additively, synergism and antagonism) have been observed. For example,

Table (59): Effect of polyethylene mulch surface color on endogenous cytokinins (i.e. cytokinin fractions) in sweet pepper (*Capsicum annuum* L.) shoots at 60 days after transplanting during 2002 season.

cytokinin / plant hormones / Treatment	Zeatin			Kinetin			Benzyl adenine			Total determined 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	% ±
Black	0.65005	241.04	+141.04	1.61511	252.23	+152.23	168.618	1497.29	+1397.29	170.883	1404.25	+1304.25
Red	0.69617	258.15	+158.15	1.00930	170.70	+70.70	185.932	1651.41	+1551.41	187.638	1541.93	+1441.93
Red + Black	0.84645	313.87	+213.87	1.71320	267.52	+167.52	199.738	1774.03	1674.03	201.451	1655.44	+1555.44
Blue	0.57673	213.86	+113.86	1.29360	202.02	+102.02	184.031	1634.52	1534.52	185.883	1527.52	+1427.52
Control	0.26968	100.00	0.00	0.64032	100.00	0.00	11.259	100.00	0.00	12.169	100.00	0.00

Table (60): Endogenous phytohormones (promoters and inhibitors) proportions in sweet pepper (*Capsicum annuum* L.) shoots at 60 days after transplanting during 2002 season.

plant hormones / Treatment	Promoters / inhibitor	% relative to the control	% ±	P : I	IAA / cytokinins	% relative to the control	% ±	I : C	IAA + Cytokinins / GA3	% relative to the control	% ±	I+C: G
Black	1062.04	398.38	+298.38	1062.04:1	0.4369	1.22	-98.78	0.4369:1	2.249	10.69	-89.31	2.249:1
Red	47249.24	177.24	+77.24	47249.24:1	0.2267	0.63	-99.37	0.2267:1	2.851	13.55	-86.45	2.851:1
Red + Black	11268.81	4227.02	+4127.02	11268.81:1	0.7417	2.08	-97.92	0.7417:1	2.866	13.63	-86.37	2.866:1
Blue	602.46	225.99	+125.99	602.46:1	0.1280	0.36	-99.64	0.1280:1	19.466	92.55	-7.45	19.466:1
Control	266.59	100.00	0.00	266.59:1	35.73	100.00	0.00	35.73:1	21.034	100.00	0.00	21.034:1

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 auxin 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 concentration and/or the sensitivity to active gibberellins GA_s **(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 **(Weller *et al.*, 1994 and Gawronska *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 concentration.

Also, **Hammerton *et al.* (1998)** shown 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.

VI- Anatomical study:

VI.1. Effect of color mulches on tomato leaf anatomy:

VI.1.1. Leaf blade anatomy:

Data in Table (61) and Figs. (66 & 67) indicate the effect of black, red, red + black and blue mulches on different anatomical traits of tomato leaf at 60 days after transplanting during 2002 season.

As for blade thickness (Table, 61) it was increased with various colors used. Increases reached to 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.

With regard to the thickness of each of upper and lower epidermis, they also were increased with different mulch colors. In this respect, red + black treatment showed their maximum 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.

Table (61): Effect of polyethylene mulch surface color on certain histological features in transverse sections of tomato (*Lycopersicon esculentum, Mill.)* leaf blade at 60 days after transplanting during 2002 season.

Parameters (μ) / Treatment	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	% ±
Black	284.40	138.60	+38.60	27.90	16.20	118.80	49.44	121.50	50.56	240.30	142.78	+42.78
Red	301.50	146.93	+46.93	28.80	18.00	126.00	49.47	128.70	50.53	254.70	151.34	+51.34
Red + black	337.50	164.47	+64.47	30.60	20.70	138.60	48.43	147.60	51.57	286.20	170.05	+70.05
Blue	279.90	136.40	+36.40	23.40	19.80	106.20	44.87	130.50	55.13	236.70	140.64	+40.64
Control	205.20	100.00	0.00	19.80	17.10	83.70	49.73	84.60	50.27	168.30	100.00	0.00

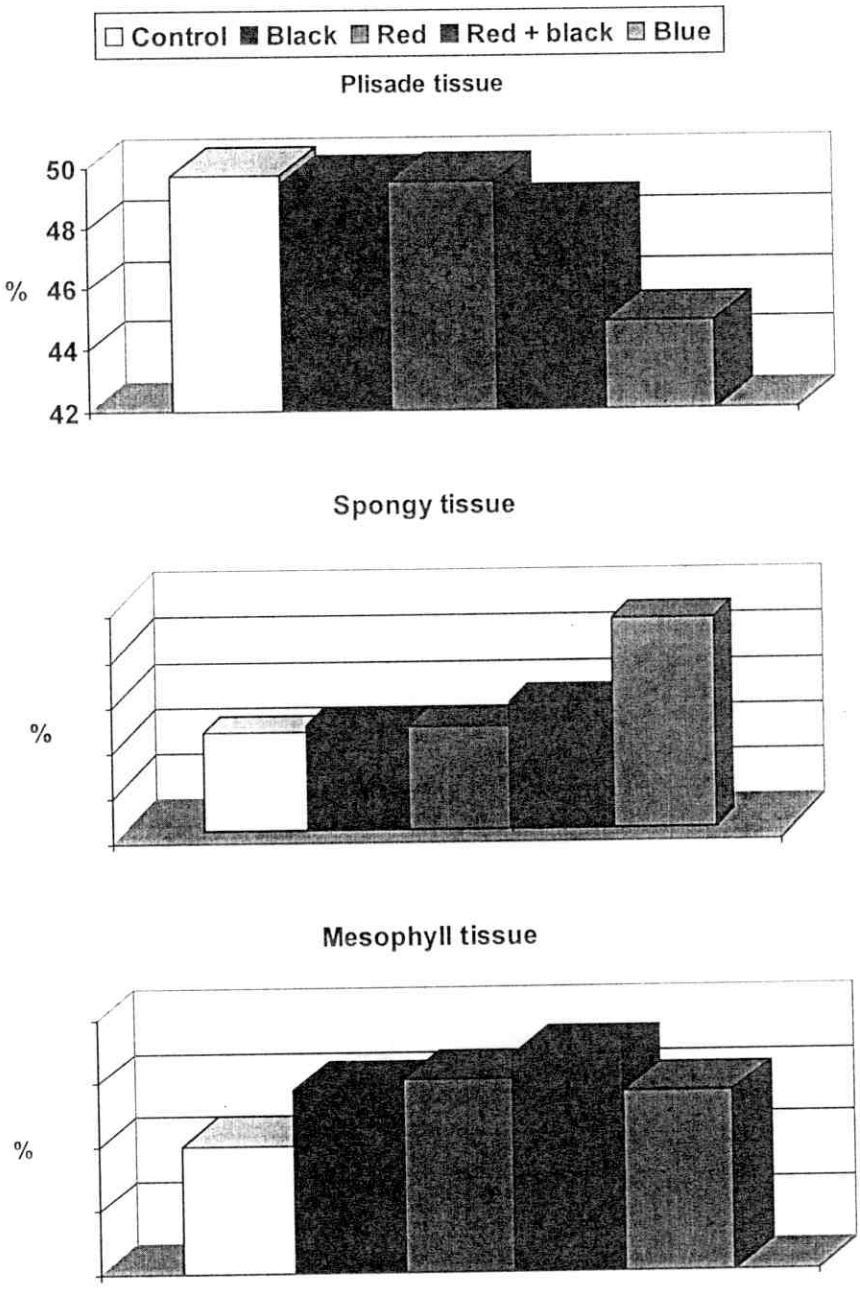
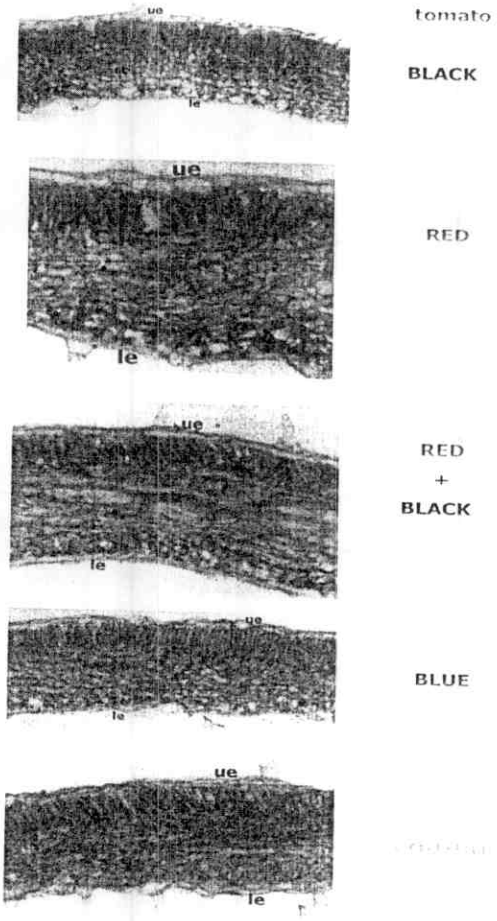


Fig. (66): Bar diagram indicating the effect of color mulches on certain histological features in transverse section of tomato (*Lycopersicon esculentum*, Mill.) leaf blade at 60 days after transplanting during 2002 season.



Where:
ue= Upper epidermis
pt= Palisade tissue
st=Spongy tissue
le= lower epidermis

Fig.(67) : Transverse sections in tomato leaf blade; indicating the effect of color mulches on certain histological features at 60 days after transplanting.

As regards, mesophyll tissue, its thickness was increased with all mulch colors used. Here, mesophyll thickness was 168.30 micron but increased to reach 286.20, 254.20, 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.

Of interest, also, to note that mesophyll tissue increase belongs to that increase of each of palisade and spongy tissue thickness (Table, 61). Since, the two components were increased with color mulch treatment but reached their maximum as other traits with red + black treatment.

In general, of great interest to note that red + black (followed by red alone) treatment gave the highest of palsade and spongy tissues thickness. 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%. Also, 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.

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 of grown tomato plant".

VI.1.2. Medvein anatomy:

Data in Table (62) and Figs. (68, 69, 70 & 71) show the effect of using colored mulches on the histological traits in the medvein of tomato leaf blade.

As for the midrib, its thickness was increased with various applied colors, but 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.

With regard to the vascular region, it could also be 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 +52.81 more than control for length and width, respectively. Here, also it could be noticed that lowest increase in length (+9.52%) existed with black mulch but for width (+4.38%) it was with the blue one.

Also, clearly it could be noticed that, except that reduction existed in phloem tissue thickness (-23.73%) with the black mulch, the rest of colors treatment increased each of phloem and xylem tissues (i.e the two component of vascular region).

In addition, it could be also noticed that red mulch gave the highest of phloem tissue thickness and the highest diameter of widest 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, 62).

Table (62): Effect of polyethylene mulch surface color on certain histological features in transverse sections of tomato (*Lycopersicon esculentum*, Mill) leaf medvein anatomy at 60 days after transplanting during 2002 season.

Parameters (µ) / Treatment	Midrib			Vascular region						Phloem tissue thickness					Xylem tissue								
	Thickness	% relative to the control	% ±	Length	% relative to the control	% ±	Width	% relative to the control	% ±	Upper most phloem tissue	Lower most 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	% ±
Black	1319.4	124.66	+24.66	372.60	109.52	+9.52	778.50	135.16	+35.16	50.40	30.60	81.00	76.27	-23.73	291.60	124.62	+24.62	56.00	107.69	+7.69	30.60	109.68	+9.68
Red	1608.30	151.96	+51.96	468.00	137.57	+37.57	880.20	152.81	+52.81	89.10	78.30	167.40	157.63	+57.63	300.60	128.46	+ 28.46	69.00	132.69	+32.69	37.80	135.48	+35.48
Red + black	1539.00	145.41	+45.41	501.30	147.35	+47.35	784.80	136.25	+36.25	70.20	80.10	150.30	141.53	+41.53	351.00	150.00	+50.00	72.00	138.46	+38.46	33.30	119.35	+19.35
Blue	1102.50	104.17	+4.17	381.60	112.17	+12.17	601.20	104.38	+4.38	54.90	72.90	127.80	120.34	+20.34	253.80	108.46	+8.46	58.00	111.54	+11.54	29.70	106.45	+6.45
Control	1058.40	100.00	0.00	340.20	100.00	0.00	576.00	100.00	0.00	57.60	48.60	106.20	100.00	0.00	234.00	100.00	0.00	52.00	100.00	0.00	27.90	100.00	0.00

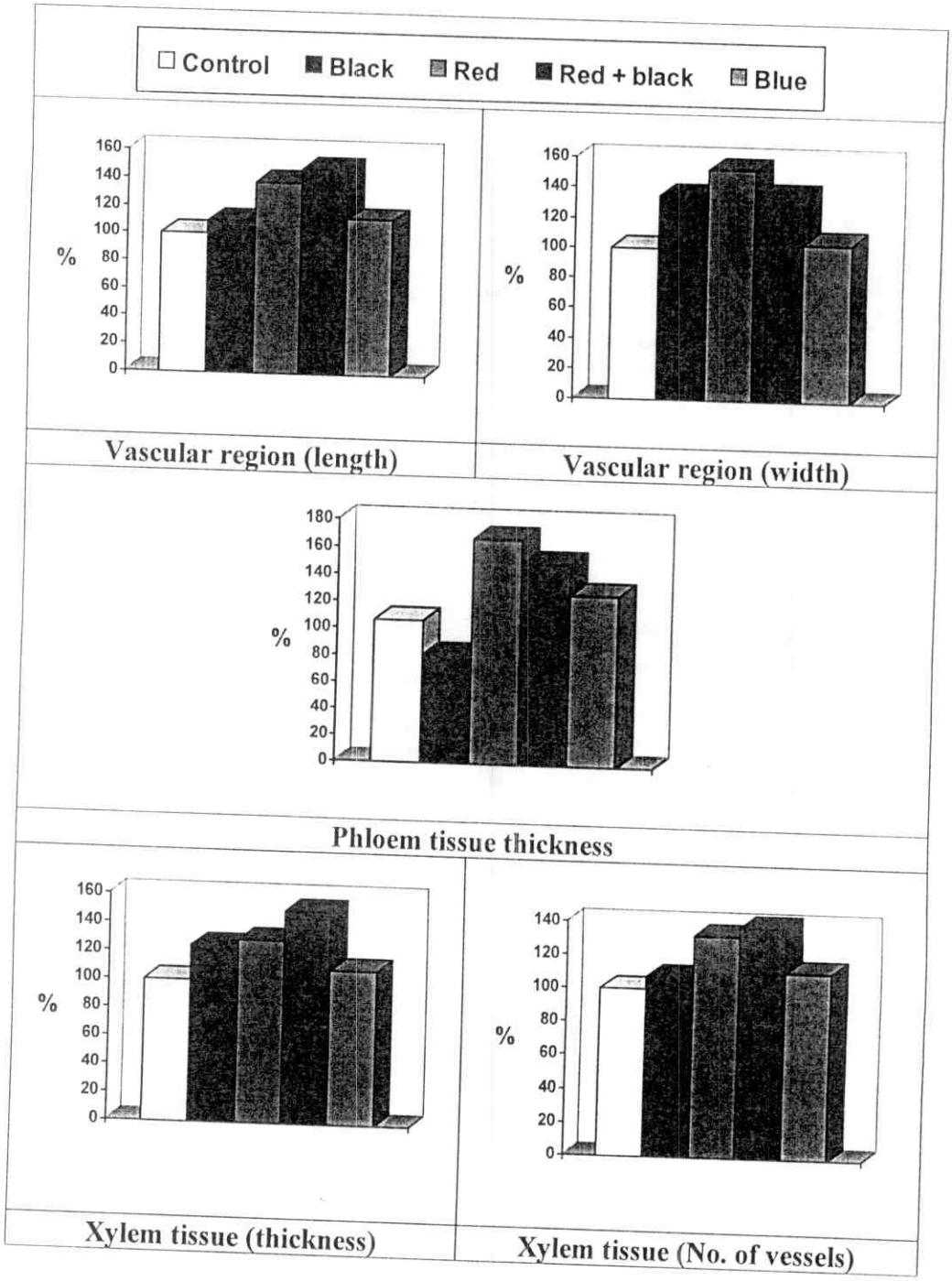


Fig. (68): Bar diagram indicating the effect of color mulches on certain histological features in transverse sections of tomato (*Lycopersicon esculentum*, Mill.) leaf medvein anatomy at 60 days after transplanting during 2002 season.

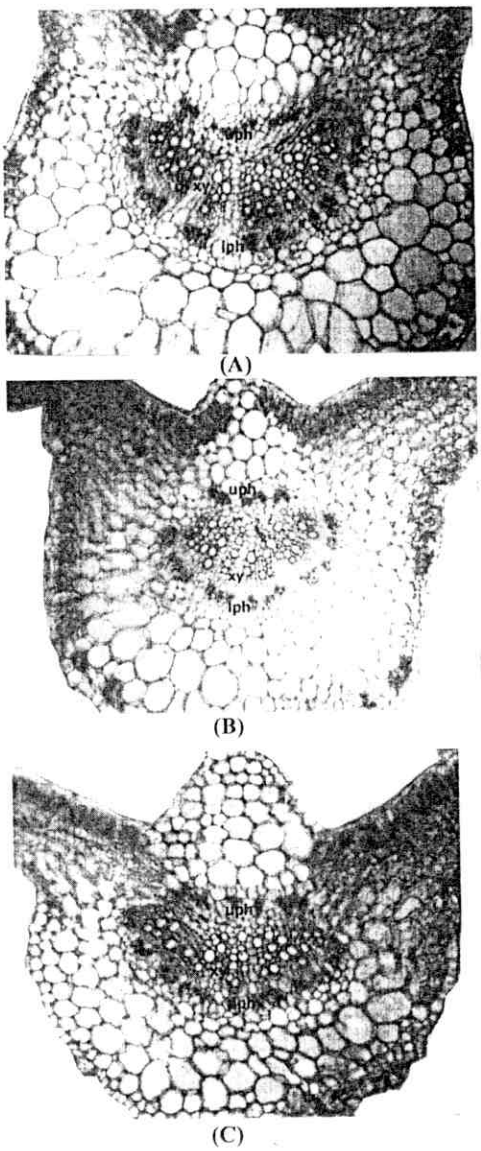
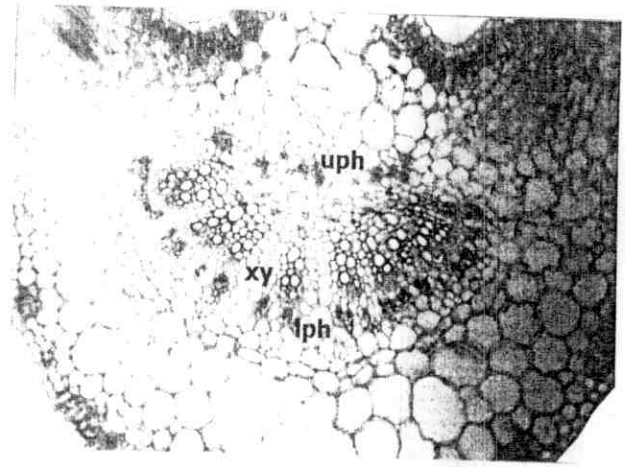
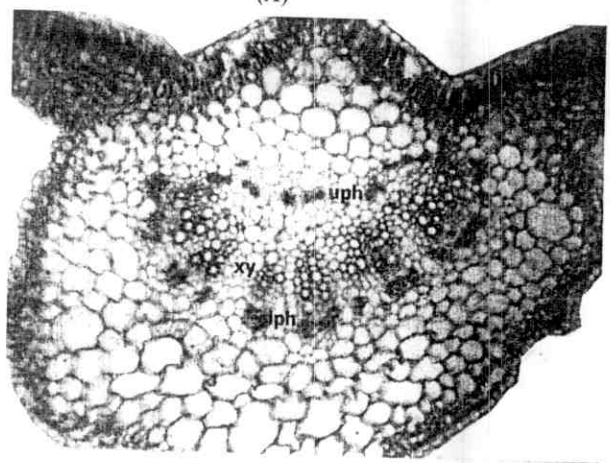


Fig.(69): Transverse sections in tomato leaf medvein; showing effect of black (A), blue (B) and control (C) mulch colors on certain histological features at 60 days after transplanting .

Where :
uph=Upper phloem tissue
xy=Xylem tissue
lph= Lower phloem tissue



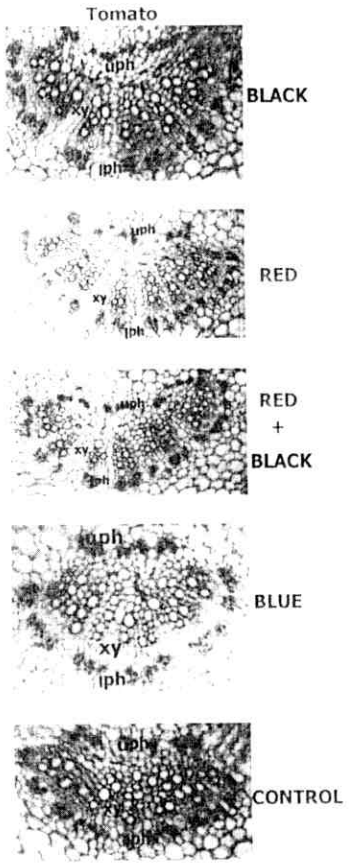
(A)



(B)

Where :
uph=Upper phloem tissue
xy=Xylem tissue
lph= Lower phloem tissue

Fig.(70):Transverse sections in tomato leaf medvein;indicating the effect of red(A) and red+ black (B) mulch colors on certain histological features at 60 days after transplanting .



Where :
uph=Upper phloem tissue
xy=Xylem tissue
lph= Lower phloem tissue

Fig.(71):Transverse sections of tomato leaf ;indicating the effect of color mulches on length and width of vascular region at 60 days after transplanting .

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

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 treatment specially with the red one.

In this respect, strong suggestion it should to be 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 bioconstituents) 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.

VI.2. Effect of color mulches on sweet pepper leaf anatomy:

VI.2.1. Leaf blade anatomy:

Data in Table (63) and Figs. (72 & 73) show the effect of color mulches on different histological traits of leaf blade of sweet pepper at 60 days after transplanting during 2002 season.

With regard to the blade thickness, it was only decreased with the black mulch meanwhile, other colors i.e. red and blue increased this thickness. Here, it should be mentioned that, with sweet pepper the case is different than that of tomato since blue mulch gave the highest thickness of leaf blade followed by red

Table (63): Effect of polyethylene mulch surface color on certain histological features in transverse sections of sweet pepper (*Capsicum annuum* L.) leaf blade at 60 days after transplanting during 2002 season.

Parameters (μ) / Treatment	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	% ±
Black	332.10	94.13	-5.87	24.30	16.20	112.50	38.58	179.10	61.42	291.60	93.37	-6.63
Red	436.50	123.72	+23.72	21.60	17.10	148.50	37.33	249.30	62.67	397.80	127.38	+27.38
Red + black	379.80	107.65	+7.65	22.50	18.00	139.50	41.11	199.80	58.89	339.30	108.65	+8.65
Blue	494.10	140.05	+40.05	23.40	18.00	202.50	44.73	250.20	55.27	452.70	144.96	+44.96
Control	352.80	100.00	0.00	25.20	15.30	134.10	42.94	128.20	57.06	262.30	100.00	0.00

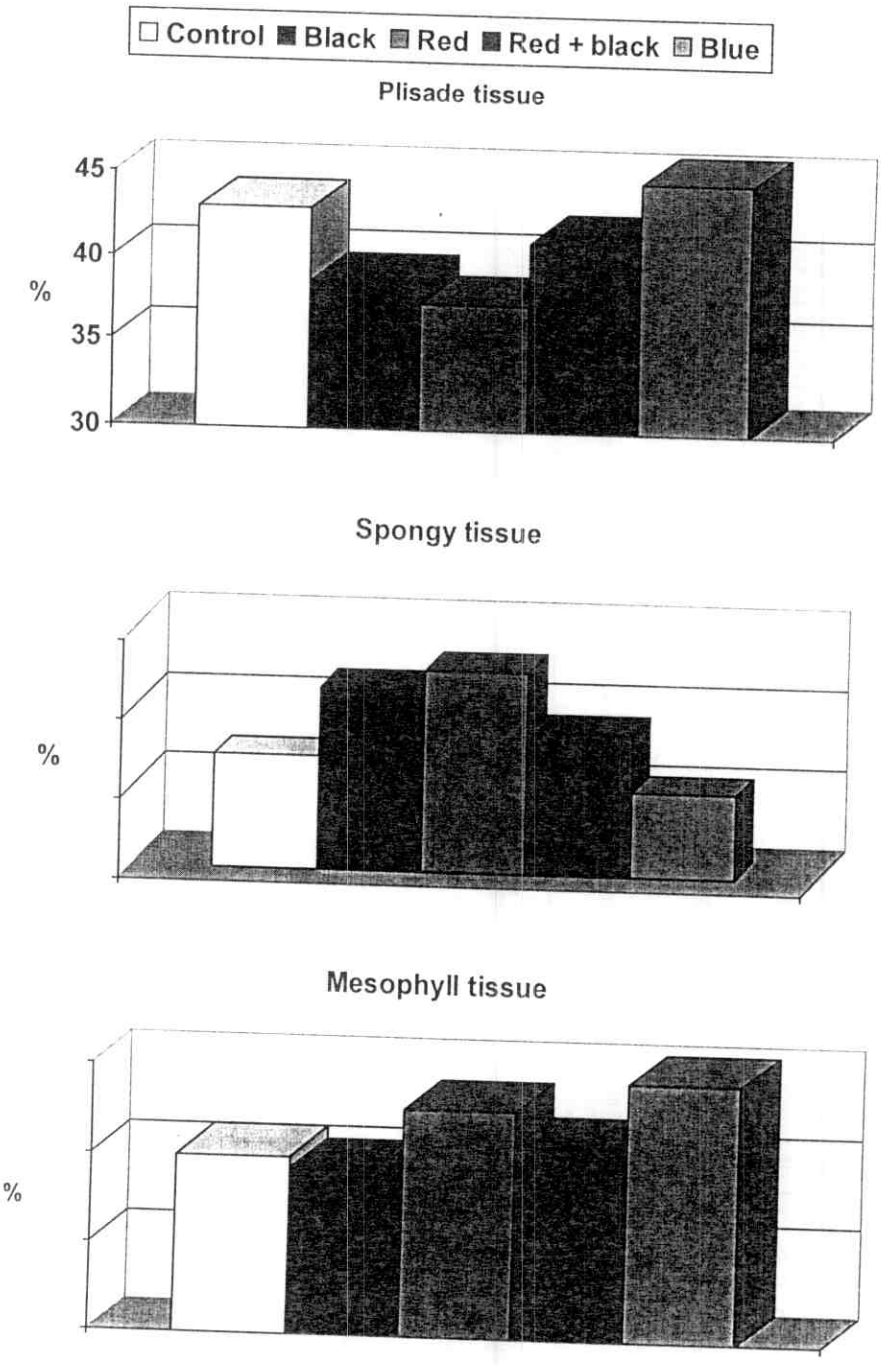


Fig. (72): Bar diagram indicating the effect of color mulches on certain histological features in transverse section of sweet pepper (*Capsicum annuum*, L.) leaf blade at 60 days after transplanting during 2002 season.

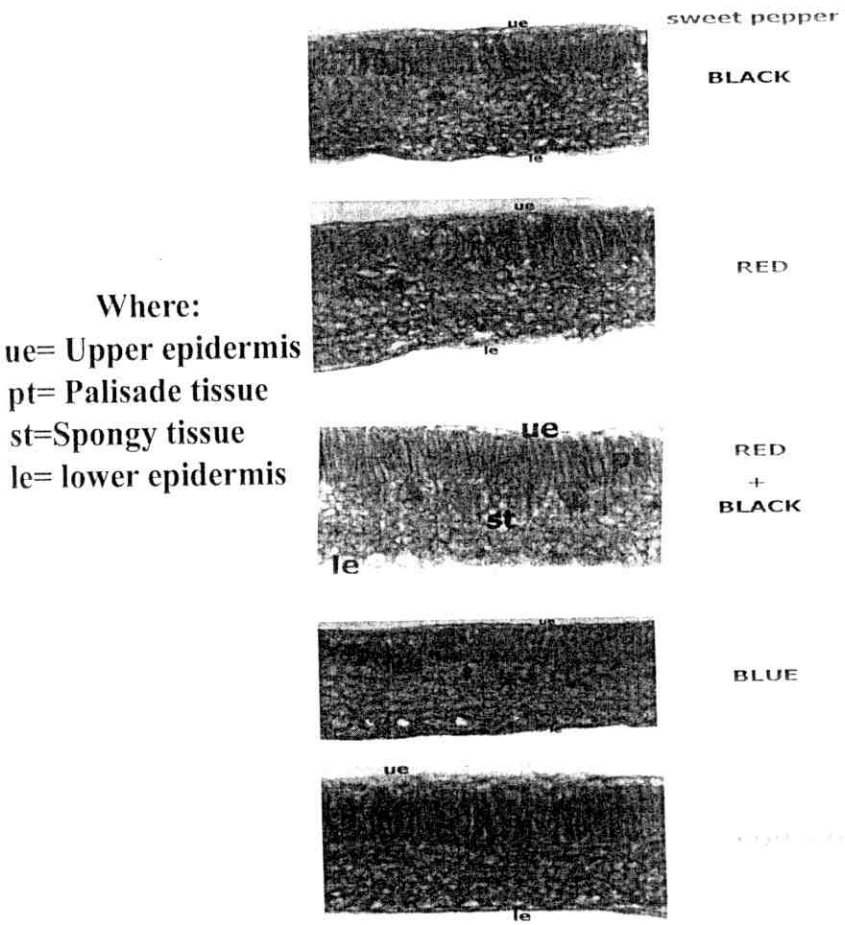


Fig.(73) : Transverse sections in sweet pepper leaf blade; showing the effect of color mulches on certain histological features at 60 days after transplanting.

and lowest increase existed with the red + black mulch. So, the case is completely reversed than that of 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.

As for the thickness of upper and lower epidermis clearly it could be noticed that they inversely behaved. Since, upper epidermis was increased, yet, lower one was decreased. 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 the mesophyll tissue, 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. Also, it could be noticed that 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.

Here, such result could be interpreated on the basis that sweet pepper plants were cultivated earlier in which day length still shorter than the normal ones. So, grown sweet 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 histological alterations enabled leaves to receive rapidly and with

efficiency more light.

VI.2.2- Medvein anatomy:

Data in Table (64) and Figs. (74, 75, 76 & 77) illustrate the effect of used mulch colors on the histological traits in medvein of sweet pepper leaf at 60 days after transplanting.

As for the midrib, 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 of midrib thickness.

With regard to the vascular region, each of its length and width 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. Thereby, the blue color mainly increased the collenchyma layer up and down the vascular bundle but red color mainly increased the size of vascular region itself.

On the other hand, it could also be 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 could be 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 widest vessel diameter 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 its only the one that decreased diameter of the widest xylem vessel.

Table (64): Effect of polyethylene mulch surface color on certain histological features in transverse sections of sweet pepper (*Capsicum annuum* L.) leaf medvein anatomy at 60 days after transplanting during 2002 season.

Parameters (μ) / Treatment	Midrib			Vascular region						Phloem tissue thickness				
	Thickness	% relative to the control	% ±	Length	% relative to the control	% ±	Width	% relative to the control	% ±	Upper most phloem tissue	Lower most phloem tissue	Total phloem tissue	% relative to the control	% ±
Black	1288.80	103.47	+3.47	328.50	122.07	+22.07	766.80	115.60	+15.60	61.20	54.00	115.20	114.29	+14.29
Red	1462.50	117.41	+17.41	384.30	142.81	+42.81	846.00	127.54	+27.54	64.80	70.20	135.00	133.93	+33.93
Red + black	1590.30	127.67	+27.67	382.50	142.14	+42.14	1121.40	169.06	+69.06	54.90	73.80	128.70	127.68	+27.68
Blue	1651.50	132.59	+32.59	375.30	139.46	+39.46	831.60	131.31	+31.31	48.60	40.50	89.10	88.39	-11.61
Control	1245.60	100.00	0.00	269.10	100.00	0.00	663.30	100.00	0.00	53.10	47.70	100.80	100.00	0.00

Parameters (μ) / Treatment	Xylem tissue								
	Thickness	% Relative to the control	% ±	No. of vessels	% Relative to the control	% ±	Widest vessel diameter	% Relative to the control	% ±
Black	123.30	73.26	-26.74	58.00	107.41	+7.41	19.80	88.00	-12.00
Red	249.30	148.13	+48.13	64.00	118.52	+18.52	24.30	108.00	+8.00
Red + black	253.80	150.80	+50.80	76.00	140.74	+40.74	25.20	112.00	+1200
Blue	286.20	170.05	+70.05	66.00	122.22	+22.22	26.10	116.00	+16.00
Control	168.30	100.00	0.00	54.00	100.00	0.00	22.50	100.00	0.00

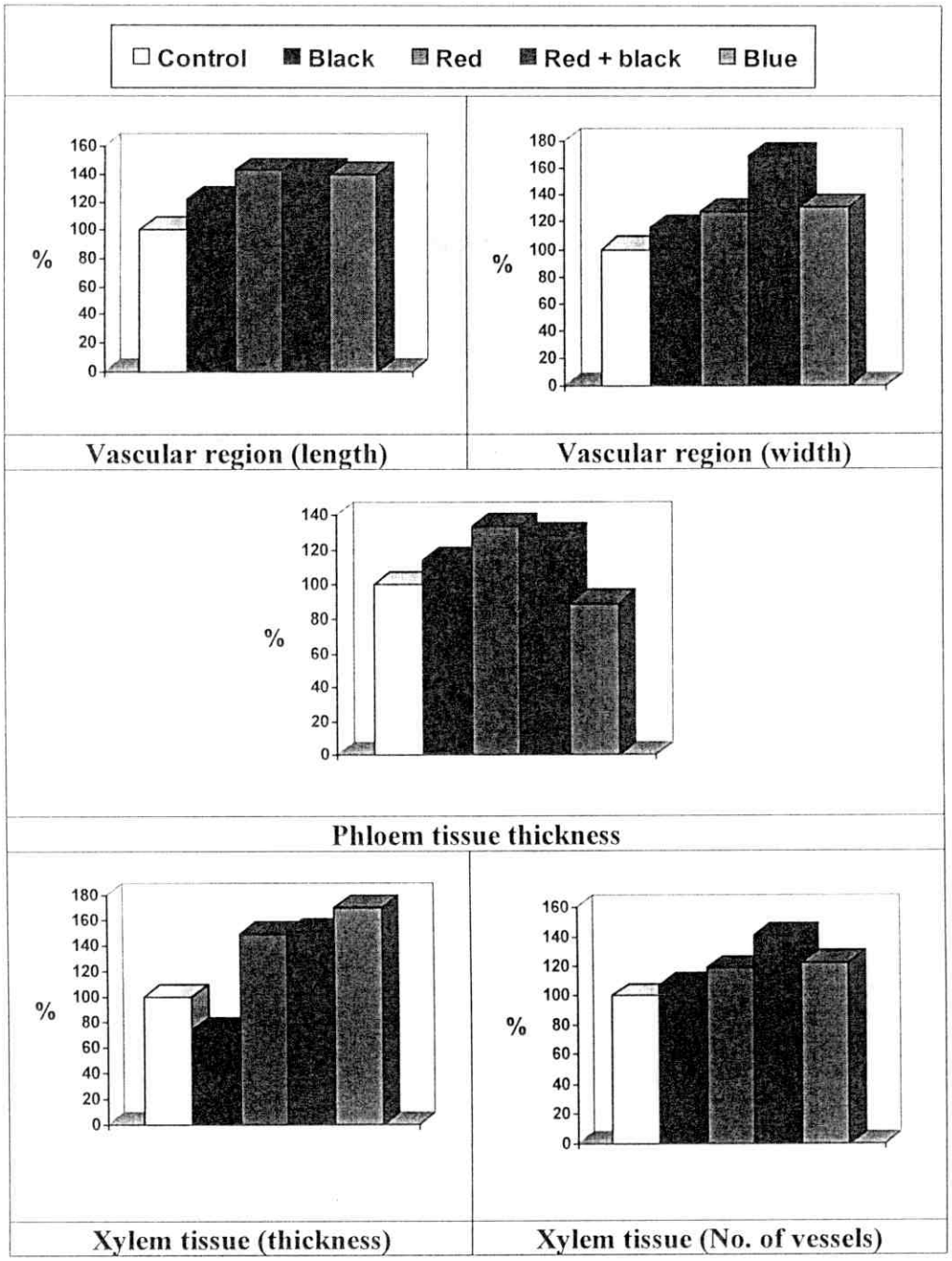


Fig. (74): Bar diagram indicating the effect of color mulches on certain histological features in transverse sections of sweet pepper (*Capsicum annuum*, L.) leaf medvein anatomy at 60 days after transplanting during 2002 season.

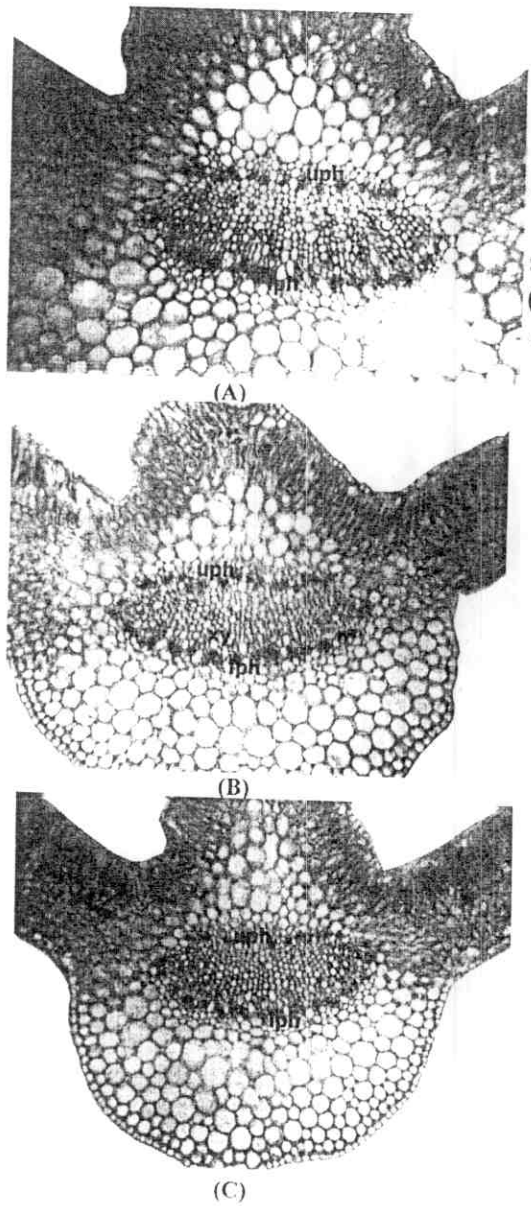
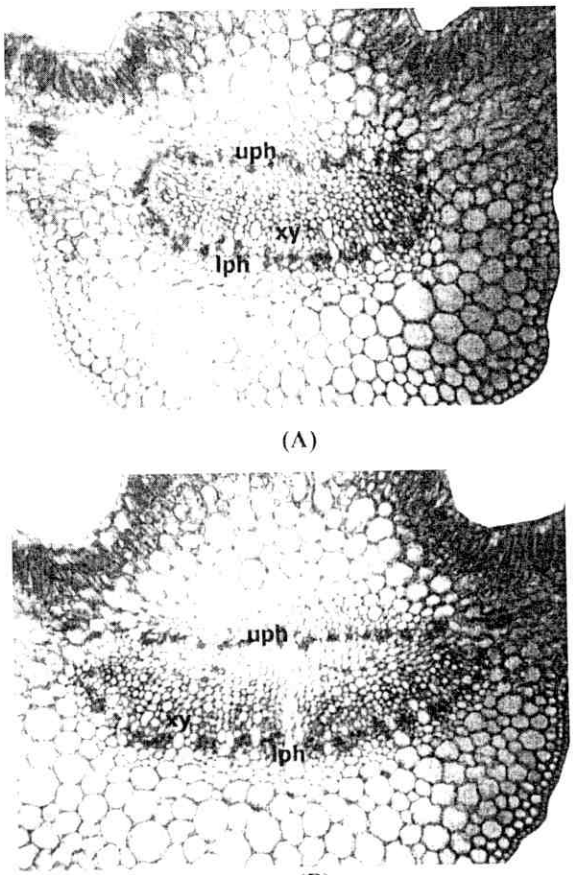


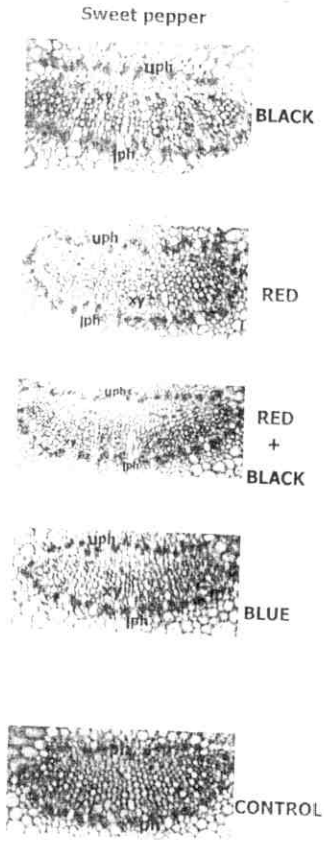
Fig.(75): Transverse sections in sweet pepper leaf medvein; showing the effect of (A)black, (B)blue and (C)control mulch colors on certain histological features at 60days after transplanting .

Where :
uph=Upper phloem tissue
xy=Xylem tissue
lph= Lower phloem tissue



Where :
uph=Upper phloem tissue
xy=Xylem tissue
lph= Lower phloem tissue

Fig.(76): Transverse sections in sweet pepper leaf medvein; showing the effect of (A)red and(B) red+black and mulch colors on certain histological features at 60days after transplanting .



Where :
uph=Upper phloem tissue
xy=Xylem tissue
lph= Lower phloem tissue

Fig.(77):Transverse sections of sweet pepper leaf ;indicating the effect of color mulches on length and width of vascular region at 60 days after transplanting .

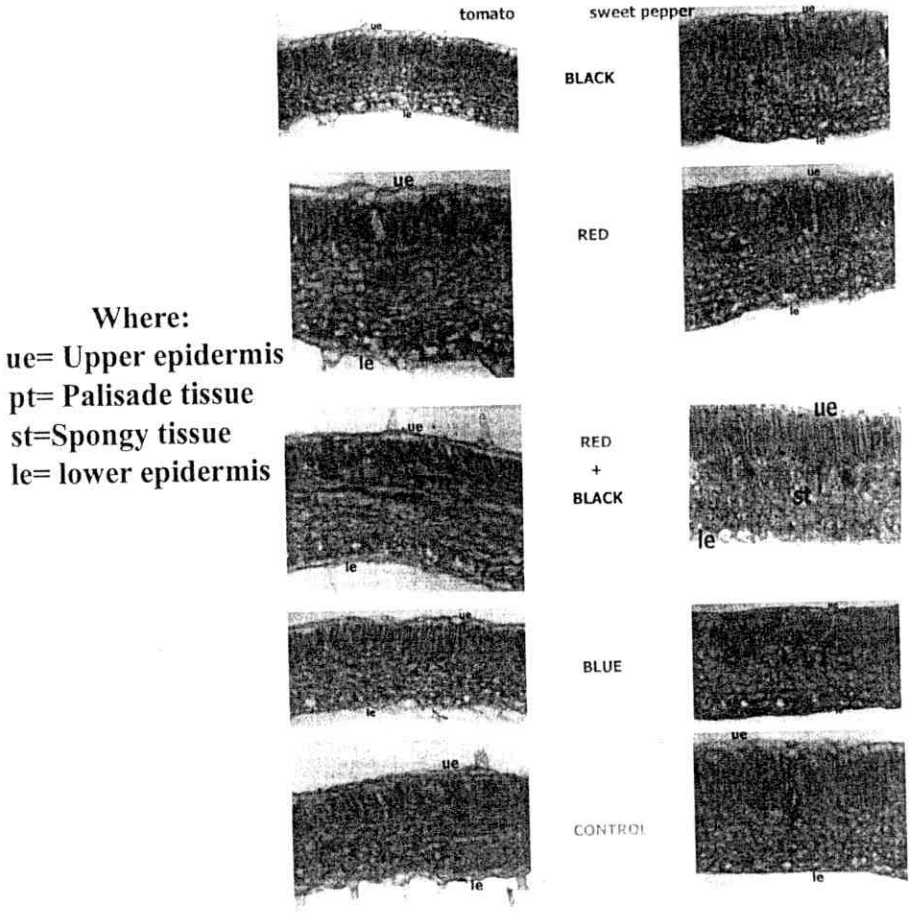


Fig.(78) : Effect of color mulches on certain histological features in transverse sections of tomato and sweet pepper leaf blade at 60 days after transplanting during 2002 season.

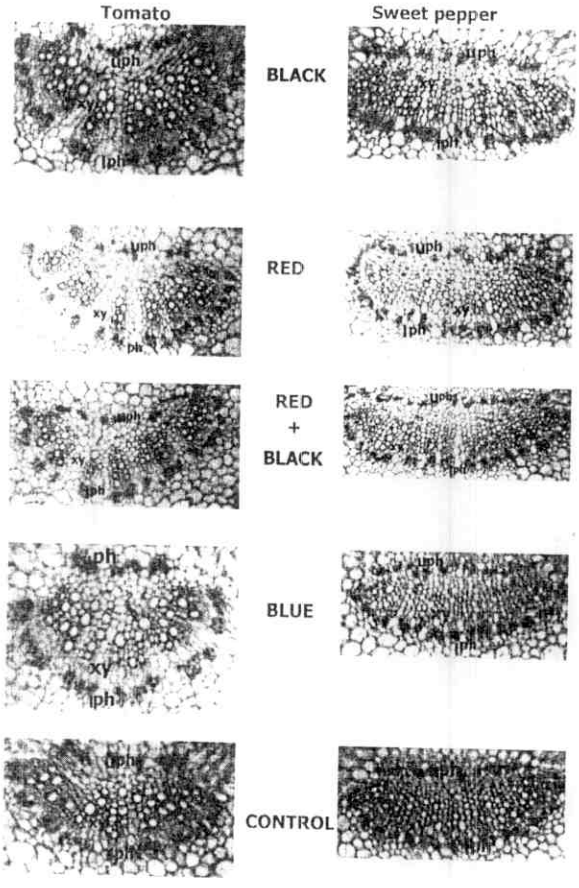


Fig.(79): Effect of color mulches on length and width of vascular region in transverse sections of tomato and sweet pepper leaves at 60 days after transplanting during 2002 season.

VII. Pioneer findings:

Based on the obtained results of the present study, those are indicated in Tables (65 & 66) and Figs. (80 – 87) could be considered as pioneer ones. Of these results are: firstly as shown in Table (65 & 66), transverse sections through stems (1/2 cm under and above the first fruiting node) exhibited percentage increase in diameter of the whole section with +44.98 and +29.86% (under 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 organts (i.e. fruits), secondary, the alternation of endogenous phytohormones profile (Tables, 55 & 58 and Figs. 65 & 66) 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. 82) with red + black treatment.

Generally, creation a new or specific microenvironment for tomato and sweet pepper plants by alteration of FR: R ratio with using color mulches gave vigorous vegetative growth (preceded with more; photosynthetic pigments synthesis Tables (12, 16, 20 & 25) and reproductive growth (preceded with more flowers formation and setted fruits) Tables (27 & 36).

Thereby, significant early and total tomato and sweet pepper fruit yields existed under red and red + black mulch treatments when compared with either other mulch colors (i.e. black and blue) or with the unmulched (bare soil) treatments.

Table (65): Effect of polyethylene mulch surface colors on histological traits of sweet pepper (*Capsicum annuum L.*) stem (1/2 cm under the first fruiting node) at 75 days after transplanting during 2002 season.

Parameters	Epidermis			Cortex			Phloem tissue			Xylem tissue									Pith			Whole section (stem)		
Treatment	Thickness	% Relative to the control	% ±	Thickness	% Relative to the control	% ±	Thickness	% Relative to the control	% ±	Thickness	% Relative to the control	% ±	No. of vessels in the row	% Relative to the control	% ±	Widest vessel diameter	% Relative to the control	% ±	Diameter	% Relative to the control	% ±	Diameter	% Relative to the control	% ±
Black	38.70	104.88	+4.88	750.6	131.13	+13.1	155.70	91.05	-8.95	988.2	140.05	+40.05	10.00	200.00	+ 100.0	77.40	124.64	+ 24.64	2886.3	73.20	-26.80	6752.7	106.35	+6.35
Red	39.60	107.32	+7.32	595.8	104.09	+4.09	212.40	124.21	+24.21	1592.1	225.64	+125.6	18.00	360.0	260.0	79.20	127.54	+ 27.54	5148.0	130.56	+30.56	10027.8	144.98	+44.98
Red + black	31.50	85.37	14.63	607.5	106.13	+6.13	215.10	125.79	+25.79	1268.1	179.72	+79.72	17.00	340.0	240.0	73.80	118.84	+ 18.84	4737.6	120.16	+20.16	8982.0	129.86	+29.86
Blue	37.80	102.44	+2.44	550.8	96.23	-3.77	194.40	113.68	+13.68	981.9	139.16	+39.16	14.00	280.0	180.0	72.90	117.39	+ 17.39	2819.7	71.51	-28.49	6349.5	91.80	-8.20
Control	36.90	100.0	0.00	572.4	100.00	0.00	171.00	100.00	0.00	705.6	100.00	0.00	5.00	100.0	0.00	62.10	100.00	0.00	3942.9	100.00	0.00	6916.5	100.00	0.00

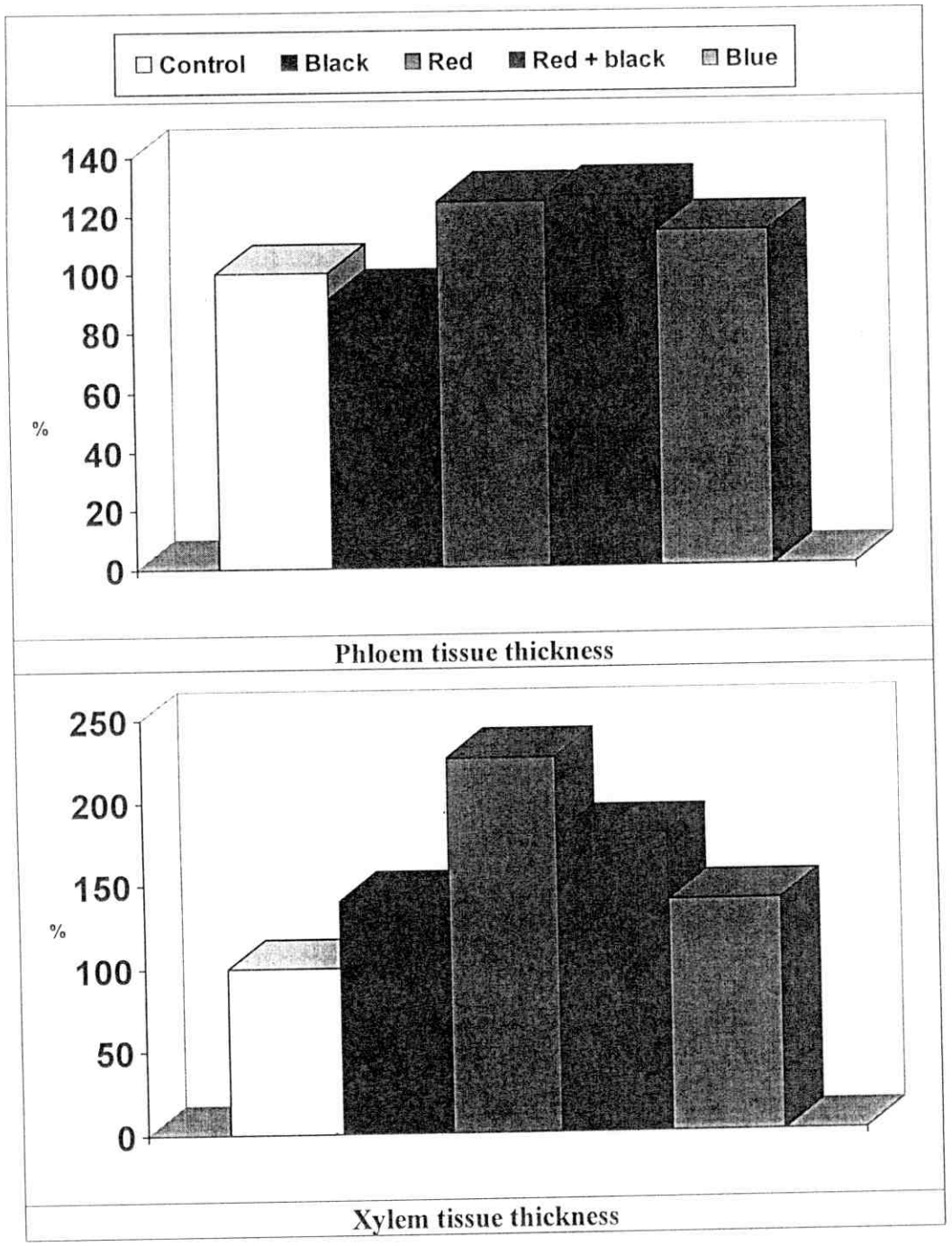


Fig. (80): Bar diagram indicating the effect of color mulches on histological traits of sweet pepper (*Capsicum annuum*, L.) stem (1/2 cm under the first fruiting node) at 75 days after transplanting during 2002 season.

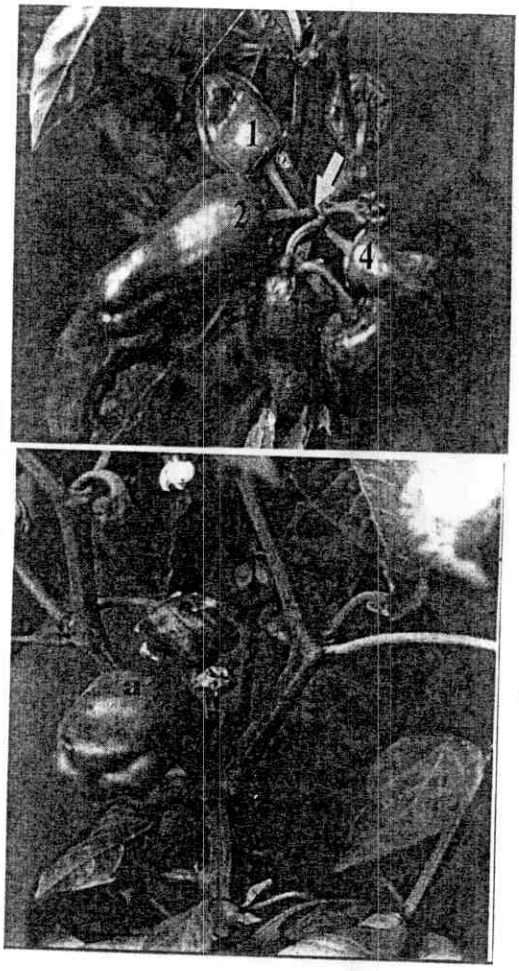


Fig.(81): A) Red + black treatment; showing five developed fruits in different ages.
B)Red treatment ; indicating the formation of three branches on the same node.

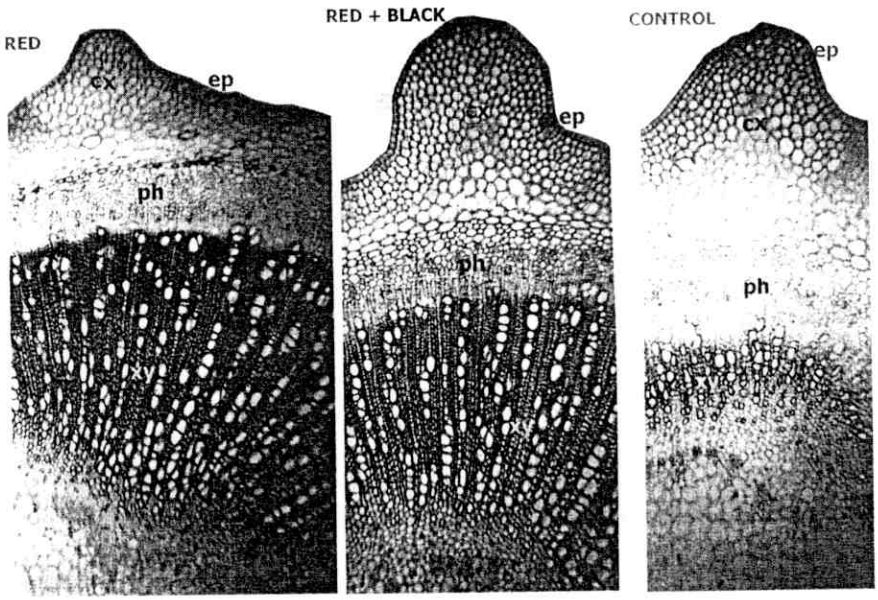


Fig.(82): Transverse sections in sweet pepper stem (1/2 cm under the first fruiting node); indicate the effect of red,red + black and control treatments on thickness of xylem and phloem tissues at 75 days after transplanting.

Where :
ep = Epidermis
cx= Cortex
ph= Phloem tissue
xy= Xylem tissue

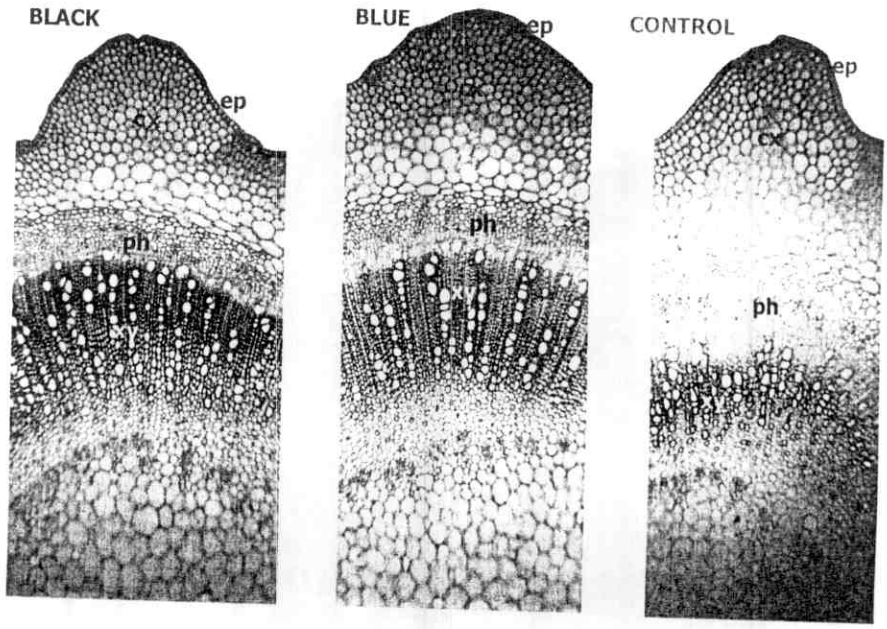


Fig.(83): Transverse sections in sweet pepper stem (1/2 cm under the first fruiting node); showing the effect of black,blue and control treatments on thickness of xylem and phloem tissues at 75 days after transplanting.

Where :
ep = Epidermis
cx= Cortex
ph= Phloem tissue
xy= Xylem tissue

Table (66): Effect of polyethylene mulch surface colors on histological traits of sweet pepper (*Capsicum annuum L.*) stem (1/2 cm above the first fruiting node) at 75 days after transplanting during 2002 season.

Parameters / Treatment	Epidermis			Cortex			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 in the row	% Relative to the control	% ±	Widest vessel diameter	% Relative to the control	% ±	Diameter	% Relative to the control	% ±	Diameter	% Relative to the control	% ±
Black	30.60	125.93	+ 25.93	403.20	82.51	- 17.49	119.70	140.00	+ 40.00	358.2	105.85	+ 5.85	6.00	150.0	+ 50.00	45.00	104.17	+4.17	362.70	138.87	+ 38.87	544.1	121.49	+ 21.49
Red	26.10	107.41	+7.41	648.90	132.78	+ 32.78	116.10	135.79	+ 35.79	725.4	214.30	+ 114.30	9.00	225.00	+ 125.00	57.60	133.33	+ 33.33	4327.2	165.96	+ 65.96	7360.2	164.25	64.25
Red + black	28.80	118.52	+ 18.52	562.50	115.10	+ 15.10	172.80	202.11	+ 102.11	831.60	245.74	+ 145.74	10.00	250.00	+ 150.00	58.50	135.42	+ 35.42	2872.8	110.18	+ 10.18	6064.2	135.3	+ 35.33
Blue	27.90	114.81	+ 14.81	498.60	102.03	2.03	131.40	153.68	+ 53.68	634.50	163.36	+ 63.36	9.00	225.00	+ 125.00	64.80	150.00	+ 50.00	2584.8	99.14	- 0.86	5525.4	124.64	24.64
Control	24.30	100.00	0.00	488.70	100.00	0.00	85.50	100.00	0.00	338.4	100.00	0.00	4.00	100.00	0.00	43.20	100.00	0.00	2607.3	100.00	0.00	4481.1	100.00	0.00

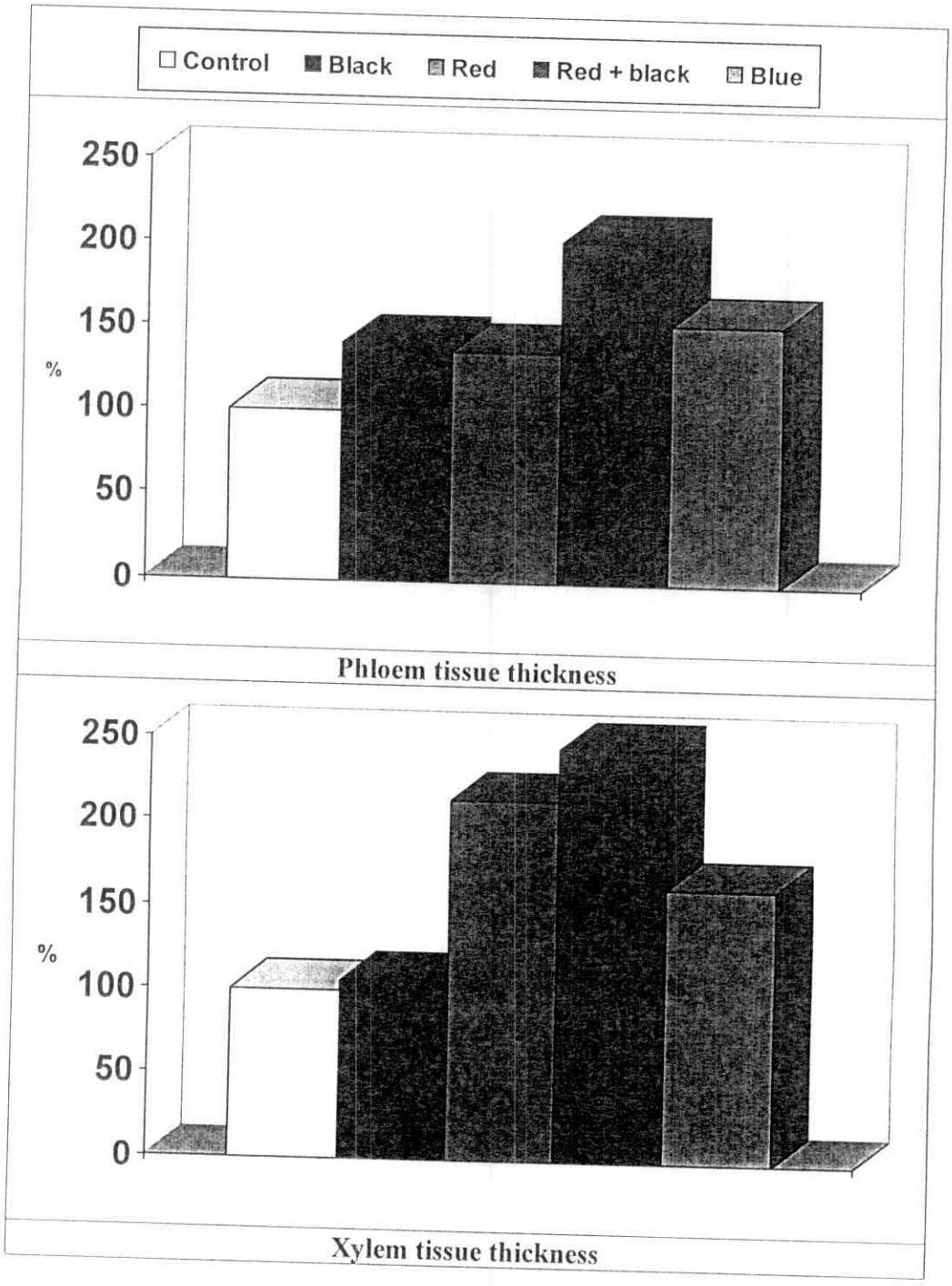


Fig. (84): Bar diagram indicating the effect of color mulches on histological traits of sweet pepper (*Capsicum annuum*, L.) stem (1/2 cm above the first fruiting node) at 75 days after transplanting during 2002 season.

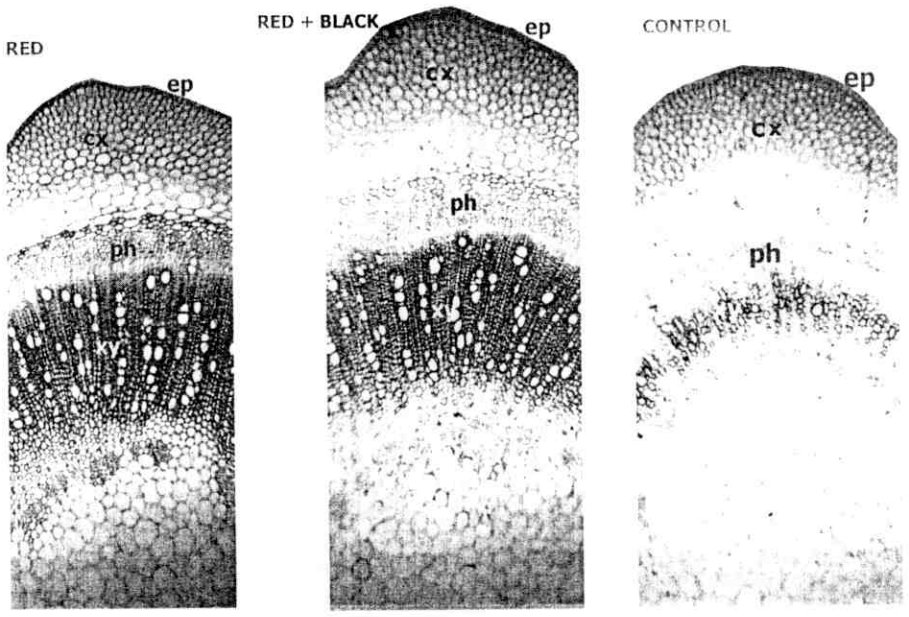


Fig.(85): **Transverse sections in sweet pepper stem (1/2 cm above the first fruiting node); indicate the effect of red,red + black and control treatments on thickness of xylem and phloem tissues at 75 days after transplanting.**

Where :
ep = Epidermis
cx= Cortex
ph= Phloem tissue
xy= Xylemtissue

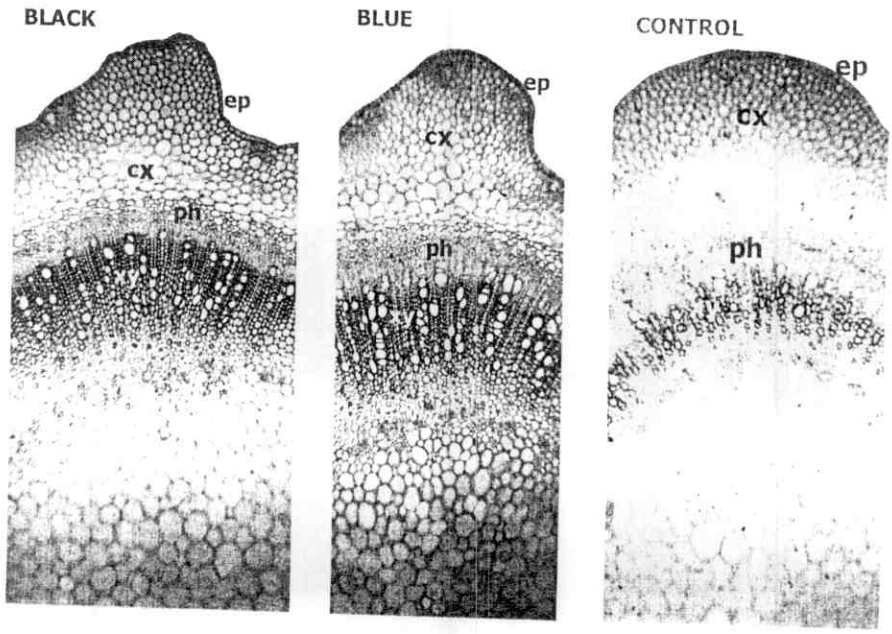


Fig.(86): Transverse sections in sweet pepper stem (1/2 cm above the first fruiting node); showing the effect of black,blue and control treatments on thickness of xylem and phloem tissues at 75 days after transplanting.

Where :
ep = Epidermis
cx= Cortex
ph= Phloem tissue
xy= Xylem tissue

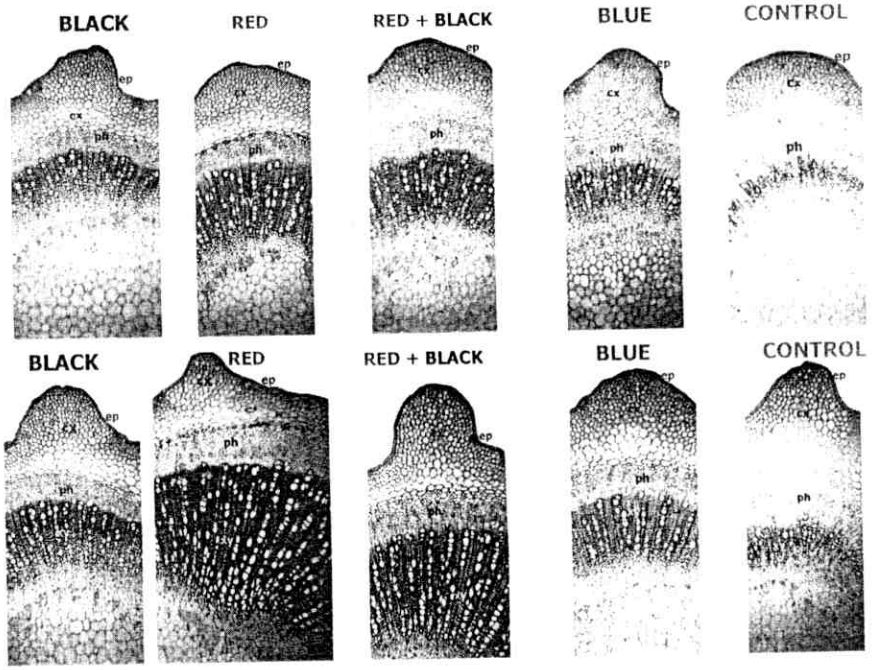


Fig.(87): Effect of mulch colors on histological traits of sweet pepper stem (1/2 cm under and above the first fruiting node)at 75 days after transplanting.

Where :
ep = Epidermis
cx= Cortex
ph= Phloem tissue
xy= Xylem tissue

Great economic yields were not only the magnitude of the present study but also the quality improvement of yielded fruits.

Supporting these pioneer findings of the present study are the conclusions of **Kasperbauer and Karlen (1994); Kasperbauer and Hunt (1998) and Kasperbauer (2000)** reported that red and far-red light are absorbed and act through a photoreversible regulatory pigment system, phytochrome. The photon ratio of FR relative to R sets the photo equilibrium between the R-absorbing and FR-absorbing forms of phytochrome, which functions as a regulator of photosynthate allocation and adaptive plant development. In the field the amount of FR (and the FR/R ratio) received by a growing plant can be increased by reflection from the used of red mulch color led to improve plant growth, development and productivity. Thus, the yield of tomato, sweet pepper, strawberry and other crops are increased when grown above red mulch color relative to yield over stander black mulch.

In addition, **Murchie and Horton (1997), Terashima *et al.* (2001) and Oguchi *et al.* (2003)** found that the response to changes in light availability, plants differentiate sun and shade leaves, where sun leaves have higher photosynthetic capacity (light-saturated rate of photosynthesis on a leaf area basis), greater leaf thickness and greater nitrogen concentration than shade leaves. However, maintaining high photosynthetic capacity is costly, and advantageous only under high light conditions.

The high photosynthetic capacity in sun leaves is supported by constructions of thick leaves with a large

investment of nitrogen in photosynthetic enzymes. Since all photosynthetic enzymes are involved in chloroplasts, sun leaves need to have a large number of chloroplasts in the mesophyll cells.