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IMPACT OF ORGANIC FERTILIZER AND PRUNING ON GROWTH AND YIELD OF SWEET PEPPER (*Capsicum annum* L.) UNDER PLASTIC HOUSE CONDITION

REZAN **S**. **S**HAREEF, **S**ANAA **M**. **R**ASHID and **S**AMIRA **T**. **A**LI
Dept. of Horticulture, College of Agricultural Engineering Science. University of Duhok, Kurdistan Region-Iraq

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ABSTRACT

This experiment was conducted under plastic house conditions in the Horticulture Department, College of Agricultural Engineering Sciences, University of Duhok, Kurdistan Region- Iraq, during the growing season (2022), to study the effect of foliar application of organic fertilizers (amino acid) at three concentrations (0 , 2 and 4 ml. L^{-1}) and pruning at three levels (control) all stem retaining, 1 and 2 stem retaining on the growth and yield characters of sweet pepper (*Capsicum annum* L.) *cv. Massouda RZ F1* . The results showed that amino acid significantly influenced most characters like chlorophyll content in leaves (SPAD), plant height, average fruits weight, plant yield, total yield and fruit vitamin C content (%), especially the concentration (4 ml. L^{-1}) which recorded the best value. Also, the pruning positively affected some characters like chlorophyll content in leaves (SPAD), average fruits weight, plant yield and total yield. The same results was obtained from the combination of amino acid and pruning, most traits was significantly affected by this combination except leaf area, as it was not affected by any factor.

KEY WORDS: Amino Acid, Organic Fertilizer, Pruning , Sweet Pepper.

INTRODUCTION

Sweet pepper (*Capsicum annuum* L.) is one of the most important vegetables around the world which is widely cultivated in vegetable fields and greenhouses in soil and soilless substrate **(Haghighi and Barzegar, 2017).** Sweet pepper is most important crop of Solanaceae family where it comes in third place after tomatoes and potatoes **(Marhoon and Abbas, 2015).** Pepper fruits is one of the highest nutritional vegetables which contain an amount of vitamins like C, A, B and contain some minerals such as P, K, Fe and Ca **(Malik *et al.*, 2011; and Maboko *et al.*, 2012).**

Even though, inorganic fertilizers improve crop yield because plants use these materials directly or indirectly which is supplied by these chemical fertilizers, the continuous and massive use of these fertilizers has various undesirable effects on the agricultural ecosystem such as soil degradation and reducing microbial diversity , atmosphere pollution and groundwater contamination **(Kaur *et al.*, 2008; and Chaudhry *et al.*, 2009).** Nowadays, the orientation of vegetable consumption in the world focused on organic crops and highly nutritive vegetables **(Van de Vijver & van Vliet, 2012; and Apaolaza *et al.*, 2018).** Organic fertilizers offer plants with a supply of mineral nutrient that serves as a substitute for artificial fertilizers. In addition to the nutrients they contain, they include bioactive compounds which have a favorable effect on productivity and growth of plant **(Fahimi *et al.*, 2016; and Souri *et al.*, 2017).**

One of the important organic fertilizers is amino acid which have a great role in plant growth and development, especially when sprayed on plant vegetative growth. Most researchers reported that amino acid have a direct or indirect effect on yield development and physiological operation of yield **(Aly *et al.*, 2019).** Amino acid is an organic form of nitrogen **(Cerdána *et al.*, 2009)** which increase the growth and yield of plant.

According to **(Sarojnee *et al.*, 2009)** amino acids can improve the uptake of fertilizer, enhance the rate of photosynthetic reaction and splitting of dry materials, raising uptake of water and nutrients, and thus raise yield and quality. Many researchers recorded that, the application

of amino acids as spraying can improve plant growth, fruit yield and quality in bell pepper **(Kamar and Omar 1987).**

The spraying of amino acids on plant vegetative growth is one of the recent techniques used to enhance plant growth and productivity because of their main role in increasing the tissue content of essential enzymes and proteins for organizing the metabolic events or activation of antioxidants. Therefore, more plant resistance is obtained against stressful conditions **(Cerdána *et al.*, 2009). Serna *et al.* (2012)** reported that spraying of pepper plants using a combination of amino acids resulted in increase the photosynthesis efficiency , and so that it gives the best vegetative growth.

Pepper plants have the characteristic of branching; so that, the fruit growth can be controlled by dealing with the pattern of branching to 1, 2, 3 and 4 main branches **(Alsadon *et al.*, 2013).** Pruning includes the careful removal of extra branches and leaves to let light pass inside plant and thus the effective production of dry materials and distribution to the plant **(Mussa and Shinichi, 2019)**.

The purpose behind pruning pepper plant in greenhouse is to train plant to grow upright to allow light to reach the entire leaf canopy, enhance fruit set, early fruit ripening obtained and increasing yield with best quality fruits **(Jovicich *et al.*, 2004; and Zende, 2008).** On the other hand, the pruning is useful in improving air circulation which brings down the relative humidity and reduces the diseases spread **(Esiyok *et al.*, 1994).** The main reason that pruning is done to get an appropriate balance between fruit quantity and fruit size through managing plant canopy. **(Alsadon *et al.*, 2013).**

According to the previous statement, the aim of this research is to study the effect of pruning, organic fertilizer (amino acid) and their interaction on growth and yield characteristics of sweet pepper (*Capsicum annum* L.) under plastic house conditions

MATERIALS & METHODS

The experiment was done in the plastic house at college of agricultural engineering sciences, University of Duhok, Kurdistan region, Iraq, during the growing season (2022).

This study was designed in a factorial experiment within Randomized Completely Block Design (RCBD), including two factors and each factor contain (3) levels. Therefore, the experiment consist of (9) treatments, (3) replications, (27) experimental units and (4) plants as observation for each experimental unit (27x4=108 plants). The treatments were randomly distributed. The data was analyzed through Duncan's multiple range test at (0.05) probability level , using a SAS computerized program (SAS, 2003).

The study was conducted under plastic house conditions on 15th February 2022. The land was ploughed well at an approximately (30-40 cm) depth. The organic matter (sheep manure) was applied to soil after decomposition about (40) days. They added to the lines in terrace. Then the soil and sheep manure were softened well together. Drip irrigation system was designed before planting.

Hybrid Pepper seeds (Massouda RZ F1) are sowed in seed trays in 6th February 2022 in greenhouse conditions. After (58) days from sowing seeds the seedling transplanted to its permanent location in plastic house, when the seedlings had (2-3) real leaves **(Aly *et al.*, 2019)**, at a distance (60 cm) between the plants and (70 cm) between rows. Other agricultural operations were applied to every experimental unit similarly.

The factors that used in this experiment are:

Foliar application of Amino Acid at three levels: (0 , 2 and 4 ml.L^{-1}) and Pruning at three levels: (control) all stem retaining, 1 and 2 stem retaining. The foliar spraying was done in three times. The first spraying was applied after (35) days from transplanting seedlings in the 10th May 2022, then every (10) days the spraying was repeated.

Pruning was done by leaving one stem, two stem and non-pruning (all stem were maintained). Pepper pruning was done after (45) days from transplanting according to the treatments in experiment. All branches on the sides were cut off weekly to keep the number of stems consistent with treatments **(Maboko *et al.*, 2012)**. The fruits of pepper were harvested every (4) days when the fruits at stage of mature green having at least (8 cm) in length **(Mussa and Shinichi, 2019)**. Then the fruit characters were measured.

Experimental Measurements:

During this research the traits that measured are plant height (cm), leaf area (cm²), chlorophyll content in leaves (SPAD), number of fruits per plant (fruit.plant^{-1}) , average fruit weight (g. fruit^{-1}), total yield (ton.

ha^{-1}) , plant yield (Kg. $plant^{-1}$) and fruit vitamin C content (%).

RESULTS

1. Plant Height (cm)

Results presented in table (1) recorded a significant influence of amino acid on plant height, the highest value (134.21 cm) was obtained when spraying pepper plant at level (4 ml. L^{-1}). The plant height was not affected by pruning system, so the best result (136.17 cm) was obtained in control plants.

The double interaction between (4 ml. L^{-1}) of spraying amino acid and control plants in pruning system had a highest results (141.38 cm).

Table (1): Effect of amino acid, pruning and their interaction on the plant height (cm) of pepper plant.

Amino Acid (ml. L^{-1})	Pruning			Effect of Amino Acid
	0	1	2	
0	132.88 a-c	124.00 c	130.38 bc	129.08 b
2	134.25 ab	123.63 c	125.63 bc	127.83 b
4	141.38 a	130.75 bc	130.50 bc	134.21 a
Effect of Pruning	136.17 a	126.13 b	128.83 b	

Means followed by the same letters are significantly not different within factor and their interactions on the basis of Duncan's test at (5%) level.

2. Leaf Area (cm^2)

Results in table (2) illustrated that there are no significant differences between treatments in both factors, spraying amino acid and pruning system when measuring leaf area of plants.

Also the interaction between spraying amino acid and pruning system didn't have any significant effects on leaf area.

Table (2): Effect of amino acid, pruning and their interaction on the leaf area (cm^2) of pepper plant.

Amino Acid (ml. L^{-1})	Pruning			Effect of Amino Acid
	0	1	2	
0	81.24 a	78.99 a	77.92 a	79.38 a
2	76.31 a	74.83 a	78.94 a	76.69 a
4	80.60 a	76.19 a	70.66 a	75.82 a
Effect of Pruning	79.38 a	76.67 a	75.84 a	

Means followed by the same letters are significantly not different within factor and their interactions on the basis of Duncan's test at (5%) level.

3. Chlorophyll content in leaves (SPAD)

The data presented in the table (3) reported that amino acid significantly affected leave chlorophyll content at concentration (4 ml. L^{-1}), which gave (71.69). Also pruning system significantly influenced on leave chlorophyll content at level (1) stem per plant, which gave (71.30) compared to other levels. The interaction between amino acid and pruning system gave a positive results (72.77) when spraying amino acid at rate (4 ml. L^{-1}) and pruning at level (1) stem per plant as compared to other treatments.

Table (3): Effect of amino acid, pruning and their interaction on the chlorophyll content in leaves (SPAD) of pepper plant.

Amino Acid (ml. L^{-1})	Pruning			Effect of Amino Acid
	0	1	2	
0	66.72 c	69.84 a-c	70.98 ab	69.18 b
2	68.39 bc	71.30 ab	70.31 a-c	70.00 ab
4	71.23 ab	72.77 a	71.06 ab	71.69 a
Effect of Pruning	68.78 b	71.30 a	70.78 ab	

Means followed by the same letters are significantly not different within factor and their interactions on the basis of Duncan's test at (5%) level

4. Number of fruits per plant (fruit.plant^{-1})

The results showed that there is no significant differences between treatments by using amino acid. While pruning has a significant effect on number of fruits per plant (34.67 fruits. Plant^{-1}) at level (2 stem per plant).

The interaction between amino acid and pruning obtained that there is a significant differences between treatments when we use amino acid at level (4 ml. L^{-1}) and no pruning, which gave (38.67 fruits. Plant^{-1}).

Table (4): Effect of amino acid, pruning and their interaction on the number of fruits per pepper plant (fruits. Plant^{-1}).

Amino Acid (ml. L^{-1})	Pruning			Effect of Amino Acid
	0	1	2	
0	36.67 ab	25.00 cd	33.33 a-d	31.67 a
2	36.67 ab	23.00 d	35.33 a-c	31.67 a
4	38.67 a	26.00 b-d	35.33 a-c	33.33 a
Effect of Pruning	37.33 a	24.67 b	34.67 a	

Means followed by the same letters are significantly not different within factor and their interactions on the basis of Duncan's test at (5%) level.

5. Average Fruits Weight (g. fruit^{-1})

The results in table (5) reported that there is a significant influences on the average fruit weight (48.95 g. fruits^{-1}) by using amino acid at level (4 ml. L^{-1}). Also pruning significantly influenced on average fruit weight by recording a highest value (49.53 g. fruits^{-1}) at level (2) stem per plant. The dual interaction between amino acid and pruning registered a highest value (53.77 g. fruits^{-1}) , by using amino acid at rate (4 ml. L^{-1}) and pruning at level (2) stem per plant.

Table (5): Effect of amino acid, pruning and their interaction on the average fruit weight (g. fruit^{-1}) of pepper plant.

Amino Acid (ml. L^{-1})	Pruning			Effect of Amino Acid
	0	1	2	
0	51.02 ab	37.30 d	47.15 bc	45.16 b
2	48.74 bc	46.27 c	47.67 bc	47.56 ab
4	45.15 c	47.94 bc	53.77 a	48.95 a
Effect of Pruning	48.30 a	43.83 b	49.53 a	

Means followed by the same letters are significantly not different within factor and their interactions on the basis of Duncan's test at (5%) level.

6. Plant Yield (Kg. plant^{-1})

The data in table (6) presented that there is a significant differences between treatments by spraying amino acid and the best result (1.71 Kg. plant^{-1}) was recorded by spraying (4 ml. L-1) as compared to other treatments. Whereas the pruning significantly influenced on plant yield only at level (2) stem per plant, which record (1.82 Kg. plant^{-1}).

Also the interaction between amino acid at concentration (4 ml. L^{-1}) and pruning at level (2) stem per plant gave a best results (2.10 Kg. plant^{-1}).

Table (6): Effect of amino acid, pruning and their interaction on the plant yield (Kg. plant^{-1}) of pepper plant.

Amino Acid (ml. L^{-1})	Pruning			Effect of Amino Acid
	0	1	2	
0	1.75 ab	1.00 d	1.47 bc	1.41 b
2	1.84 ab	1.18 cd	1.89 a	1.64 a
4	1.74 ab	1.28 cd	2.10 a	1.71 a
Effect of Pruning	1.78 a	1.15 b	1.82 a	

Means followed by the same letters are significantly not different within factor and their interactions on the basis of Duncan's test at (5%) level.

7. Total yield (ton. ha^{-1})

The results in table (7) revealed that amino acid significantly influenced total yield and the highest number (151.58 ton. ha^{-1}) was recorded at concentration (4 ml. L^{-1}) as compared to other concentrations. Also pruning system significantly affected on total yield, which gave (161.73 ton. ha^{-1}) at level (2) stem per plant.

The interaction between amino acid and pruning significantly influenced on total yield and the highest result was obtained (186.41 ton. ha^{-1}) from combination between (4 ml. L^{-1}) of amino acid and (2) stem per plant for pruning.

Table (7): Effect of amino acid, pruning and their interaction on the total yield (ton. ha^{-1}) of pepper plant.

Amino Acid (ml. L^{-1})	Pruning			Effect of Amino Acid
	0	1	2	
0	155.72 ab	88.91 d	130.58 bc	125.07 b
2	163.56 ab	104.52 cd	168.20 a	145.42 a
4	154.63 ab	113.69 cd	186.41 a	151.58 a
Effect of Pruning	157.97 a	102.37 b	161.73 a	

Means followed by the same letters are significantly not different within factor and their interactions on the basis of Duncan's test at (5%) level

8. Fruit vitamin C content (%)

It is clear from the table (8) spraying amino acid at concentration (4 ml. L^{-1}) significantly influenced vitamin C content in fruit (4.04 %). Whereas in pruning the control treatments gave a highest value (4.12 %).

In the double interaction the amino acid at concentration (4 ml. L^{-1}) and pruning at control treatment recorded a highest value (9.24 %).

Table (8): Effect of amino acid, pruning and their interaction on the fruit vitamin C content (%) of pepper plant.

Amino Acid (ml. L^{-1})	Pruning			Effect of Amino Acid
	0	1	2	
0	1.32 bc	1.32 bc	1.56 bc	1.40 b
2	1.80 bc	2.96 b	1.08 c	1.95 b
4	9.24 a	1.20 bc	1.68 bc	4.04 a
Effect of Pruning	4.12 a	1.83 b	1.44 b	

Means followed by the same letters are significantly not different within factor and their interactions on the basis of Duncan's test at (5%) level.

DISCUSSION

It was shown from the previous results that amino acid significantly increased most characters, which are plant yield, average fruits weight, total yield, plant height, fruit vitamin C content and chlorophyll content in leaves. This increase may be attributed to the role of amino acids in the motivation of metabolic processes in plant leading to stimulate growth resulting from the formation of new types of enzymes, some essential vitamins and proteins **(Attoa *et al.*, 2002).** On the other hand this promote may be the result of raising the efficiency of photosynthesis process and thus the vegetative growth is increased **(Serna *et al.*, 2012).**

Application of amino acids as foliar spraying on vegetative parts of plant is considered one of the effective method to improve plant growth and productivity because amino acid directly increased the content of tissue from essential enzymes and proteins for organizing the metabolic events or activation of antioxidants **(Shehata and Abdel-Wahab, 2018).**

Several researchers say that amino acids may affect the physiological activities during the plants growth and thereby increasing the productivity **(Mendes *et al.*, 2016).** The amino acids ornithine and phenylalanine are included in the gibberellins synthesis indirectly, which has an effective role in internodes elongation and promoting the development and appearance of lateral buds and thus increasing branches number and height of plant **(Taiz and Zeiger, 2002).**

Additionally , **(Sarojnee *et al.*, 2009 ; and Korkmaz *et al.*, 2012)** reported that the spraying of amino acids resulted in an obvious increase in number of branches and plant height in pepper plant, in comparison to untreated plants, especially after (50) days of treatment. The same results are agreed by **(El-Zohiri and Asfour, 2009 ; and Moraditochaee *et al.*, 2012),** which revealed that foliar spraying of amino acids increased growth and improved quality of fruits in plant like in chili pepper.

The pruning resulted in significant differences in average fruits weight, total yield, plant yield and chlorophyll content in leaves (SPAD). The causes behind pruning of sweet pepper under plastic house conditions are to encourage a plant to grow upright, so as to allow light to penetrate the plant canopy and thus improving fruit set, early fruit ripening and increasing yield with increasing fruits size **(Jovicich *et al.*, 2004; and Zende, 2008).**

However, non-pruned sweet pepper plant gave taller plants compared to pruned plants, this increase in plant height might be back to the competition between pepper plant to available light, water and nutrients as a result of increasing plant density in cubic meter.

Also, **alsadon *et al.* (2013)** illustrated that pepper plants that pruned to four branches produced the highest number of fruits and total yield compared to one and two branches. This results is similar to our finding, where it appears two stem pruning resulted in more fruits compared to one stem. Whereas, there are no significant differences between control and two stem pruning in plant yield and total yield, but the highest results was recorded in two stem pruning , this increase may be back to average fruits weight of pepper.

CONCLUSION

The following points are concluded from this study:

1. Concerning the foliar application of amino acid, we conclude that

spraying of amino acid increased growth and yield traits, especially in concentration (4 ml. L^{-1}).

2. Pruning system are useful for increasing some traits like average fruits weight and chlorophyll content in leaves (SPAD), whereas plant yield and total yield increased by raising number of stem per plant, and depends on average fruits weight.

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كارتێكرنا زبلێ ئورگانیك و كەزاختنێ لسەر گەشەكرن و بەرهەمێ فلفلا شرین (Capsicum annum L.) ل ژێر كاودانێت خانیێ پلاستیكی

پوختە

ئەڤ ڤەكولینە هاتە ئەنجامدان ل ژێر كاودانێت خانیێ پلاستیكی ل پشكا یستانكاری، كولیژا زانستێن ئەندازیاریا چاندنێ، زانكویا دهوك، هەرێما كوردستان، عیراقَ. ل وەرزێ چاندنێ ێ سالا (2022)، بو تاقیكرنا كارتێكرنا رەشاندنێ ب زبلێ ئورگانیك (ترشێ ئەمینی) ب سێَ تیراتیا (0 ، 2 و 4 مل. لتر-1) و كارتێكرنا كەزاختنی ب سێ ئاستا ئەو ژی نەكەزاختن ((Cont r ol، 1)) هێلانا ئێك تای و (2) هێلانا دوو تایا لسەر گەشە و بەرهەمێ فلفلا شرین (Capsicum annum L.) ژ جورێ هەجین (Massouda RZ F1)، ئەنجاما دا دیاركرن كو ترشێ ئەمینی ب شێوەیەكێ بەرچاڤ كارتێكرن یا كری لسەر پتریا ساخلەتا وەكی بلندیا رووەكی، رێژەیا كلوروفیلی د بەلگاندا (SPAD)، تێكرایێ كێشا بەرێ رووەكی، بەرهەمێ هەر رووەكەكی، بەرهەمێ گشتی ، رێژەیا فیتامین C د بەرێ رووەكیدا (%)، و ب تایبەتی تیراتیا (4 مل. لتر-1) كو باشترین رێژە تومار كر. هەروەسا كەزاختنێ كارتێكرنەكا ئەرێنی هەبو لسەر هندەك ساخلەتا وەكی رێژەیا كلوروفیلی د بەلگاندا (SPAD)، تێكرایێ كێشا بەرێ رووەكی، بەرهەمێ هەر رووەكەكی، بەرهەمێ گشتی. هەمان ئەنجام ب دەست مە كەفتن ژ كارتێكرنێن جوت دناڤ بەینا ترشێ ئەمینی و كەزاختنێ دا، كو پتریا ساخلەتا ب شێوەیەكێ بەرچاڤ كارتێكرن یا لێ هاتیە كرن ژلایێ ڤێ تیكەلی ڤە ژبلی روبەرێ بەلگی كو چ كارتێكرن لسەر نە هاتە كرن ژلایێ چ فاكتەرا ڤە.

تأثير السماد العضوي و التقليم على نمو و حاصل الفلفل الحلو (*Capsicum annum* L.) تحت ظروف البيت البلاستيكي

الخلاصة

أجريت هذه التجربة تحت ظروف البيت البلاستيكي في قسم البستنة , كلية علوم الهندسة الزراعية، جامعة دهوك ، أقليم كردستان العراق، خلال موسم النمو (2022) ، لدراسة تأثير رش السماد العضوي (الحامض الأميني) بثلاث تراكيز (0 ، 2 و 4 مل/ لتر) و تأثير التقليم بثلاث مستويات وهي عدم عمل التقليم (Control) ، (1) الأبقاء على فرع واحد و (2) الأبقاء على فرعين، على صفات النمو و الحاصل للفلفل الحلو (*Capsicum annum* L.) صنف (*Massouda RZ F1*). أظهرت النتائج أن الحامض الأميني أثر بشكل معنوي على أغلب الصفات مثل أرتفاع النبات، محتوى الكلوروفيل في الأوراق (SPAD)، معدل وزن الثمار، حاصل النبات الواحد، الحاصل الكلي و محتوى الفيتامين C في الثمار (%)، و خاصة التركيز (4 مل/ لتر) حيث سجل أعلى قيمة. و كذلك التقليم أثر بشكل أيجابي على بعض الصفات مثل محتوى الكلوروفيل في الأوراق (SPAD)، معدل وزن الثمار، حاصل النبات الواحد و الحاصل الكلي. و تم الحصول على نفس النتائج من المعاملات المزدوجة بين الحامض الأميني و التقليم، معظم الصفات تأثرت بشكل معنوى بهذا الدمج ما عدا المساحة الورقية حيث لم تتأثر بأي من المعاملات.