J. of Plant Production, Mansoura Univ., Vol. 12 (3):323-328, 2021

Journal of Plant Production

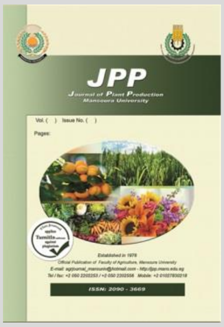
Journal homepage: www.jpp.mans.edu.eg
Available online at: www.jpp.journals.ekb.eg

Role of Calcium Fertilizers on Yellow Pepper Productivity

Walaa M. E. Swelam[1*] and E. A. Abd El-Basir[2]

[1] Veget. and Flori. Dept. Fac. Agric., Mans. Univ., Egypt.
[2] Self-Pollination Vegetables Crops Research Dept., Hort. Res. Inst., Agric. Res. Center, Giza, Egypt.

Cross Mark



ABSTRACT

Optimal calcium nutation of yellow pepper plants is considered one of the most significant factor for best growth, development and yield as well as fruits quality. So, foliar fertilizations have been applied with large in horticultural production especially vegetable crops. Calcium is one of vital nutrients all over plant life cycle. The aim of this research was to compare and evaluate the effects of different Ca fertilizers (sources) on productivity of yellow pepper hybrid VZ 461 grown under open filed conditions. Ca was applied in the following forms chelated, chloride, nitrate, sulphate, superphosphate and complex with boron. All calcium sources have positive effects on growth, biochemical content, photosynthetic pigments, yield and fruits quality compared with the control. Also, all Ca treatments caused a few numbers of fruits with blossom end root (BER) symptoms percentage compared with control fruits. The superior one was Ca chelated in most cases and followed by calcium nitrate and complex with boron in both seasons of study.

Keywords: plant nutrition, yellow pepper, calcium, BER.

INTRODUCTION

Yellow sweet pepper (*Capsicum annum L.)* belongs to family Solanaceae a group of crops commonly referred to as perishables (Onwubuya *et al.*, 2009). Also, it is the worlds' second most important vegetable crops after tomato (Yoon *et al.*, 1989). Its fruits eaten raw in salads, cooked in various ways (Purseglove, 1991) or processed into canned, frozen, picked, fermented, dehydrated or extracted products (Bosland and Votava, 2000). So, it plays a vital role in the nutritional balance of the rural and urban dwellers by supplying vitamins and minerals in their diets (Leung *et al.*, 1968). Pepper (sweet and hot) is an excellent source of natural antioxidants (carotenoids), vitamins (A, C and E) and micronutrients (calcium and Iron) which are critically important in preventing/treating chronic and age-related diseases (Namiki, 1990). Also, it acts as a therapeutic agent for cancer diseases, soothes gout, relieve cramps and improve complexion (Palevitch and Craker, 1996). Obtaining excellent marketable yield of pepper fruits (green / color) from open filed cultivation in less favorable conditions depends to far extent on many factors i.e., correct choice of hybrid/cultivar, time of transplanting and agricultural practices that enhance the yield and fruits quality (Buczkowska, 2007 and Gajc-Wolska *et al.*, 2007) including nutrients feeding on different plant growth stages (Michalojc and Dzida, 2012). So, integrated nutrition management plays vital role in plants shaping and growth as well as quality attributes of fruits. Nowadays, foliar fertilization is frequently applied in agricultural practice. This type of fertilization should be recommended in plant production because it is environmental friendly and gives the possibility to achieve high productivity and good quality fruits (Del-Amor and Rubio, 2009). The plant leaf is structured in such a way that it naturally resists infiltration of fertilizer. Foliar fertilizers treatments increased root and shoot growth, increased resistance to stress and increased water uptake, which in consequence minimizes transplant shock (Vernieri *et al.*, 2006 and Tuteja, 2007).

Calcium (Ca) is known as a fundamental mineral nutrient in all plants, had a wide range of structural, physiological, protective as well as regulatory roles. In recent years, Ca nutrient has become more popular as its additional function of a secondary information transmitter was discovered. Plant requires Ca to develop strong cell walls and membrane and calcium pectate in the middle lamella of the cell wall which regulates the entry of only those nutrients which are not toxic to plants (Bouzo and Cortez, 2012). It also involved in cell division and extention in all plant meristems (roots, shoots and flowers) and helps to maintain the chromosome structure. In root tip, calcium is very essential for the meristematic activity, provides a base for neutralization of organic acids and other toxins (like Al) produced in plants. In flowering stage, Ca stimulate pollen grain germination, pollen tube elongation and penetrability there by flowers pollination and fertilization (Marschner, 1995). Ca nutrient stimulate the bio transporter enzymes (membrane pumps and H-ATPase), photosynthesis and protein synthesis. In addition, Ca can or prevent the incidence of its related disorders as blossom end rot (BER) of tomato and pepper fruits, so the exogenous Ca foliar spraying id considered one of the to prevent or control BER. Also, Ca act as a secondary messenger in signal transduction system, alter gene expression and transcription of some molecules and protein responsible for stresses protection (Marschner, 1995).

On the other hand, Ca ion uptake by plants is to a large extent genetically controlled. The process of Ca absorption, transportation and distribution in plants is influenced by many soil, biological and climatic factors (White and Broadley, 2003 and Shakoor and Bhat, 2014). Ca faces serious problems in soil as antagonistic complexation by K^{+}, Mg^{++} and other positive cations on root uptake sites, added to that its poor mobility and translocation with in plant vessels, it only translocated in plant tissues through xylem not phloem and it doesn't distribute in plant tissue or among organs. Conversely, insufficient Ca in plants leads to a breakdown of cell walls and membranes, susceptibility to a variety of diseases and post-harvest problems

*** Corresponding author.**
E-mail address: walaamohameed@mans.edu.eg
DOI: 10.21608/jpp.2021.160677

particularly in fresh produce such as pepper and tomato (Husein *et al.*, 2015 and Akladious and Mohamed, 2018). Due to its limited mobility, translocation and distribution with in plant and its related physiological disorders in Ca deficient fruits, two strategies could be followed. The first one, a quick and effective way to limit the occurrence of Ca deficiency symptoms in a plant is to deliver that component directly in the form of spraying those parts of the plants where its transfer is limited and also mostly exhibited Ca deficiency and Ca related disorders (leaves, fruits) (Casado-Vela *et al.*, 2007; Kowalska and Sady, 2012 and Michałojc and Dzida, 2012). Although spraying Ca nutrient normally prevent most physiological disorders, but the degree of success varies according to natural predisposition to the symptoms, growing season, cultivar and environmental conditions. The second one, complexation and/or chelation with/by organic, EDTA or synergetic inorganic elements as boron to turn it to be more translocated and distributed elements, easily reached to the organs. The premise of current research was to compare and evaluate the possible effects of calcium sources fertilization in plant performance of yellow pepper under open filed cultivation.

MATERIALS AND METHODS

Experimental work:

Two field experiments were carried out to evaluate the effect of calcium fertilizers (sources Table 1) as foliar spray treatments on yellow pepper quality production (growth, mineral composition, yield attributes and chemical constituents of fruits). The experiments were conducted at privet vegetable farm in Aga, EL-Mansoura Site, El-Dakahlia Governorate, Delta Egypt under drip irrigation system with dark net (darkens 73%) model of cultivation during 2019 and 2020 summer seasons.

Table 1. Calcium fertilizers (sources, chemical formula and calcium percentage)

Calcium source	Chemical formula	Ca^{+2} (%)
Calcium chelated with EDTA		30
Calcium chloride	$CaCl_2$	36
Calcium complex with boron		12
Calcium nitrate	$Ca(NO_3)_2$	19
Calcium sulphate (gypsum)	$CaSO_4.2H_2O$	22
Calcium superphosphate	$Ca(H_2PO_4)_2.H_2O$	15

Soil analysis:

Some physical and chemical properties of soil samples were determined as shown in Table 2.

Table 2. Some physical and chemical properties of the experimental soil profile of cultivated area during 2010 and 2011 seasons.

Soil properties		2019	2020
Physical analysis	Texture	Clay-loam	Clay-loam
Chemical analysis	pH	8.11	8.10
	E.C. (dSm^{-1})	1.12	1.13
	Organic matter (%)	1.45	1.45
	Available P (ppm)	11.72	11.70
	$CaCO_3$ (%)	4.55	4.58
	Total N %	0.2	0.2
Soluble anions (meq/L)	HCO^-_3	3.20	3.40
	CO^-_3	0.00	0.00
	SO^-_4	5.16	5.26
Soluble cations (meq/L)	Ca^{++}	4.03	4.03
	Mg^{++}	1.35	1.35
	Na^+	1.21	1.21
	K^+	5.33	5.33
Available micronutrients (ppm)	Fe^{++}	3.62	3.62
	Mn^{++}	1.51	1.51
	Zn^{++}	1.35	1.35
	Cu^{++}	0.52	0.52

Experimental administration:

Each experiment contains 21 plot. Each plot area 15 m^2 (5*4*0.75 m) containing 3 rows. Each row planted with 10 yellow pepper plants with 50 cm interval space. Planting in one said of the row. Seed of yellow pepper (*Capccicum annum* L.) hybrid VZ 641 were obtained from Vitazad company. Seeds were sown on 5 February in both 2019 and 2020 summer seasons. Transplanting seedlings after 35 days from sowing seeds to open field (dark net system) and the drip irrigation system was applied. All plants (from sown seed to harvest fruits) received all agriculture practices according to Egyptian Ministry of Agriculture and Land Reclamation.

Experimental design:

Randomized complete block design was used with seven treatments and three replicates. Calcium fertilizers (sources Table 1) were applied as foliar application treatments with one concentration 1 g Ca/L at 30, 40 and 50 days after transplanting seedlings to open field.

Vegetative growth parameters:

In the two growing summer seasons, five random plants were taken from each plot at 60 days after transplanting to determine the following parameters as plant height (cm), number of leaves and branches/plant, total fresh and dray weight(gm) according to Koller, 1972.

Biochemical leaves parameters:

Photosynthetic pigments (chlorophyll a, chlorophyll b, total chlorophylls and carotenoids) content were calculated according to Wellburn, 1994.

Leaf macro and micro elements content:

Total nitrogen (N%) as described by FAO, 1980, phosphorus (P%) as described by Chapman and Pratt, 1982 and available of K and Cu according to Westerman, 1990.

Fruits yield parameters:

Early yield/fed was calculated as the sum of the first three pickings, total yield/fed was calculated as the sum of all total picking, unmarketable yield/fed were calculated as non-usually healthy fruits (are not in conformity with hybrid fruits, infected by disease, physiologically defected and the wounded and bruised/or broken and BER).

Fruits quality parameters:

Blossom end root percentage (PER%), total soluble solids (T.S.S.) (%), vitamin C (mg/g fresh weight) and titratable acidity were calculated according to the method described by the AOAC, 1990.

Statistical analysis:

All data of both seasons were arranged and statistically analyzed using Co-Stat software program by using Dunken Test at 5% probability.

RESULTS AND DISCUSSION

Results

Vegetative growth parameters:

Foliar treatments of calcium sources significantly stimulated plants growth attributes of yellow pepper (Table 3) as compared with control plants in both seasons of study. The same results showed that calcium chelated source was of the significantly highest values of all studied yellow pepper growth attributes while control treatment was of the significantly lowest values in the two seasons. Calcium complex with boron (Ca source) gave similar significant effect to chelated Ca source dealing only with plant height and total dray weight also, Ca nitrate source gave similar significant effect on plant total dry weight. The results were the same at both seasons. Generally, the applied different Ca sources i.e., Ca chelated, Ca and B complex, Ca nitrate, Ca superphosphate, Ca sulphate and at least Ca chloride were in descending order and significantly superior the control in their positive effect on yellow pepper growth parameters in the two seasons.

Table 3. Effect of calcium fertilization sources on vegetative growth parameters of yellow pepper plants during 2019 and 2020 seasons.

Treatments	Plant height (cm)		No. leaves/plant		Total fresh weight (g)		Total dry weight (g)	
	2019	2020	2019	2020	2019	2020	2019	2020
Control	56.6 d	54.4 d	172.6 d	163.6 d	562.0 e	557.3 d	107.4 d	106.2 d
Calcium nitrate	69.0 bc	68.3 bc	260.6 b	252.0 b	852.0 bc	847.4 b	195.7 a	192.3 a
Calcium sulphate	67.2 bc	67.1 bc	254.6 b	241.6 b	833.3 c	827.2 b	132.8 c	127.8 c
Calcium complex with boron	71.4 ab	70.9 ab	261.0 b	255.6 b	910.6 b	855.3 b	185.2 ab	184.7 a
Calcium chloride	63.7 c	63.0 c	229.0 c	221.6 c	717.4 d	708.9 c	143.9 c	149.2 b
Calcium chelated with EDTA	75.0 a	74.9 a	305.6 a	296.3 a	992.4 a	982.2 a	196.0 a	194.9 a
Calcium superphosphate	67.3 bc	67.6 bc	256.3 b	244.0 b	835.8 c	826.9 b	168.5 b	165.8 b

Means followed by the same letter in the same column are significantly different at the 5% level according to Duncan's multiple range test.

Biochemical leaves parameters:

The data of Table 4 exhibited the effect of foliar spray of different Ca-sources on yellow pepper photosynthetic pigments leaves content in the study two seasons. This data revealed that the significantly highest values of Chl. a, b and the total were of chelated followed by Ca-B complex source and Ca nitrate source with significant differences among them in the two seasons. The highest significantly values of carotenoids were of calcium nitrate followed by calcium chelated with EDTA sources with significant differences among them at both seasons. While the lowest values were of the control in the two seasons.

Leaf macro and micro elements content:

The presented data in Table 5 proved that highest N, P and K content of yellow pepper leaves obtained by chelated calcium source foliar spray followed by that of calcium complex with boron and calcium nitrate sources within significant differences between all except of K content in the two seasons. While the lowest significantly values were of the control treatment at both seasons of study. Generally, Ca chelated, Ca-B complex, Ca nitrate, Ca superphosphate, Ca sulphate and at least Ca chloride sources in descending order superiored significantly the control in their enhancable effect on yellow pepper leaves N, P and K minerals content in this work two seasons.

Table 4. Effect of calcium fertilization sources on photosynthetic pigments content on yellow pepper leaves during 2019 and 2020 seasons.

Treatments	Carotenoids (mg/gm FW)		Chlorophyll a (mg/gm FW)		Chlorophyll b (mg/gm FW)		Total Chlorophylls (mg/gm FW)	
	2019	2020	2019	2019	2019	2020	2019	2020
Control	0.248 f	0.252 e	1.254 c	1.194 d	0.721 c	0.732 b	1.975 c	1.926 c
Calcium nitrate	0.442 a	0.447 a	1.649 b	1.606 b	0.959 ab	0.951 ab	2.609 b	2.588 b
Calcium sulphate	0.334 d	0.340 c	1.588 b	1.579 bc	0.903 bc	0.900 b	2.492 b	2.480 b
Calcium complex with boron	0.363 c	0.340 c	1.687 b	1.609 b	0.960 ab	0.955 ab	2.647 b	2.195 b
Calcium chloride	0.308 e	0.307 d	1.630 b	1.551 c	0.899 bc	0.884 b	2.529 b	2.436 b
Calcium chelated with EDTA	0.393 b	0.372 b	1.836 a	1.723 a	1.141 a	1.205 a	2.977 a	2.929 a
Calcium superphosphate	0.336 d	0.343 c	1.588 b	1.592 b	0.962 ab	0.939 ab	2.551 b	2.532 b

Means followed by the same letter in the same column are significantly different at the 5% level according to Duncan's multiple range test.

Table 5. Effect of calcium fertilization sources on minerals content on yellow pepper leaves during 2019 and 2020 seasons.

Treatments	N (%)		P (%)		K (%)		Ca (%)	
	2019	2020	2019	2019	2019	2020	2019	2020
Control	1.045 c	1.028 d	0.353 e	0.359 d	1.526 d	1.527 d	0.705 e	0.743 e
Calcium nitrate	3.794 ab	3.783 bc	0.761 bc	0.755 b	1.832 b	1.825 c	2.200 a	2.241 a
Calcium sulphate	3.487 b	3.467 bc	0.631 cd	0.628 bc	1.631 c	1.620 d	1.259 cd	1.460 c
Calcium complex with boron	4.045 ab	3.999 ab	0.929 ab	0.876 ab	1.894 b	1.944 b	2.178 a	2.214 a
Calcium chloride	2.700 b	2.678 c	0.501 de	0.511 c	1.816 b	1.810 c	1.424 bc	1.507 c
Calcium chelated with EDTA	5.101 a	5.014 a	0.988 a	0.993 a	2.095 a	2.084 a	1.793 b	1.833 b
Calcium superphosphate	3.663 b	3.641 bc	0.660 cd	0.665 b	1.824 b	1.816 c	0.969 de	1.004 d

Means followed by the same letter in the same column are significantly different at the 5% level according to Duncan's multiple range test.

Fruits yield parameters:

The data presented in Table 6 indicated that the best highest values of early, marketable and total yellow pepper fruit yields were of chelated calcium foliar spray also, it was of the lowest non-marketable fruit yield significantly values in the two seasons. This treatment followed by calcium complex with boron and calcium nitrate sources with significant differences among them at both seasons. It was obvious that, chelated Ca, Ca-B complex, Ca nitrate, Ca sulphate, Ca chloride and at least the control treatment (in descending order) affected total and marketable fruit yields. The same data cleared that control treatment was of the highest non marketable fruit yield followed by Ca chloride, Ca superphosphate, Ca nitrate and at least Ca chelated source of calcium. Additionally, the highest early fruit yield was observed by calcium chelated followed by calcium nitrate and calcium complex with boron with insignificant differences among the last ones in two seasons.

Likewise, the increase in yield attributes of yellow pepper was associated with significant increase in vegetative growth, minerals content as well as photosynthetic pigments content (Tables 4, 5 and 6).

Fruits quality parameters:

Regarding the effect of different Ca sources on yellow pepper fruit quality i.e., percentage of BER, vitamin C, TSS and total acidity content, the data of Table 7 cleared that the lowest BER % value (4.9 %) started from fruits of chelated calcium sprayed yellow pepper plants increased slightly and gradually as a result of applied Ca superphosphate (5.6 %), Ca nitrate (6.3%), Ca complex with boron (6.5%), Ca chloride (13%) and Ca sulphate (16.3%) to reach the significantly highest value (32.4%) in control plant fruits. The same data revealed that, the highest significantly values of vitamin C fruit content were of chelated Ca source followed by that of Ca-B complex, Ca nitrate, Ca sulphate, Ca superphosphate and Ca chloride with less significant differences between them and the significantly lowest values were of control fruits (the results behave in descending trend and were the same in the two seasons). Approximately the TSS and acidity percentage of yellow pepper fruits as affected by the same treatments (Ca different sources) were behave in similar fashion as vitamin C content was affected at both seasons.

Table 6. Effect of calcium fertilization sources on yield parameters of yellow pepper plants during 2019 and 2020 seasons.

Treatments	Early yield (ten/fed)		Marketable yield (ten/fed)		Unmarketable yield (ten/fed)		Total yield (ten/fed)	
	2019	2019	2019	2020	2019	2020	2019	2020
Control	1.933 c	1.873 c	9.045 f	8.801 f	1.647 a	1.758 a	10.692 f	10.559 f
Calcium nitrate	4.226 b	4.130 b	14.541 b	14.301 b	1.332 b	1.444 b	15.873 b	15.745 b
Calcium sulphate	3.940 b	3.776 b	13.919 c	13.643 c	1.395 b	1.527 b	15.314 c	15.171 c
Calcium complex with boron	4.163 b	3.993 b	14.774 b	14.501 b	1.309 b	1.443 b	16.084 b	15.944 b
Calcium chloride	3.826 b	3.903 b	12.041 e	11.741 e	1.476 ab	1.611 ab	13.518 e	13.352 e
Calcium chelated with EDTA	4.830 a	4.770 a	17.791 a	17.844 a	0.974 c	0.918 c	18.766 a	18.763 a
Calcium superphosphate	3.996 b	3.940 b	12.526 d	12.265 d	1.371 b	1.509 b	13.898 d	13.774 d

Means followed by the same letter in the same column are significantly different at the 5% level according to Duncan's multiple range test.

Table 7. Effect of calcium fertilization sources on yield quality parameters of yellow pepper fruits during 2019 and 2020 seasons.

Treatments	BER (%)		Vitamin C (mg/100g)		Total soluble solids (%)		Acidity (%)	
	2019	2020	2019	2019	2019	2020	2019	2020
Control	31.63 a	33.16 a	48.3 d	48.3 c	3.70 d	3.56 c	0.54 c	0.54 c
Calcium nitrate	6.35 de	6.25 d	64.1 bc	64.0 ab	4.84 bc	4.36 b	0.79 a	0.78 a
Calcium sulphate	16.42 b	16.29 b	61.9 bc	61.3 b	4.80 bc	4.4 b	0.75 ab	0.64 bc
Calcium complex with boron	6.58 d	6.45 d	66.2 ab	64.9 ab	4.87 b	4.77 ab	0.80 a	0.81 a
Calcium chloride	12.83 c	13.17 c	57.7 c	58.4 b	4.63 c	4.20 b	0.66 bc	0.75 ab
Calcium chelated with EDTA	4.98 e	4.96 e	72.5 a	70.8 a	5.24 a	5.13 a	0.87 a	0.86 a
Calcium superphosphate	5.76 de	5.50 de	62.3 bc	60.8 b	4.83 bc	4.71 ab	0.76 ab	0.75 ab

Means followed by the same letter in the same column are significantly different at the 5% level according to Duncan's multiple range test.

Discussion

The superiority of Ca chelated with EDTA, Ca complex with boron and Ca nitrate sources and the considerable benefits of the other Ca sources as the mentioned order (Ca superphosphate, Ca sulphate and at least Ca chloride) were explained on their similar effect of minerals N, P, K and Ca, photosynthetic pigments and carotenoids in yellow pepper leaves as shown in Tables (3, 4 and 5), this mean that they improved the uptake and content of N, P, K and Ca, increased content of chlorophylls and carotenoids. This may be due to their stimulatory effect on photosynthesis and photo-metabolites synthesis and translocation in turn enhancement of growth parameters.

Calcium foliar feeding impacts depend on some factors i.e., rate of application, chemical form, time of application, supplementary elements with Ca and physiological form activity (Wojcik, 2004). Additionally, the positive effect of calcium source is depending on the role of Ca in plant physiology as well as the role of Ca^{++} complementary (a companion) negative ions ($EDTA^-$, BO_3^-, SO_4^{--}, PO_4^{---} and Cl^-). On the other hand, Ca complementary anions gave added positive nutritional, physiological and metabolic effects. EDTA known to protect, facilitate Ca absorption, translocation and redistribution within plants. Also, N, S, and P were of enhancable effects, while Cl gave less photosynthesis involved or no effects. Also, Dong *et al.,* 2005 and Marisa *et al.,* 2015 found that Ca^{+2} fertilization from many sources had appositive effects on root growth and development which reflected on nutrients absorption, translocation and concentration in plant tissues (leaves).

Calcium known to be involved in cell wall structure and stability, cell membrane integrity and permeability, cell division and extension, nitrogen metabolism (Assmann, 1995 and White, 2000), increases in photosynthetic pigments may be due to calcium acts as a vital role in the biosynthesis of cytokinin which part of chlorophyll biosynthesis pathway (Lechowski and Białczyk, 1993) and protecting the chloroplasts wall as well as helps the activity of photosynthesis enzymes (Yeo *et al.,* 1985), activation of transporter enzymes (ATPase), CO_2 fixation and act as secondary messenger controlled gene expiration and transcription, prevent the leakage of the solute from the cytoplasm and effectiveness of the pH in plant cell (El-Beltagi and Mohamed, 2013), mediated and mitigated stress effects and increasing shoot length (Tamura *et al.*, 2001). Calcium ion sharing in many growing processes and nearly involves in all plant development aspects (Hetherington and Brownlee, 2004 and Reddy and Reddy, 2004).

Concerning to the superior effect of Ca-sources on fruits yield and its quality attributes in the mentioned order could be expected under present work conditions, since they gave similar effect on growth (Table 3), photosynthetic pigments content (Table 4) and minerals content (Table 5) those which known to be associated with fruit yield components and quality improvements. Moreover, Ca sources via the roles and involvement of Ca in cell division, pollen grain germination, its tube elongation and penetration, gene expression and transcription process as well as know role of Ca in reduction and/or preventation of the incidence of BER in fruits. As results to calcium translocation in plants is very difficult to achieve due to Ca ions limited absorption and penetration in fruits as well as its movement in fruits tissue. On the other hand, Ca complementary anions (EDTA, BO_3, NO_3, SO_4 and PO_4) gave also beneficial effects (Marschner, 1995). The leaf fertilizers which an inorganic mineral structure hardly diffuses from the leaf surface into the plant because of high weight molecular structure. Chelating agents describe a kind of organic chemical complex that can encapsulate certain metallic salts and then release these metallic salts slowly to become available for up take by plants (Marschner, 1995 and Zocchi and Mignani, 1995). Hence synthetic portent like EDTA (ethylene diamine tetra acetic acid) and EDDHA (ethylene diamino–hydroxyphenylacetic acid) which has the ability of making strong chelate is almost used in plant growing medium. Foliar fertilizers as chelate should be easily absorbed by the plants rapidly transported and should be easily release their ions to affect the plant (Zocchi and Mignani 1995).

Our results are in harmony with El-Tohamy *et al.,* 2006; Elzbieta and Zenia, 2009; Buczkowska *et al.,* 2016 and Akladious and Mohamed, 2018 on pepper, Tuna *et al.,* 2007 and Husein *et al.,* 2015 on tomato, El-Hadidi *et al.,* 2017 on potato, Youssef *et al.,* 2017 on lettuce and recently Salim *et al.,* 2020 on eggplant and El-Hady *et al.,* 2020 on olive.

The negative response of control plants which may be suffer from Ca deficiency because plant roots absorb calcium from the soil solution in the form of Ca^{2+} ions (Clarkson, 1993 and White, 2000) Ca mineral, relatively insoluble in soil in this state and considered a leachable nutrient, which reduce the calcium uptake by plants. With regard to uptake and mobility of Ca in plants, Ca uptake is passive which means not require energy input. Ca mobility occurs fundamentally in the xylem, flow with the movement of water. Thus, uptake of Ca related directly to the rate of transpiration in plant. Deficiency of Ca will appear in younger leaves and in fruits, due to its low rate of transpiration. Thence, it is necessary to have a constant supply of calcium to continue growing. (Kadir, 2004).

REFERENCES

Akladious, S.A. and Mohamed, H.I. (2018). Ameliorative effects of calcium nitrate and humic acid on the growth, yield component and biochemical attribute of pepper (*Capsicum annuum*) plants grown under salt stress. Scientia Horticulturae. 236:244-250.

AOAC (1990). Official Methods of Analysis of the Association of the Official Analytical Chemists (A.O.A.C.). 15th Edit., Published by A.O.A.C., Washington D.C.

Assmann, S.M. (1995). Cyclic AMP as a second messenger in higher plants. Pl. Physiol. 108, 885- 889.

Bosland, P.W. and Votava, E.J. (2000). Peppers: Vegetable and Spice Capsicums eds. P.W. BOSLAND & E.J. VOTAVA, CABI Publishing, Wallingford, UK, pp 204.

Bouzo, C.A. and Cortez, S.B. (2012). Effect of calcium foliar application on the fruit quality of melon. Revista de Investigaciones Agropecuarias. 38: 1-6.

Buczkowska, H. (2007). Evaluation of yielding of Polish sweet pepper cultivars in the field cultivation in the aspect of breeding progress. In: Niemirowicz-Szczytt K, editor. Progress in Research on Capsicum & Eggplant. Proceedings of the XIIIth EUCARPIA Meeting, 5-7 September 2007; Warsaw, Poland. Warsaw, Poland: Warsaw University of Life Sciences Press, pp. 257-265.

Buczkowska, H.; Michałojć, Z., Nurzyńska-wierdak, R. (2016). Yield and fruit quality of sweet pepper depending on foliar application of calcium. Turkish Journal of Agriculture and Forestry, 40: 222-228.

Casado-Vela, J.; Sellés, S.; Díaz-Crespo, C.; Navarro-Pedreño, J.; Mataix- Benyto, J. and Gómez, I. (2007). Effect of composted sewage sludge application to soil on sweet pepper crop (*Capsicum annuum* var. annuum) grown under two exploitation regimes. Waste Manage. 27: 1509-1518.

Chapman, H.D. and Pratt, F.P. (1982). Methods of analysis for soils, plants and water, 2nd. Oakland, CA: Division of Agricultural Sciences, California University.

Del-Amor, F.M. and Rubio, J.S. (2009). Effects of anti-transpirant spray and potassium: calcium: magnesium ratio on photosynthesis, nutrient and water uptake. Growth, and yield of sweet pepper. J Plant Nutr. 32:97-111.

Dong, C.X.; Zhou, J.M.; Fan, X.H.; Wang, H.Y.; Duan, Z.Q. and Tang, C. (2005). Application methods of calcium supplements affect nutrient levels and calcium forms in mature tomato fruits. J. Plant Nutr. 27(8): 1443-1455.

El-Beltagi, H.S. and Mohamed, H.I. (2013). Alleviation of cadmium toxicity in *Pisum sativum* L. seedlings by calcium chloride. Not. Botanicae Horti. Agrobotanici. Cluj-Napoca 41 (1), 1-12.

El-Hadidi, E.M.; El-Dissoky, R.A. and AbdElhafez, A.A.H. (2017). Foliar calcium and magnesium application effect on potato crop grown in clay loam soils. J. Soil Sci. Agric. Eng. Mansoura Univ. 8(1): 1-8.

El-Hady, E.S., Merwad, M.A., Shahin, M.F.M. and Hagagg L.F. (2020). Influence of foliar spray with some calcium sources on flowering, fruit set, yield and fruit quality of olive Kalmata and Manzanillo cultivars under salt stress. *Bull Natl Res Cent* 44, 197. https://doi.org/10.1186/s42269-020-00452-3 .

El-Tohamy, W.A.; Ghoname, A.A. and Abou-Hussein, S.D. (2006). Improvement of pepper growth and productivity in sandy soil by different fertilization treatments under protected cultivation. J Appl. Sci. Res., 2: 8-12.

FAO (1980). Food and agriculture organization. Soil and plant analysis, Soil Bulletin, 38/ 2, 250 p.

Gajc-Wolska, J.; Zielony, T. and Łyszkowska, M. (2007). The effect of Goteo and BM 86 on field and fruit quality of sweet pepper (*Capsicum annuum* L.) cultivars in the field production. In: Niemirowicz-Szczytt K, editor. Progress in Research on Capsicum & Eggplant. Proceedings of the XIIIth EUCARPIA Meeting, 5-7 September 2007; Warsaw, Poland. Warsaw, Poland: Warsaw University of Life Sciences Press, pp. 267-274.

Hetherington, A.M. and Brownlee, C. (2004). The generation of Ca^{2+} signals in plants. Annu Rev Plant Biol. 55:401-427.

Husein, M.E.; Abou El Hassan, S. and Shahein, M.M. (2015). Effect of humic, fulvic acid and calcium foliar application on growth and yield of tomato plants. International Journal of Biosciences. 7(1): 132-140.

Kadir, S.A. (2004) Fruit quality at harvest of 'Jonathan' apple treated with foliar applied calcium chloride. J. Plant Nut., 27, 1991-2006.

Koller, H.R. (1972). Leaf area-leaf weight relationships in the soybean canopy. Crop Sci. 12(2): 180-183.

Kowalska, I. and Sady, W. (2012). Effect of nitrogen form, type of polyethylene film covering the tunnel and stage of fruit development on calcium content in sweet pepper fruits. Acta Sci. Pol. Hortorum Cultus. 11: 91-100.

Lechowski, Z. and Białczyk, J. (1993). Calcium mediated cytokinin action on chlorophyll synthesis in isolated embryo of Scots pine. Biol. Plant. 35 (1), 53-62.

Leung, W.T.W.; Busson, F. and Jardin, C. (1968). Food composition table for use in Africa. Food and Agriculture Organization (FAO), Rome, Italy. pp 306.

Marisa, W.; Madani, B.; Mirshekari, A.' Bah, A. and Mohamed, M.T.M. (2015). Influence of calcium foliar fertilization on plant growth, nutrient concentrations, and fruit quality of papaya. Hort. Technol. 25(4): 496-504.

Marschner, H. (1995). Mineral nutrition of higher plants. Academic Press: London.

Michałojc, Z. and Dzida, K. (2012). Yielding and biological value of sweet pepper fruits depending on foliar feeding using calcium. Acta. Sci. Pol. Hortorum. Cultus. 11: 255-264.

Namiki, M. (1990). Antioxidants/antimutagens in food. Food Science and Nutrition, 29: 273-300.

Onwubuya, E.A.; Okporie, E.O. and Nenna, M.G. (2009). Nsukka yellow pepper: Processing & preservation techniques among women farmers. J. Agric. Res.4(9): 859-863.

Palevitch, D. and Craker, L.E. (1996). Nutritional and medical importance of red pepper (*Capsicum spp*). J. Herbs, Spices & Medicinal Plants. 3(2):55-83.

Purseglove, J.W. (1991). Tropical Crops: Dicotyledons, Longman Publisher Ltd., London, pp 525-527.

Reddy, A.S.N. and Reddy, V.S. (2001). Calcium as a messenger in stress signal transduction chapter. Handbook of Plant and Crop Physiology, edited by Mohammad Pessarakli, Copyright © 2002 by Marcel Dekker, Inc. All Rights Reserved.

Reddy, V.S. and Reddy, A.S.N. (2004). Proteomics of calcium-signaling components in plants. Phytochemistry, 65, 1745-1776.

Salim, B.B.M.; Hikal, M.S.; Salama, Y.A.M.; Abou El-Yazied, A. and Abd El-Gawad, H.G. (2020). Influence of different calcium sources foliar spray on growth, yield and some biochemical changes of eggplant. Acad. J. Agric. Res. 8(4): 134-142.

Shakoor, S.A. and Bhat, M.A. (2014). Bio-mineralisation of silicon and calcium in plants and its control: an overview. Plant 2: 6-13.

Tamura, S.; Kuramochi, H. and Ishizawa, K. (2001). Involvement of calcium ion in the stimulated shoot elongation of arrowhead tubers under anaerobic conditions. J. Plant Cell Physiol. 42, 717-722.

Tuna, A.L.; Kaya, C.; Ashraf, M.; Altunlu, H.; Yokas, I. and Yagmur, B. (2007). The effects of calcium sulphate on growth, membrane stability and nutrient uptake of tomato plants grown under salt stress. Environ. Exp. Bot. 59(2): 173-178.

Tuteja, N. (2007). Review abscisic acid and abiotic stress signaling. Plant Signaling & Behavior 2(3):135-138.

Vernieri, P.; Borghesi, E.; Tognoni, F.; Ferrante, A.; Serra, G. and Piaggesi, A. (2006). Use of biostimulants for reducing nutrient solution concentration in floating system. Acta Hort. 718: 477-484.

Wellburn, A.R. (1994). The spectral determination of chlorophyll a and b, as well as total carotenoids, using various solvents with spectrophotometers of different resolution. J. Plant Physiol. 144(3): 307- 313.

Westerman, R.L. (1990). Soil testing and plant analysis, 3rd ed., SSSA Book Series Number 39 Soil Science Society of America, Madison, WI.

White, P.J. (2000). Calcium channels in higher plants. Biochem. Biophys. Acta. 1465, 171-189.

White, P.J. and Broadley, M.R. (2003). Calcium in plant. Ann. Bot. 92: 487-511.

Wojcik, P. (2004). Nutrition and calcium fertilization of apple trees. R. Dris and S. M. Jain (eds.), Production Practices and Quality Assessment of Food Crops, c 2004 Kluwer Academic Publishers. Printed in the Netherlands Vol. 2, "Plant Mineral Nutrition and Pesticide Management". pp. 111-128.

Yeo, A.R.; Caporn, S.J.M. and Flowers, T.J. (1985). The effect of salinity on photosynthesis in rice (*Oryza sativa* L.): gas exchange by individual leaves in relation to their salt content. J. Exp. Bot. 36, 1240-1248.

Yoon, J.Y.; Green, S.K.; Tshanz, A.T.; Tsou, S.C.S. and Chenge, L.C. (1989). Pepper Improvement for the tropics. Problems and Approach. In: Tomato and Pepper Production in the tropics. Asian Vegetable Research and Development Centre(AVRDC), Shantine, Taiwan pp 86-90.

Youssef, S.M.S.; Abd El-Hady, S.A.; Nashwa, A.I. and Abu El-Azm, El-Shinawy, M.Z. (2017). Foliar application of salicylic acid and calcium chloride enhances growth and productivity of lettuce (*Lactuca sativa*). Egypt. J. Hort. 44(1): 1-16.

دور أسمدة الكالسيوم على إنتاجية الفلفل الأصفر

ولاء محمد السعيد سويلم[1]* و عبد البصير السيد عبدالبصير[2]

[1] قسم الخضر والزينة ـ كلية الزراعة ـ جامعة المنصورة ـ مصر

[2] قسم بحوث محاصيل الخضر الذاتية التلقيح ـ معهد بحوث البساتين ـ مركز البحوث الزراعية ـ جيزة – مصر

تعتبر التغذية المثلى لنبات الفلفل الأصفر من أهم العوامل التى تتحكم في نمو النباتات وتطورها وإنتاجيتها وجودة ثمارها. لذلك تم استخدام التسميد الورقي بكميات كبيرة في إنتاج الحاصلات البستانية وخاصة محاصيل الخضر. الكالسيوم هو أحد المغذيات الدقيقة الحيوية في جميع مراحل دورة حياة النبات. كان الهدف من هذا البحث هو مقارنة وتقييم تأثيرات الأسمدة (المصادر) المختلفة على إنتاجية هجين الفلفل الأصفر VZ 461 المزروع في ظروف الحقول المفتوحة. تم تطبيق الكالسيوم في الأشكال التالية ، مخلّبى ، كلوريد ، نترات ، كبريتات ، سوبر فوسفات ومعقد مع البورون. أظهرت النتائج أن جميع مصادر الكالسيوم لها تأثيرات إيجابية على النمو والمحتوى البيوكيميائي والمحصول وجودة الثمار مقارنة بنباتات الكنترول. كما تسببت جميع معاملات الكالسيوم في ظهور أعداد قليلة من الثمار ذات مظهر الأصابة بعفن الطرف الزهري للثمار. وكان الكالسيوم المخلبي في معظم الحالات ، يليه نترات الكالسيوم والمركب مع البورون أفضل المعاملات التجريبية في موسمي الدراسة.