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EFFECT OF ARGININE, CHITOSAN AND AGRYL MULCHING ON THE GROWTH AND YIELD OF PEPPER PLANT UNDER THE CONDITIONS OF UNHEATED GREENHOUSES

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Abstract

An experiment was carried out at the research station in the field of agricultural engineering - University of Baghdad at the site of the Jadriya, in one of the greenhouses for the autumn season 2017 on sweet pepper plant (*Capsicum annuum* L.) that characterized by sweet Italian (Bull Horn type). The experiment included three factors: Arginine (R) spraying at concentrations of 0, 75 and 150 mg.L^{-1} represented by R0, R1, and R2 respectively, and the first spraying was after one month of planting and the plants were sprayed every month until the end of the season. The chitosan (k) was sprayed at four concentrations 0, 12.5, 25, 37.5 mg.L^{-1} represented by K0, K1, K2 and K3 respectively, and the first spraying was after one month of planting and the plants were sprayed every 15 days until the end of the season. The third factor was Agryl p17 (A) mulching. The experiment was carried out according to Nested Design with three replicates. The obtained results showed that the agryl mulching was superior in plant high, dry weight of the total vegetative, and the early yield while uncovered plants were significantly superior in flowers number and the fruit nodule percentage. Arginine spraying resulted in a significant superiority in plant height for both R1 and R2 as well as the highest number of flowers was recorded in R1 while R2 showed the highest early yield amounted to 0.531 tons.h^{-1}. The chitosan did not significantly affect the plant height and a significant superiority was noted for K2 in the number of flowers and early yield while k3 recorded a significant superiority in dry weight of the total vegetative and the percentage of the nodule.

***Keywords* :** Arginine, Chitosan, Mulching, Greenhouses.

Introduction

The availability of food has become an important issue in light of the increases in all societies and has two dimensions, human and economic dimension, therefore workers in the agricultural field seek all the available means to increase the agricultural production, both vegetative and animal in quality and quantity. The importance of vegetable crops was highlighted by the nutritional value, yield, productivity and diversity at the same time in addition to the flexibility to cultivate them in different lands and environmental conditions as well, its inclusion on many plant families. The family of Solanaceae includes many crops, such as *Capsicum annuum* L, and in recent years its importance has grown in Iraq due to the increasing demand for it. This has led to use protected cultivation patterns to be provided throughout the year. Pepper is characterized by variety of varieties, including helical (Sweet long fruits) which exceeds the price of marketing on other types. The large variation in temperature between night and day has a negative effect on protected agriculture as well as increased humidity that provides a suitable environment for the spread of pathological injuries which consistent with the concern of increasing costs. Therefore the idea of using the agryl cover was highlighted by Bachmann, (2005) as a polypropylene cover with small pores that withstand ultraviolet light and can be placed directly on plants for its light weight and provides an environmentally friendly environment for plant growth as well as provides plant service of watering and control.

Amino acids are of great importance due to the direct or indirect effects on the physiological processes of the plant through its role in the formation of many organic compounds such as vitamins and hormones, which is an essential component of living matter, protoplasm and is involved in the formation of enzymes as well as its a store of carbon and energy (Rai, 2002). The effect of Arginin on vegetative properties represented by a positive role as an important source of nitrogen during the formation of proteins and enzymes which is necessary in cell formation and its effect on increasing of carbohydrates and proteins manufacture as well as stimulating physiological and biological processes within the plant, which is reflected in increased plant growth (Liu et al., 2006). The use of natural substances such as chitosan is a contribution to the achievement of sustainable agriculture. It is a soluble form of Chitin extracted from marine oysters and contributes to the compounds derived from it by providing protection to plants from fungal infections (Hirano et al., 1990). In the light of the above, the present study aims to increase the production and to improve the quality of pepper fruits.

Materials and Methods

The field experiment was carried out at the research station B of the Faculty of Agricultural Engineering Sciences, University of Baghdad at the site of Al-Jadriya, in one of the greenhouses for the autumn season 2017. Sweet Pepper was planted (Bull Horn type) and when the seedlings reached four real leaves then transferred to the plastic house on 1 of October 2017. The experiment included three factors: Arginine (R) spraying at concentrations of 0, 75 and 150 mg.L^{-1} represented by R0, R1, and R2 respectively, and the first spraying was after one month of planting and the plants were sprayed every month until the end of the season. The chitosan (k) was sprayed at four concentrations 0, 12.5, 25, 37.5 mg.L^{-1} represented by K0, K1, K2 and K3 respectively, and the first spraying was after one month of planting and the plants were sprayed every 15 days until the end of the season. The third factor was Agryl p17 (A) mulching. The experiment was carried out according to the design of Nested Design and included 24 treatments divided randomly into three replicates. The experimental units were 72 and distributed into five tables. The experimental unit included 14 plants and the distance between plants was 0.4 m. The results were statistically analyzed using the Genstat program. The mean was compared with the least significant difference

(LSD) and 5% probability. The average height of plants (cm), dry weight of vegetative group ($g.plant^{-1}$), number of flowers ($flower.plant^{-1}$), percentage of fruit nodules and early harvest ($ton.h^{-1}$) were calculated.

Results

Average height of plants (cm)

The results of Table 1 showed that there was a significant superiority in A1 which recorded mean of 137.25 cm compared with A0 that reached a height of 110.44 cm. As for the effect of arginine, there was no significant difference between R1 and R2, with a plant height of 130.38 and 128.92 cm respectively, but they were significantly higher than R0 which was of 112.25 cm. The results of the same table showed that there was no significant effect of k on the average height of plant while the interaction treatment between A and R showed a significant difference where the plant height was 140.83 and 140.75 cm in A1R2 and A1R1 respectively which exceeded all treatments and the recorded plant height in A0R0 was 94.33 cm. The results of the table also showed significant differences in the interaction between A and K. The treatment A1K3 exceeded with a height of 138.89 cm compared to A0K0, which reached 108.22 cm while there was no significant effect of the interaction between R and K as well as the effect of the triangular interaction between the A, R and K.

The dry weight of the vegetative group ($g.plant^{-1}$)

The results of Table (2) showed a significant effect of A1 on dry weight increase of the total vegetation of pepper plant reached 311.1 g. $plant^{-1}$ compared to the uncovered plants (A0) which was of 245.7 $g.plant^{-1}$. As for the effect of A, it was found to be insignificant while the spraying of k had a significant effect where all the treatments exceeded and the maximum weight was of 323.3 $g.plant^{-1}$ in K3, while it was 213.1 $g.plant^{-1}$ in K0. The same results showed that the double interaction between A and R did not have a significant effect on the dry weight of the vegetative group of the pepper plant. The interaction between A and K had a significant effect where A1K2 and A1K3 increasing by 355.2 and 350.8 $g.plant^{-1}$ respectively compared with A0K0 which recorded mean of 185.0 $g.plant^{-1}$. Regarding the interaction between R and K, there was no significant effect in the studied character. However, the triple interaction between A, R and K revealed that A1R2K2 has significantly exceeded in dry weight of the vegetative group with mean of 357.5 $g.plant^{-1}$ compared with A0R0K0 which reached 181.8 $g.plant^{-1}$.

Number of flowers ($flower.plant^{-1}$)

The statistical analysis of the data in Table 3 shows that the A0 was significantly superior with the highest number of flowers which was 146.08 $flower.plant^{-1}$ compared to A1 which recorded mean of 136.08 $flower.plant^{-1}$. It was also shown that the effect of R was significant on the increase of the flowers number, and the highest number of flowers was 144.58 $flower.plant^{-1}$ in R1 while the lowest number in R0 which was 136.58 $flower.plant^{-1}$. The effect of K spraying was also significant and resulted in an increase in the number of flowers with the highest number was noted in K2 and reached 149.22 $flower.plant^{-1}$ while the lower number of flowers was detected in K0 and reached 129.33 flower. $plant^{-1}$. The obtained result also indicates that the double interaction between A and R did not have a significant effect on the increase of the number of flowers, while the interaction between A and K had a significant effect where A0K2 having the highest number of flowers with mean of 156.33 $flower.plant^{-1}$ compared to the A1K0 that recorded mean of 124.33 $flower.plant^{-1}$. As for the treatment of the interaction between R and K, treatment R1K2 was superior with the highest number of 154.83 flower. $plant^{-1}$ compared with R0K0 which was of 124.83 $flower.plant^{-1}$. Regarding the triangular interaction between the factors of the study, the result shows that the A0R1K2 exceeded with the largest number of flowers 159.83 $flower.plant^{-1}$ compared to the lowest number in A1R0K0 treatment which had mean of 119.83 $flower.plant^{-1}$.

Percentage of fruit nodules

The results of the statistical analysis in Table 4 indicated that a significant increase in percentage of fruit nodules was detected in A0 which increased by 52.20% compared to 48.20% in A1. Additionally, it was found that the effect of R on the percentage of fruit nodules was not significant, while a significant effect of K was revealed. The K3 was higher than K2, K1 and K0 and the recorded percentage was 52.07% for K3 and means of 48.99, 51.39 and 48.35% for K2, K1 and K0 respectively. As for the effect of the interactions between the study factors, the results indicated that they were not significant in their effects.

Early yield ($ton.plastic\ house^{-1}$)

A significant positive effect for A on the early yield was noted (Table 5). Treatment A1 was superior in the early increase with mean of 0.527 $ton.h^{-1}$ compared to A0 which recorded 0.430 $ton.h^{-1}$ with an increase of 18.4%. Furthermore, a significant effect of R was demonstrated where R2 was significantly exceeded with higher yield of 0.531 $ton.h^{-1}$ compared to R1 and R0 which reached 0.509 and 0.396 $ton.h^{-1}$ respectively as well as R1 was significantly superior on R0. The obtained results indicated that the K spraying had a significant effect on the early yield with a higher value in K2 with mean of 0.545 $ton.h^{-1}$ compared to 0.498, 0.446 and 0.424 $ton.h^{-1}$ for K3, K1 and K0 respectively. As for the interaction between A and R, it had a significant effect on the early yield of pepper plants whereas A1R2 was superior with value of 0.562 $ton.h^{-1}$ compared to A0R0 which reached 0.326 $ton.h^{-1}$ with an increased ratio of 41.99%. Regarding the interaction between A and K, there were no significant differences between them while the interaction between R and K had significantly affected the early yield whereas R2K2 showed the highest yield of 0.618 $ton.h^{-1}$ compared with R0K0, which reached an early yield of 0.322 $ton.h^{-1}$. The results of the table also showed a significant effect of the triple interaction between A, R and K where A1R2K2 and A1R1K2 was superior with mean of 0.631 $ton.h^{-1}$ compared to A0R0K0 which reached 0.260 $ton.h^{-1}$.

Table 1 : Effect of Agryl mulching (A), Arginine (R) and Chitosan (K) spraying and their interaction on the average height of pepper plants (cm).

A x R	K3	K2	K1	K0	Treatments	Coverage
94.33	100	96	89.67	91.67	R0	AO
117.08	115.33	120.33	120.33	112.33	R1	
119.92	126.33	117	115.67	120.67	R2	
130.17	134	129	128	129.67	R0	A1
140.75	141.67	142.67	138.33	140.33	R1	
140.83	141	139.33	140	143	R2	
A						
110.44	113.89	111.11	108.56	108.22	A0	A x K
137.25	138.89	137	135.44	137.67	A1	
R						
112.25	117	112.5	108.83	110.67	R0	R x K
128.92	128.5	131.5	129.33	126.33	R1	
130.38	133.67	128.17	127.83	131.83	R2	
	126.39	124.06	122	122.94	K	

ARK	RK	AK	AR	K	R	A	L.S.D
N.S	N.S	6.22	5.13	N.S	4.31	1.79	0.05

Table 2 : Effect of Agryl mulching (A), Arginine (R) and Chitosan (K) spraying and their interaction on the dry weight of vegetative group (g.plant^{-1}) of pepper plant

A x R	K3	K2	K1	K0	Treatments	Coverage
242.5	292.7	251.1	244.5	181.8	R0	AO
246.5	296.7	255.1	248.5	185.8	R1	
248.0	298.2	256.6	250.0	187.3	R2	
308.0	347.6	352.0	294.2	238.0	R0	A1
312.0	351.6	356.0	298.2	242.0	R1	
313.5	353.1	357.5	299.7	243.5	R2	
A						
245.7	295.8	254.2	247.7	185.0	A0	A x K
311.1	350.8	355.2	297.4	241.2	A1	
R						
275.2	320.1	301.6	269.4	209.9	R0	R x K
279.2	324.1	305.6	273.4	213.9	R1	
280.7	325.6	307.1	274.9	215.4	R2	
	323.3	304.7	272.6	213.1	K	

ARK	RK	AK	AR	K	R	A	L.S.D
53.3	N.S	39.1	N.S	19.3	N.S	37.5	0.05

Table 3 : Effect of Agryl mulching (A), Arginine (R) and Chitosan (K) spraying and their interaction on the number of flowers of pepper plants (flower.plant^{-1})

A x R	K3	K2	K1	K0	Treatments	Coverage
242.5	145.50	151.83	139.17	129.83	R0	AO
246.5	153.50	159.83	147.17	137.83	R1	
248.0	151.00	157.33	144.67	135.33	R2	
308.0	135.50	129.17	141.83	119.83	R0	A1
312.0	143.50	149.83	137.17	127.83	R1	
313.5	141.00	147.33	134.67	125.33	R2	
A						
245.7	150.00	156.33	143.67	134.33	A0	A x K
311.1	140.00	142.11	137.89	124.33	A1	
R						
136.58	140.50	140.50	140.50	124.83	R0	R x K
144.58	148.50	154.83	142.17	132.83	R1	
142.08	146.00	152.33	139.67	130.33	R2	
	145.00	149.22	140.78	129.33	K	

ARK	RK	AK	AR	K	R	A	L.S.D
2.84	1.96	**1.77**	N.S	1.13	0.98	1.42	0.05

Table 4 : Effect of Agryl mulching (A), Arginine (R) and Chitosan (K) spraying and their interactions on the percentage of fruit nodules of Pepper plants (%)

A x R	K3	K2	K1	K0	Treatments	Coverage
51.67	52.20	49.86	52.96	51.68	R0	AO
52.86	53.57	53.13	56.13	48.61	R1	
52.07	52.65	52.30	54.65	48.70	R2	
49.03	52.25	49.01	49.19	45.47	R0	A1
47.83	51.04	43.68	48.59	47.99	R1	
47.73	50.74	45.94	46.80	47.46	R2	
A						
52.20	52.81	51.76	54.58	49.66	A0	A x K
48.20	51.34	46.21	48.19	47.04	A1	
R						
50.35	52.23	49.44	51.07	48.67	R0	R x K
50.34	52.30	48.40	52.36	48.30	R1	
49.90	51.69	49.12	50.72	48.08	R2	
	52.07	48.99	51.39	48.35	K	

ARK	RK	AK	AR	K	R	A	L.S.D
0.067	0.044	N.S	0.042	**0.025**	0.022	**0.040**	0.05

Table 5 : Effect of Agryl mulching (A), Arginine (R) and Chitosan (K) spraying and their interactions on the early yield of pepper plants (ton.h^{-1})

A x R	K3	K2	K1	K0	Treatments	Coverage
0.326	0.371	0.365	0.309	0.260	R0	AO
0.455	0.490	0.566	0.407	0.359	R1	
0.510	0.551	0.605	0.465	0.457	R2	
0.466	0.536	0.474	0.470	0.384	R0	A1
0.562	0.561	0.631	0.551	0.507	R1	
0.552	0.521	0.631	0.477	0.578	R2	
A						
0.430	0.457	0.512	0.393	0.359	A0	A x K
0.527	0.539	0.579	0.499	0.490	A1	
R						
0.396	0.453	0.419	0.389	0.322	R0	R x K
0.509	0.525	0.599	0.479	0.433	R1	
0.531	0.516	0.618	0.471	0.518	R2	
	0.498	0.545	0.446	0.424	K	

ARK	RK	AK	AR	K	R	A	L.S.D
0.067	0.044	N.S	0.042	**0.025**	0.022	**0.040**	0.05

Discussion

In light of the results presented above, it was shown that the pepper plants covered by agryl p17 were characterized in most vegetative traits such as plant height and dry weight of the vegetative group compared to the uncovered plants which may be due to the lack of intensity of light through agryl cover compared with plants that were exposed to direct lighting which caused a defect of the hormonal balance of plants and led to an increase in the plant height (Kraepiel et al., 2001), which reflected positively in the rest of the growth attributes. Additionally, light oxidation occurs in the plants that exposed to direct lighting causing the inhibition of plant hormones which affect plant growth as well as the role of the agryl cover in reducing the difference in the temperature degrees between night and day and its reflection in the growth traits, moreover agryl cover reduce the variation in the relative humidity of covered plants between night and day that provide appropriate moisture in the soil resulted in an increase of the roots efficiency in covered plants which has contributed to an increase in the withdrawal of mineral elements from soil to the plant (Taiz and Zeiger, 2010). The obtained results were agreed with Carlos *et al*. (2013).

It has been noted that stomata of leaves for covered plants were wide causing an increase in the process of transpiration which helps increase the absorption of water and mineral elements as well as increase paper area through the irregularity of the sponge layer (Chalabi, 2019, Taiz and Zeiger, 2010). The results were consistent with Al-Bayati and Hassani (2010); Milenkovic, (2012); Carlos, (2013); Ilahy *et al*. (2013); Ilic *et al*. (2017). The effect of the amino acid arginine in the characteristics of vegetative growth represented by its positive role as a source of nitrogen which was important in proteins and enzymes formation that in turn necessary in the formation of cells and its direct or indirect impact in increasing the manufacture of carbohydrates and proteins as well as stimulate the physiological and biological processes within the plant, which is reflected in the growth of plants (Liu And others, 2006). It stimulates plants to produce proteins and produce hormones such as auxins by building essential amino acids, especially tryptophan (the initiator of IAA formation) which promotes supremacy and encourages elongation in cells (Sahaf, 1989; Wampel *et al.*, 1991 and Wona *et al.*, 2011). The use of amino acids increases the vital functions, especially the division and expansion of plant cells, as well as the role of increasing the activity of enzymes that decompose organic compounds, which works to liberate the elements resulting in an increases in the readiness and increase growth rates as a result of encouraging the division and expansion of cells (Claussen, 2004) and (Nur *et al.*, 2006). The result was consistent with El-Tantawy (2009); El-Bassiouny *et al.* (2008), Ghoname *et al.* (2010); Ferg, (2011); Gerry *et al.* (2014); Gerry and Surgeon (2015); Zubaidi (2016); Al-Shamri (2017).

The spraying of pepper plants with chitosan resulted in a significant increase in all vegetative growth characteristics of the plant as well as the content of the leaves of chlorophyll. The chitosan led to increase the growth of the plants through providing plants with necessary mineral elements that the plant may not be able to provide it due to soil problems or due to the provision of certain amino compounds required for plants (Chibu and Shibayama, 2001). The growth of root hairs has been enhanced and the plant was good because of the increased spread of roots in the soil (Gornik *et al.,* 2008; Borkowski, 2007; Chmielewski *et al.*, 2007). Chitosan has high absorption properties for a number of metal ions because it possesses a number of functional groups such as the hydroxyl group and the amines group, which can be linked to metal ions, either by chemical adsorption or by physical adsorption (Dean and Dixon, 1992; Findon *et al.*, 1993; Bailey *et al.*, 1999). Chitosan acts on the metal element as it corresponds to the basic natural properties of multiple positive ions (Khan, 2003). Chitosan stimulates the activity of the main enzymes to metabolize nitrogen and improve its transfer in leaves. This stimulates leaf function in growth and development (Chibu *et al.*, 2000; Abdel-Mawgoud and Tantawy, 2010). Furthermore, Chitosan increases the build-up of photosynthesis (Barka *et al.*, 2004). The chitosan molecule varies in action from one cell to another and depends on its physiological chemistry. It causes an increase in root mass, flowering, and eventual production (Chandrkrachang and Ahernhausen, 2005). The obtained results were consistent with ELTantawy (2009), Ghonam (2010), Mondal (2012), Salma *et al.* (2017), Abdul Kader (2018) and Monirul (2018).

The results of Table 3 showed that increasing the number of flowers in uncovered plants may be due to several factors including the effect of light. It was found that the light intensity and high temperature increases the formation of flowers due to planting time (1 of October) which means it is subjected to a long period of light and high temperature during the stage of modernity, or may be due to nutritional factors whereas it has been found that the absorption of nutrients was higher in plants covered with agryl than the absorption of plants not covered, which detected that the nutrients were few and the height of the plant, the number of leaves, paper area, and chlorophyll also was less than in the plants which is covered by acryl and indicates that the plants were experiencing difficult environmental conditions compared to the covered plants (Mohamed and Elriss, 1982). The low temperature resulted in flowering stimulation which was received by macrophages where the molecular mechanism is unknown. The stimulation was done by entering an active element, which is the glycrylene hormone and an unknown hormone called Florigene. The difference between night and day was very important for biological phenomena, affecting the formation, for example, plants develop better when the heat between night and day at 7 degrees celsius in the temperate regions (Taiz and Zeiger, 2010).

Table 4 indicated that the increase in the percentage of the nodules in plants without cover at the highest nodules rate was due to the ease of movement of insects inside and it helps to increase the vaccination as many flowers as possible, while the agryl cover prevents access to the plant. Or may be the low light intensity causes the prevention of pollination to prevent the opening of the maysams at a time when it was open and ready to receive the pollen (Mohamed and Elriss, 1982). The results were agreed with Al-Hassani (2012) and Basile *et al.* (2008).

The effect of arginine on the increase in the number of flowers may be attributed to its role in increasing the concentration of mineral nutrients in the leaves as well as the effect of arginine in the increase of vegetative indices and its role in the production of strong plants reflected in improving indicators of flowering growth or the role of amino acids in increasing the size of the plant, which produce higher number of flowers. Additionally, the role of amino acids in improving the balance of nutrients, which helps to stimulate flower buds and regulate the rate of flowers as well as regulate the transfer of solubility, mineral elements and their accumulation in flowers (Abdel-Hafiz, 2006). The results were agreed with Faraj (2011), Gerry (2014), Gerry and Al-jarah (2015).

The increase in the number of both flowers and nodules (Tables 3 and 4) may be due to the increase in the concentration of mineral nutrients in the plant, as well as the effect of K on the increase of vegetative indices and their role in producing strong plants reflected in the improvement of vegetative growth indicators such as flower and nodules number. Studies have not been sufficient in terms of the effect of K on flowering but found it affects the increase in the number of flowers and nodules (Ohta *et al.*, 1999). The results were consistent with Ghoname *et al.* (2010), Mondal (2013) and Salma *et al.* (2017).

Regarding early yield, plants of A treatments were superior with higher early yield due to an increase in the average weight of the fruit which can be attributed to the reflection of all vegetative characteristics and appropriate environmental effects. The results were in agreement with Milenkovic *et al.* (2012), Carlos and Diaz (2013), Ilahy *et al.* (2013), Ambrozy *et al.* (2015) and Ilic *et al.* (2017). It was found that amino acid spraying increases the total phenolic content of the plant and this increases the IAA content in the branches, which was reflected in the activation of growth and production (Graham and Graham, 1996). This was accompanied by an increase in the amount of processed feed as a result of the increase in the volume of the vegetative group resulting in yield increase. There was a positive linear relationship between vegetative growth and plant production (Bolarin *et al.*, 1995). The results of the arginine have agreed with both El-Bassiouny *et al.* (2008), Ghoname *et al.* (2010), Verg (2011), Jaguar (2013), Gerry (2014) and Gerry and Al-Jarah (2015).

All growth indicators, such as plant height, number of dry leaves, vegetative growth, photosynthesis, chlorophyll, and yield in cowpea plant were increased when treated with chitosan (Mondal *et al*., 2013). There was a lack of studies that demonstrated the effect of chitosan on flowers, however, it was found that chitosan affect the increase in the number of flowers and nodules (Ohta *et al*., 1999). Furthermore, it was found that chitosan increased the yield of tomato plant (Lafontaine and Benhamou, 1996) as well as it affects the increase of biomass in relation to the amount of water by reducing transpiration (Bittelli *et al*., 2001). Moreover, chitosan had an important role in the plant nutrition also a positive role in increasing the speed of growth, vegetable qualities and metal elements. As a result for the previous effects of chitosan and the abundance of feed from carbohydrates and sugars, the early yield has been increased. The results of the chitosan were in agreement with EL-Tantawy (2009), Mondal (2012) and Mondal *et al*. (2013).

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