STIMULATION GROWTH, YIELD, AND ACCUMILATION OF ANTIOXIDANT COMPOUNDS OF ONION HYBRIDS BY COLORED SHADES OF POLY ETHYLENE COVERS

A. M. H. H. Al-Khafaji
Assist. lecturer
College of Agricultural Engineering Sciences / University of Baghdad
Aseel.Mohammed1005@coagri.uobaghdad.edu.iq

ABSTRACT

This research was conducted at vegetable field of the Department of Horticulture and Landscape Gardening –College of Agricultural Engineering Sciences - University of Baghdad. The experiment was conducted using Randomized Complete Block Design within split plot arrangement with three replicates. The hybrids (white, yellow, red) represented the main plots, symbolized (HW, HY, HR) and the colored covers of the tunnels (without cover, transparent, red, yellow, blue) represented the sub plots, which symbolized (C0, CW, CR, CY, CB).The statistical analysis revealed significant differences of HR in producing the highest values of the studied traits, such as, leaves number (14.73), leaf area (24.79 dcm^2), plant yield (190 gm.), chlorophyll concentration (9.733 mg.100^{-1}gm f. w.). Also the results revealed the significant superiority of yellow cover, in leaves number (18.11), leaf area (29.63 dcm^2), plant yield (222 gm.), chlorophyll concentration (10.44 mg.100^{-1}gm f. w.), anthocyanin concentration (24.67 mg.100^{-1}gm f. w.). The results that obtained from interaction between hybrids and covers were showed the significant predomination of HRCY in producing the highest numbers in the mentioned characters (18.33 leaves, 34.18 dcm^2, 233.3 gm. 11.33 mg.100^{-1}gm f. w.) respectively.

Keywords: wave length, quercetin, anthocyanin, pungency, light intensity

تحفيز النمو والانتاجية وتراكم مضادات الاكسدة لهجن من نبات البصل باستعمال اغطية البولي اثلين الملونة

اسيل محمد حسن هاتف الخفاجي
مدرس مساعد
كلية علوم الهندسة الزراعية/جامعة بغداد
Aseel.Mohammed1005@coagri.uobaghdad.edu.iq

المستخلص

نفذت تجربة حقلية في قسم البستنة وهندسة الحدائق/كلية علوم الهندسة الزراعية/جامعة بغداد. طُبقت التجربة باستعمال تصميم القطاعات الكاملة المعشاة حسب ترتيب الالواح المنشقة وبثلاث مكررات، مثلت الهجن الثلاثة (ابيض، اصفر، احمر) الالواح الرئيسة والتي رُمز لها (HW، HY، HR) ، اما الالواح الثانوية فكانت للاغطية (مكشوف، شفاف، احمر، اصفر، ازرق) والتي رُمز لها (C0، CW، CR، CY، CB)، اظهرت نتائج التحليل الاحصائي تفوق الهجين الاحمر HR في معظم الصفات المدروسة، عدد الاوراق (14.73) والمساحة الورقية (24.79 دسم^2) وحاصل النبات (190 غم) وكمية الكلوروفيل (9.733 ملغم.100 غم $^{-1}$)، كما بينت النتائج التأثير المعنوي للغطاء الاصفر CY في صفات عدد الاوراق (18.11) والمساحة الورقية (29.63 دسم^2) وحاصل النبات (222 غم) وكمية الكلوروفيل (10.44 ملغم.100 غم $^{-1}$) وتركيز الانثوسيانين (24.67 ملغم لكل 100 غم وزن طري)، اما عن نتائج التداخل فقد تفوقت معاملة CYHR في الصفات المدروسة منها (18.33 ورقة، 34.18 دسم^2، 233 غم،11 ملغم.100 غم $^{-1}$) على التتابع.

الكلمات المفتاحية: الطول الموجي، كيورستين، انثوسيانين، حرافة، شدة الاستضاءة

***Received:29/4/2019, Accepted:7/7/2019**

INTRODUCTION

Onion plant *Allium cepa* L. considered one of the best known vegetable crops all over worldwide. it ranks second after tomato in productivity and consumption (6). Furthermore, onions have numerous health benefits which come from its chemical composition. In fact, onion plant classified as a great source of flavonoids and alk(en)yl cysteine sulfoxides compounds (10). Quercetin comprises 96% of total flavonoids in onion's tissues and it is the most famous flavonol antioxidant vasodilating compound in onion due to its potential to diminish the risk of cancers and cardiovascular diseases (22). In addition, the latter has an inhibiting impact on inflammations, histamine, and aging (8). As a result, it is recommended to take from 4 to 68 mg from quercetin daily for a healthy lifestyle (7). Anthocyanin which exists in red bulbs only is a flavonoid that responsible for the cyanic color in plants and shares the same health benefits with quercetin (12). Indeed, the amounts of quercetin and anthocyanin vary in a large scale among varieties (5). Pungency is a prominent feature of onions. Admittedly, alk(en)yl cysteine sulfoxides compounds is the causative of pungency (14). Pungency is highly correlating with high dry matter and long storage of onions (20). However, people tends to consume slight pungent varieties (sweet) with high water content for fresh uses (10). Similarly with flavonoids content, onion varieties show a remarkable differences in pungency and dry matter content (9). In last decade, many researches dedicated in studying the influence of different shades of poly ethylene covers on plant traits (1,2,3). Khandaker et al (17) showed that the colored plastic covers reflect different waves from visible light which impact the growth and development of the crops. Jin et al (16) classified the colored plastic covers according to the transmission of light intensity through them. The highest light density was obtained under the transparent cover followed by the yellow and the red cover while the lowest light density found under the blue cover. Hussein and Al-Sahaf (15) illustrated that tomato plants grown under yellow poly ethylene tunnels had a significant increase in ascorbic acid and beta carotene. AL-Mousawi and Mohammed (2) observed in their study on *Tanacetuim Parthenuim* L. plant that the highest value of parthenolide and dry matter obtained under yellow cover. The objective of this study is to examine the performance of various onion hybrids to different colored shades of poly ethylene and in which extent those factors affect growth traits and accumulation of antioxidant compounds in onion plant.

MATERIALS AND METHODS

This research was conducted at vegetable field of the Department of Horticulture and Landscape Gardening –College of Agricultural Engineering Sciences, University of Baghdad. The experiment was conducted using randomized complete block design within split plot with 3 replicates (3X5). The hybrids (white, yellow, red) from ISI Sementi S.P.A company were represented the main plots symbolized (HW, HY, HR) and the colored covers of the tunnels (without cover, transparent, red, yellow, blue) represented the sub plots which symbolized (C0, CW, CR, CY, CB). The seeds of onion were sowed in 15/September and transplanted after two months according to the treatments in their permanent place at the field. The bulbs from all the plots harvested in June. The thickness of the poly ethylene covers that used to cover the tunnels was 200 micron. The characteristics of the covers were determined by spectrophotometer (Figure 1) in order to assess their transmission to the different wave lengths. The distance between plants within the rows 0.1 meter. Light density registered for all the treatments by lux-meter weekly. Soil sample were took from depth (30 cm) to analyze it in the laboratories of the Department of Soil and Water Sciences, College of Agricultural Engineering Sciences, University of Baghdad. Table 1 shows the chemical and physical characteristics of the soil before planting. The characters that measured is the plant height (cm), leaves number.plant^{-1}, leaf area, plant^{-1}(dcm^2) (11) ,dried vegetative growth weight (gm.), chlorophyll concentration (mg.100^{-1}gm fresh weight) (13), bulbing rate (5), bolting percentage, quercetin concentration in bulbs (mg.kgm^{-1}) (22), anthocyanin concentration determined in red bulbs only and it analyzed according to RCBD (mg.100^{-1}gm fresh weight) (21), pungency in

bulbs (as a pyruvic acid concentration) (μM.gm^{-1} fresh weight) (4), dry matter %), total soluble solids (%), bulb diameter (cm), and plant yield (gm.). The collected data analyzed using analyses of variance and the means were compared according to Dunkin multiple range test under 5% probability.

Table 1. physical and chemical characteristics of the soil.

character	values
pH	7.2
EC	2.3dS.m^{-1}
Carbonate metals	266 gm.kgm^{-1}
available nitrogen	66.25 mg.kgm^{-1}
available phosphorus	18.19 mg.kgm^{-1}
available potassium	207 mg.kgm^{-1}
sand	149 gm.kgm^{-1}
alluvium	585 gm.kgm^{-1}
clay	266 gm.kgm^{-1}
soil type	alluvial

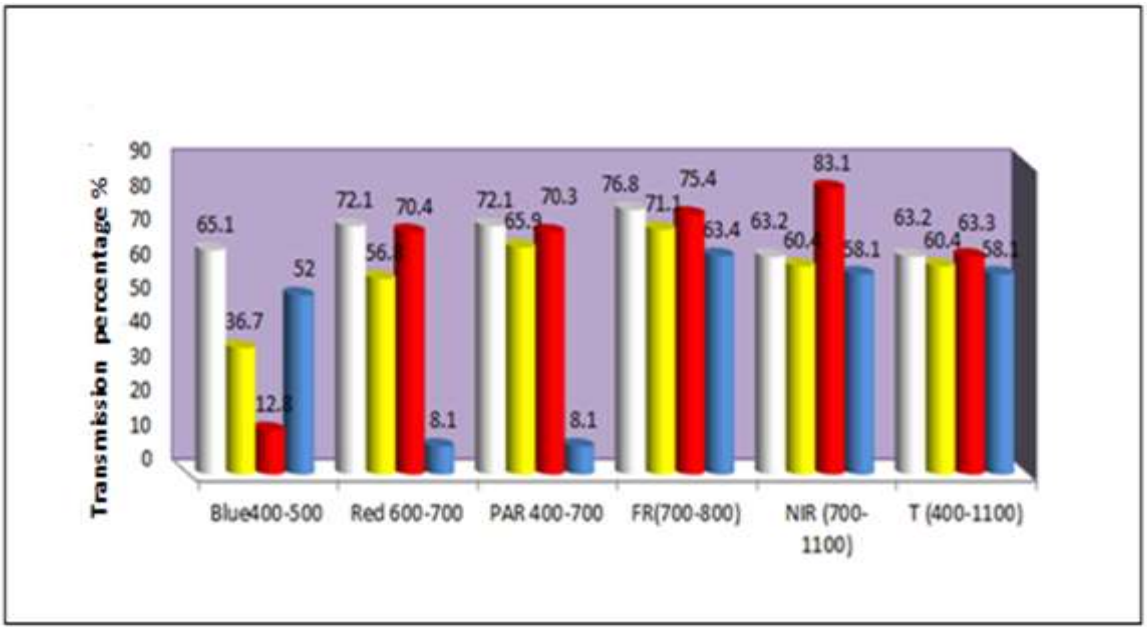

Figure 1. Wave lengths characteristics for the studied covers

RESULTS AND DISCUSSION

Vegetative growth traits of onion plant

Table 2 shows the significant impact of hybrids on plant height. The highest values was attained in HY (62.13 cm), while the lowest values found in HW (54.2 cm) which, didn't differ significantly from HR (54.27 cm). There is no remarkable differences among hybrids in their leaves number. However, Table 2 shows the superiority of HR in leaf area, dried weight of vegetative growth, chlorophyll concentration (24.79 dcm^2,7.333 gm., 9.733 mg.100^{-1}gm f. w.) respectively. In compare with the lowest values of HY (20.31dcm^2,4.833 gm., 8.167 mg.100^{-1}gm f. w.) respectively. Covering the plants with yellow shade showed clear influence in all the traits except plant height (18.ll leaves, 29.63 dcm^2,7.411 gm., 10.44 mg.100^{-1}gm f. w.) respectively. The minimum numbers was found in CB (9.67l leaves, 15.56 dcm^2,4.222 gm., 6.7222 mg.100^{-1}gm f. w.) respectively. However, CB showed a superiority in plant height (61.56 cm) in compare with CO (53.78 cm). The results which obtained from interaction between hybrids and covers showed the significant differences of HRCY, and produced the highest numbers in most of the characters (Table 2) (18.33 leaves, 34.18 dcm^2,8.667 gm., 11.33 mg.100^{-1}gm f. w.) respectively whereas the lowest numbers found with HRCB (8.67 leaves, HYCB (14.30 dcm^2), HWCB (3.333 gm.) and HYCB (6.167 mg.100^{-1}gmf.w.).

Table 2. Impact of hybrid and cover color and their interaction on vegetative growth traits of onion plant

traits treatments	plant height (cm)	leaves number	leaf area (dcm^2)	dried vegetative growth (gm.)	chlorophyll concentration ($mg.100^{-1}$gm f. w.)
			hybrids (H)		
HW	b 54.20	a 15.07	ab 21.83	b 5.180	b 9.160
HY	a 62.13	a 15.07	b 20.31	b 4.833	c 8.167
HR	b 54.27	a 14.73	a 24.79	a 7.333	a 9.733
			cover color (C)		
CO	b 53.78	b 16.56	b 24.78	b 6.333	a 9.889
CW	b 54.56	b 16.67	b 23.67	b 5.889	b 9.600
CR	a 60.56	c 13.78	c 17.92	c 5.056	c 8.444
CY	b 53.89	a 18.11	a 29.63	a 7.411	a 10.44
CB	a 61.56	d 9.67	c 15.56	d 4.222	d 6.722
			hybrids X covers (H X C)		
HWC0	c 52.00	b 16.67	cde 22.99	fg 5.333	bc 10.00
HWCW	c 52.33	b 16.33	bc 24.51	fgh 5.000	ab 10.467
HWCR	b 57.67	c 13.67	fgh 17.04	hi 4.167	d 8.333
HWCY	c 51.00	ab 18.00	a 29.93	def 6.333	ab 10.667
HWCB	b 58.00	d 10.67	gh 14.70	i 3.333	e 6.333
HYC0	b 58.33	b 16.67	cdef 22.10	ef 5.667	d 8.667
HYCW	b 59.67	b 17.00	cde 22.52	fgh 5.000	d 8.333
HYCR	a 66.67	c 14.00	efgh 17.85	ghi 4.333	d 8.333
HYCY	b 57.67	ab 18.00	bc 24.77	bcd 7.233	cd 9.333
HYCB	a 68.33	de 9.67	h 14.30	i 3.667	e 6.167
HRC0	c 51.00	b 16.33	ab 29.26	ab 8.000	ab 11.00
HRCW	c 51.67	b 16.67	cd 23.98	bc 7.667	bc 10.00
HRCR	b 57.33	c 13.67	defg 18.88	cde 6.667	d 8.667
HRCY	c 53.00	a 18.33	a 34.18	a 8.667	a 11.33
HRCB	b 58.33	e 8.67	efgh 17.67	ef 5.667	d 7.667

the means of individual factors and their overlap in the character that have the same letters are not significantly different from each other

yield traits of onion plant

The results in Table 3 reveal the superiority of HR in producing the maximum numbers in bulbing rate, bulb diameter, and plant yield (2.553, 7cm, 190 gm.) respectively. In comparing with HY in bulbing rate and bulb diameter (2.14, 6.07cm and HW in plant yield (164.7 gm.). The highest values of dry matter and TSS was obtained in HW (9.87%, 11.13) respectively in comparing with the lowest values which found in HR (6.3%, 7.4) respectively. HY had remarkable bolting percentage (2.933%) in compare with HW and HR (1%). Results in Table 3 shows significant influences of CY in bulbing rate, bulb diameter, and plant yield (2.689, 7.89cm, 222.2 gm.) respectively in compare with CB which exhibits non-significant results (1.744, 5.22 cm, 141.7 gm.) respectively. However, CB produced the highest values of dry matter and TSS (8.89%, 11) respectively in comparing with the lowest values which found in CY (7.67%) for dry matter and CW (8.66) for TSS. The blue cover increases the bolting percentage (3.222%) in compare with CO and CW (0.1%). Interaction treatments, HRC0 had the maximum number in bulbing rate (2.867) (table 4). While the minimum number found in HYCB (1.633). Many treatments had the impact of making bolting percentage zero such as HRCW, HRCO, HWCW, HWCO in compare with the highest bolting rate at HYCB. The highest numbers in dry matter and TSS was found in HWCB (10.67%, 12.66%) respectively in compare with the lowest numbers of treatments HRCY (6%, 6.66%) respectively and HRCW (6%, 7%) respectively. The highest bulb diameter and plant yield was obtained from HRCY treatment (8cm, 233.3 gm.) respectively in compare with HYCB which exhibits non-significant results (4.33 cm, 123.3 gm.) respectively.

Table 3. Impact of hybrid and cover color and their interaction on yield traits of onion plant

traits treatments	bulbing rate	bolting percentage %	dry matter %	T.S.S.	bulb diameter (cm)	plant yield (gm.)
			hybrids (H)			
HW	ab 2.340	a 1.000	a 9.87	a 11.13	ab 6.67	c 164.7
HY	b 2.140	b 2.933	b 8.23	b 9.86	b 6.07	b 175.0
HR	a 2.553	b 1.000	c 6.30	c 7.40	a 7.00	a 190.0
			cover color (C)			
CO	a 2.578	c 0.111	b 7.78	c 8.88	b 6.67	b 185.6
CW	a 2.567	c 0.111	b 7.78	d 8.66	b 6.89	b 191.7
CR	b 2.144	a 3.676	a 8.56	b 9.88	b 6.22	c 141.7
CY	a 2.689	b 1.111	b 7.67	c 8.88	a 7.89	a 222.2
CB	c 1.744	a 3.222	a 8.89	a 11.00	c 5.22	c 141.7
			hybrids X covers (H X C)			
HWC0	b 2.533	c 0.000	ab 9.67	c 10.66	bcd 6.67	cde 166.7
HWCW	b 2.533	c 0.000	bc 9.33	c 10.33	bcd 6.67	cde 166.7
HWCR	c 2.133	b 2.333	ab 10.33	b 11.66	de 5.67	ef 141.7
HWCY	a 2.767	c 0.333	bc 9.33	c 10.33	a 8.67	ab 225.0
HWCB	de 1.733	b 2.333	a 10.67	a 12.66	de 5.67	f 123.3
HYC0	bc 2.333	c 0.333	ef 7.67	e 8.66	cd 6.00	bcd 190.0
HYCW	bc 2.333	c 0.333	def 8.00	e 8.66	bcd 6.33	ab 208.3
HYCR	d 1.867	a 6.000	cde 8.67	c 10.66	bcd 6.67	f 125.0
HYCY	b 2.533	b 2.667	ef 7.67	d 9.66	bcd 7.00	ab 208.3
HYCB	e 1.633	a 5.333	bcd 9.17	b 11.66	e 4.33	e 123.3
HRC0	a 2.867	c 0.000	g 6.00	f 7.33	abcd 7.33	abc 200.0
HRCW	a 2.833	c 0.000	g 6.00	f 7.00	abc 7.67	abc 200.0
HRCR	b 2.433	b 2.667	fg 6.67	f 7.33	bcd 6.33	def 158.3
HRCY	a 2.767	c 0.333	g 6.00	f 6.66	ab 8.00	a 233.3
HRCB	d 1.867	b 2.000	fg 6.83	e 8.66	de 5.67	def 158.3

the means of individual factors and their overlap in the character that have the same letters are not significantly different from each other

Quercetin concentration in bulbs (mg.kgm^{-1}) and pyruvic acid concentration in bulbs (µM.gm^{-1}.gm^{-1} f.w.) of onion plant

Results in Table 4 shows the superiority of HY in producing the highest concentration of quercetin (66.41 mg.kgm^{-1}) while, the lowest concentration is in HW (14.68 mg.kgm^{-1}). Nevertheless, HW has the impact to produce the highest concentration of pyruvic acid (12.40 µM.gm^{-1} f.w.) in comparing with the lowest value that obtained from HR (6.467 µM.gm^{-1} f.w.). As for the covers, Table 4 shows the significant superiority of CY in producing the highest concentration of quercetin (49.17 mg.kgm^{-1}) while the lowest concentration is in CB (40.27 mg.kgm^{-1}). Nonetheless, CB had the highest concentration of pyruvic acid (10.444 µM.gm^{-1} f.w.) in comparing with the lowest value that obtained from CW (8.333 µM.gm^{-1} f.w.). Many of interaction treatments exhibit significant results (Table 4) such as HYCY which shows the highest concentration of quercetin (73.67mg.kgm^{-1}) while the lowest concentration is in HWCB (14.13 mg.kgm^{-1}). The latter had the highest concentration of pyruvic acid (14.33 µM.gm^{-1} f.w.) in comparing with the lowest value that obtained from HRCW(5.333µM.gm^{-1}f.w.).

Table 4. Impact of hybrid and cover color and their interaction on quercetin concentration in bulbs (mg.kgm^{-1}) and pyruvic acid concentration in bulbs (micromole.gm^{-1} f.w.) of onion plant

traits treatments	quercetin concentration in bulbs (mg.kgm^{-1})	pyruvic acid concentration in bulbs (µM .gm^{-1} f.w.)
	hybrids (H)	
HW	c 14.68	a 12.400
HY	a 66.41	b 8.800
HR	b 53.60	c 6.467
	cover color (C)	
CO	bc 45.04	b 8.556
CW	c 43.71	b 8.333
CR	b 46.29	a 10.000
CY	a 49.17	b 8.778
CB	d 40.27	a 10.444
	hybrids X covers (H X C)	
HWC0	i 14.77	b 11.667
HWCW	i 14.47	b 11.334
HWCR	i 14.53	a 13.333
HWCY	i 15.50	b 11.331
HWCB	i 14.13	a 14.333
HYC0	bc 65.70	cde 8.333
HYCW	cd 63.33	cde 8.330
HYCR	b 68.33	c 9.333
HYCY	a 73.67	cd 8.667
HYCB	de 61.00	c 9.333
HRC0	g 54.67	g 5.667
HRCW	g 53.33	g 5.333
HRCR	gh 56.00	ef 7.334
HRCY	ef 58.33	fg 6.331
HRCB	h 45.67	de 7.667

the means of individual factors and their overlap in the character that have the same letters are not significantly different from each other

Anthocyanin concentration in red bulbs (mg.100^{-1}gm f. w.) of onion plant

It is noticeable from Table 5 the impact of cover color on anthocyanin accumulation in red bulbs. The yellow cover uniquely increased the anthocyanin pigment in bulbs (24.67 mg.100^{-1}gm f. w.) in compare with the lowest value that obtained from the blue cover treatment (11.33 mg.100^{-1}gm f. w.).

Table 5. Impact of cover color on anthocyanin concentration in red bulbs (mg.100^{-1}gm f. w.) of onion plant

treatments	anthocyanin concentration (mg.100^{-1}gm f. w.)
C0	b 18.00
CW	c 12.00
CR	ab 22.33
CY	a 24.67
CB	c 11.33

the means of individual factors and their overlap in the character that have the same letters are not significantly different from each other

It can be observed from these results the impact of genotype of onion hybrids. Yellow hybrid exhibits delayed in bulbing, increase in bolting percentage (marketablely unfavorable). However, yellow hybrid showed abundant amount of quercetin (a prominent feature of yellow varieties), moderate amount of pyruvic acid (moderate pungency), TSS, and dry matter and that makes it excellent choice for health aspects and moderate storage. White hybrid showed very tiny amount of quercetin and high amount of pyruvic acid, TSS, and dry matter and that makes it excellent choice for long storage and cooking purposes. Red hybrid demonstrated good concentration of quercetin and anthocyanin, low amount of pyruvic acid (light pungency), low TSS, and dry matter and that makes it ideal choice for health aspects, fresh consumption, and short storage. The significant superiority of yellow cover in most of the studied characters is due to increasing the light density in the mentioned covers.

Furthermore, increasing the transmission of photosynthetically active radiation (PAR) (Figure 1), which led to raise the potential of photosynthesis and that reflected on primary and secondary metabolism. Additionally, blue light that transmitted from the yellow cover contributed in chlorophyll formation and enzyme activation (19). Increasing of plant height and decreasing the other vegetative traits of blue poly ethylene covers can be interpreted by decreasing the light density of these covers which leads to elongation of the plant (18 and 23). Moreover, decreasing (PAR) (from 400-700 nanometer) through blue covers (Figure 1). As a result reducing the efficiency of photosynthesis which led to reduction in growth traits. Increasing of dry matter of the bulbs under those covers was due to reduction the water content of them (the smaller the bulb the drier in water content) because of their small size. Consequently, increasing the pungency and TSS of those bulbs. The interaction between red hybrid and yellow cover exhibits significant differences in most of study traits and that may be result from the synergistic impact of good marketable characteristics of the red hybrid and the properties of yellow cover which conducive to accretion in most of the studied characters. Clearly, the growth, yield and quality of onion plant affected in a large scale by the kind of the hybrid and the cover color.

REFERENCES

1. Al-Mahdawe, M.M.I. Z.T. Khodair and Z.G. Fadhil. 2018. The effect of light selective cover and spraying with paclobutrazol on the vegetative growth of *Antirrhinum majus* plants. The Iraqi Journal of Agricultural Sciences. ,49(2):243-250

2. AL-Mousawi, Z. J. and S. O. Mohammed. 2017. Effect of the plastic colour and electrocution in some vegetative growth indicators and parthenolide content In leaves of *Tanacetuim parthenuim* L. plant. The Iraqi Journal of Agricultural Sciences., (6) 48 – 1512-1522

3. AL-Mousawi, Z. J. and S. O. Mohammed. 2017. Effect of the plastic colour and electrocution in root growth indicators and volatile oils content of the *Tanacetuim parthenuim* L. of plant roots. The Iraqi Journal of Agricultural Sciences., (6) 48 –1504-1511

4. Anthon, G. E. and D. M. Barrett. 2003. Modified method for the determination of pyruvic acid with dinitrophenylhydrazine in the assessment of onion pungency. Journal of the Science of Food and Agriculture, 83:1210–1213

5. Brewster, J. L and G. D . Rabinowitch.1990. Onions and Allied Crops. Vol.3. Biochemistry, Food Science, and Minor Crops. CRC press, Inc. Boca Raton. Florida. pp: 265

6. Bystricka, J., J. Musliova, J. Tomas, J. Noskovic, E. Dadakova and P. Kavalkova, 2015. Dynamics of quercetin formation in onion *Allium cepa* L. during vegetation. Acta Alimentaria, 44 (3): 383–389

7. Chen, C., J., Zhou, and C. Ji, 2010. Quercetin: a potential drug to reverse multidrug resistance Life Sci., 87:333-338

8. Dmitrienko, S. G., V. A. Kudrinskaya, and V. V. Apyari. 2012. Methods of extraction, preconcentration and determination of quercetin. Journal of Analytical Chemistry, 67 (4): 299–311

9. Elhassaneen, Y.A. and M.I. Sanad. 2009. Phenolics, selenium, vitamin C, amino acids and pungency levels and antioxidant activities of two Egyptian onion varieties. Amer. J. Food Technol. 4(6):241–254

10. Gallina, PM, G,Cabassi, A, Maggioni, A,Natalini, and A,Ferrante, 2012. Changes in the pyruvic acid content correlates with phenotype traits in onion clones. Australian Journal of Crop Science, 6(1): 36-40

11. Gamiely, S.,W. M. Randle, H. A. Mills, and D. A. Smittle. 1991. A rapid and nondestructive method for estimating leaf area of onion. Hort. Science,26(2):206

12. Geetha, M., P. Ponmozhi, M. Saravanakumar, and P. Suganyadevi. 2011. Extraction of anthocyanin and analyzing its antioxidant properties from different onion *Allium cepa* L.varieties. Res. Pharm. Sci.,2(3):497-506

13. Goodwin, T. W. 1976. Chemistry and Biochemistry of Plant Pigments. Volumes 1 and 2. Chemis. and Biochemistry of Plant Pigments. Volumes 1 and 2., 2nd ed. pp:376

14. Griffiths, G, L, Trueman, T, Crowther, B, Thomas, and B, Smith. 2002. 'Onions: a global benefit to health', Phytotherapy Research, 16(7): 603-615

15. Hussein, W. A. and F. H. Al-Sahaf. 2017. Effect of wave length on quality of tomato fruit. Iraqi J. Agric. Res., 22(9):96-111

16. Jin, M., Z., Zhu, Q., Guo, H., Shen, and Y., Wang, 2012. Growth and accumulation of bioactive compounds in medicinal *Chrysanthemum morifolium* Ramat. cv. Chuju under different colored shade poly ethylene. J. of Medicinal PLants Res., 6(3), 398-404

17. Khandaker, L., A. M., Akond, M. B., ALi, and S., Oba, 2010. Biomass yield and accumulations of bioactive compounds in red amaranth (*Amaranthus tricolor* L.) grown under different colored shade poly ethylene in spring season. Sci. Horticu., 123(3), 289-294

18. Langhans, R. W. and T. W. Tibbitts. 1997. PLant Growth Chamber Handbook. North Central Regional Research Publication No. 340 Iowa AgricuLture and Home Economics Experiment Station Special Report No. 99. pp:197

19. Menard, C.; M. Dorais; T. Hovi and A. Gosselin. 2006. Developmental and physiological responses of tomato and cucumber to additional blue light. Acta Horticulture, 711, 291-296

20. Pavlovic, N., D. Cvikic, J. Zdravkovic, M. Mijatovic, and M. B. Jokanovic. 2011. Mode of inheritance of dry matter content of onion (*Allium cepa* L.) bulb. Genetika, 43(1): 19-28

21. Ranganna, S. 1977. Manual of Analysis of Fruit and Vegetable Product. TATA MC Graw Hill pub. Co. ltd. Newdelhi. pp:634

22. Smith, C., K. A. Lombard, E. B. Peffley, and W. Liu. 2003. Genetic analysis of quercetin in onion (*Allium cepa* L.) 'Lady Raider'. The Texas Journal of Agriculture and Natural Resource 16:24-28

23. Taiz, L. , E. Zeiger, I. M. Moller and A. Murphy. 2014. Plant Physiology and Development. 6th ed, Sinauer Assotiates, Inc., Publishers Sunderland, Massachusetts. pp, 761.