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RESPONSE OF GROWTH, YIELD, FRUIT QUALITY AND CHEMICAL COMPOSITION OF SQUASH PLANTS (*Cucurbita pepo cv.El-Askandrani*) TO FOLIAR APPLICATION OF DIFFERENT PHOSPHATIC COMPOUNDS

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ABSTRACT

This study was conducted during the two spring seasons of 2013 and 2014, to investigate the response of growth, yield, fruit quality and chemical composition of squash plants (Cucurbita pepo cv.El-Askandrani) to foliar application of different phosphatic compounds. The experiment consisted of 10 P-foliar treatments. These trials were arranged as a randomized complete block design (RCBD) with 4 replicates and giving a total of 40 plots.

Foliar spray with calcium superphosphate at 0.20% was the most effective treatment on vegetative growth and leaf chlorophyll in the two growing seasons. In this respect, the highest values of fruit length, fruit diameter and total fruit yield of squash were obtained with potassium phosphate (28.6 K) at 0.20%. Foliar application of mono-ammonium phosphate at 0.20% led to significant increase N% of dry matter in vegetative organs of squash plants. Likewise, the foliar application of calcium superphosphate at 0.20% increased P% of dry matter in vegetative organs of squash plants. In addition, the treatment of potassium phosphate at 0.20% caused a significant increased K% of dry matter in vegetative organs of squash plants. The nutritive values of squash fruits; i.e. total soluble solids and titrable acidity, as well as, dry matter % were significantly affected by calcium superphosphate at high concentration of 0.20% compared with the other treatments and control treatment.

***Conclusively,** it could be concluded that foliar application of phosphorus fertilizer can improve growth and productivity of squash plant by providing additional available dose of essential macronutrients (potassium phosphate at 0.20% and calcium superphosphate at 0.20% to growing squash plant with higher yield and good quality.*

Keyword: *Cucurbita pepo*, Cucurbitaceae, phosphatic compounds, foliar application, fruits quality.

INTRODUCTION

Squash is one of the most important vegetable crops in Egypt. Squash plants as a member of the family of Cucurbitaceae is a highly polymorphic vegetable (Kathiravan *et al.,* 2006), which grown in tropical and sub-tropical zone and harvested when the fruits are physiologically immature. Generally, tropical soils require additional fertilizer application for crops to yield optimally. The tropical soils are degraded and are of low soil fertility status due to excessive rainfall and intensive cultivation. Hence, most the tropical soils are deficient in essential nutrients particularly nitrogen and phosphorus (Obalum *et al*., 2012). Squash is very rich in nutrients and bioactive compounds such as flavonoids, antioxidants, vitamins (B complex group and A, B-carotene, amino acids, carbohydrates, and minerals (especially, K). Moreover; it contains protein 1.0gm, carbohydrates 11.69gm., total fats 0.1g calcium 48 mg, phosphorus 33mg, dietary fiber 2g, vitamin C 21mg, vitamin E 1.44 mg, vitamin A, 143 IU per pound of edible vegetable (Tamer *et. al*., 2010). It has various health and medicinal benefits to human such as comprising antidiabetic, antitumor, antimutagenic, and antinflammation (Kostalova *et al*., 2009 and Mohammad *et al*., 2011). Foliar fertilization is a convenient alternative to soil application for introducing chemicals into plants due to the fixation of phosphorus under Egyptian soil conditions, many investigators showed that the foliar application of phosphorus is more effective (Taha *et al*., 1989). For instances, phosphate ions in the form of H_2PO_4-^{1} and sometimes as HPO_4-2 (Marschner, 1995), which are available for plant absorption react readily with the soil and become in a fixed form. Phosphorus is one of the 17 elements required for plant growth and genetic material of all cells-DNA and RNA, as well as, phospholipids (Starnes *et al.,* 2008). Phosphorus is a component of many cell constituents and plays a major role in several processes, including photosynthesis, respiration, reproduction, energy storage and transfer, cell division, and cell enlargement. Adequate phosphorus is needed for the promotion of early root formation and growth; also it improves crop quality and is necessary for seed formation (Mulins, 2009). Buwalda and Freemans (1988) studied the effect of different levels of phosphorus on squash hybrids grown in the field he found that phosphorus increased the squash growth and yield. Also, Barker and Pilbeam (2000) demonstrated the importance and functions of plant macronutrients including phosphorus and potassium in different plants including vegetable crops. Tantawy *et al*., (2010) showed that applying phosphorus in different forms combined with potassium improved squash growth, productivity and fruit quality. Tartoura *et al*., (2014) found that the best results of both vegetative growth parameters and chlorophyll contents in leaves were recorded when squash plants fertilized by 80 kg P_2O_5 / feddan, compared with the control treatment. Mady (2009) showed that, different phosphorus forms and levels significantly increased all vegetative and reproductive growth traits fruit production as well as total fruit yield / plant significantly was increased of squash compared with control, also found that, chemical composition such as minerals content in leaves as well as total soluble solids and titratable acidity in fruits were increased with phosphorus treatments.

Therefore, the aim of this work is to evaluate the response of growth yield, fruit quality and chemical composition of squash plants (*Cucurbita pepo cv.El-Askandrani*) to foliar application of different phosphatic compounds.

MATERIALS AND METHODS

Field experiment was carried out at a Private Farm in Mit-Anter Village, Talkha, Dakahlia Governorate during the two spring successive seasons of 2013 and 2014. Seeds of squash variety "El-Askandrani" were sown on 10^{th} and 12^{th} March respectively in both growing seasons. A random sample from experimental soil at a depth of 30 cm was taken during the two growing seasons. Some soil properties, as an average of the two growing seasons are presented in Table 1.

Table 1: Some physical and chemical characteristics of experimental soil as an average during the two growing seasons:

Soil properties	Value
Clay %	46.5
Silt %	32.5
Sand %	23.7
Texture	Clay loam
pH	7.81
E. C. dSm^{-1} (at 25^0)	1.65
Total N %	0.14
Available P ppm	10
Available K ppm	390
Available Ca ppm	415
Available Mn ppm	9.2
Available Fe ppm	14
Available Zn ppm	3.5
$CaCO_3$ %	2.73
Organic matter (%)	1.90

The experiment consisted of 10 P-foliar treatments, as shown in Table 2.

Table 2: Phosphatic compounds and P% in different phosphatic compounds and foliar solutions:

No.	Phosphatic compounds	P %	P % in the foliar solution
1	Control (distilled water)	0	0
2	Potassium phosphate "KH_2PO_4. (28.6 K)" at 0.05 %	23	0.05
3	Potassium phosphate "KH_2PO_4. (28.6 K)" at 0.10 %	23	0.10
4	Potassium phosphate "KH_2PO_4. (28.6 K)" at 0.20 %	23	0.20
5	Con. super phosphate "$Ca(H_2PO_4)_2$" at 0.05 %	21	0.05
6	Con. super phosphate "$Ca(H_2PO_4)_2$" at 0.10 %	21	0.10
7	Con. super phosphate "$Ca(H_2PO_4)_2$" at 0.20 %	21	0.20
8	Mono-ammonium phosphate "$(NH_4)H_2PO_4$" .(N=11) at 0.05 %	26	0.05
9	Mono-ammonium phosphate "$(NH_4)H_2PO_4$" .(N=11) at 0.10 %	26	0.10
10	Mono-ammonium phosphate "$(NH_4)H_2PO_4$" .(N=11) at 0.20 %	26	0.20

Foliar application was made at 4-6 true leaf stage, using spray solution at the rate of 400 liter / feddan^{-1}. These trials were arranged as a randomized complete block design (RCBD) with 4 replicates and giving a total of 40 plots. The plot area was 2.8 x 5 m =14 m^2, consisted of 4 ridges, 0.7 m apart and 0.5 m long. The distance between plants was 30 cm. Nitrogen fertilizer was added as urea (46% N) at the rate of 60 Kg / fedddan in two equal doses before the first and second irrigation. Meanwhile all plots were fertilized with 100 Kg ordinary super-phosphate (15.5% P_2O_5), before the first irrigation. In both seasons, plants were sampled 45 days from sowing to represent the vegetative stage. Five plants were collected from each plot to determine the number of leaves / plant, chlorophyll content in leaves and dry weight / plant. At the same time, the dry matter of plants at vegetative growth stage were ground and wet digested as described by Black (1983) to determine N, P and K. contents. Nitrogen was determined by the micro-kjeldahl method according to A.O.A.C. (2007), phosphorus was estimated colorimeterically using the method as described by Jackson (1967) and potassium was determined using flame photometer according to Jackson (1967). Chlorophyll reading in leaf samples was assessed by SPAD-502 (Minolta, 1990 Co Ltd., Osaka, Japan). Total fruits were harvest at 3-4 days intervals – upon reaching 12-15(cm) length, the fruits were picked from each plot was weighted and expressed as ton per feddan. Some physical characters of squash fruits were measured in five samples of fruits from each plot, length and diameter (cm) of fruits were recorded. In addition, in fresh fruits a hand refractometer and the method of A.O.A.C. (1990) were used for the total soluble solids and titeratable acidity determination, respectively, as well as, dry matter % was recorded in fresh fruits of squash. All recorded data were statistical analysis of variance and least significance differences L.S.D (0.05) was used to separate the means according to Gomez and Gomez (1991).

RESULTS AND DISCUSSION

Vegetative growth and total chlorophyll contents:

Data in Table 3 indicate that all the studied treatments had different significant effects on most studied of vegetative growth parameters of squash plant; i.e. number of leaves / plant and plant dry weight, as well as total chlorophyll contents compared to the control treatment. Foliar spray with calcium superphosphate at 0.20% was the most effective treatment on vegetative growth and total chlorophyll contents in the two growing seasons. As the role of phosphorus at the rate of 0.20% as foliar application, Bidwell (1979) illustrated that phosphorus plays a vital role in the enzyme system for the energy transform in photosynthesis and respiration. It is also a constituent of cell nucleus and essential for cell division and for the development of meristem tissues.

These results are in agreement with the results obtained by Mady (2009) who clear that phosphorus compound increased plant dry weight of winter squash. Moreover chlorophyll a and b content was significantly increased with application of phosphorus treatment compared with control, (Mulins, 2009 and Starnes *et al.*, 2008).

Total yield (ton/fed.$^{-1}$) and some characters of fruits (cm):

All tested treatments had an effect on total fruit yield, fruit length and fruit diameter of squash as shown in Table, 4 and Figures (1, 2 and 3). In this respect, the highest values of fruit length, fruit diameter and total fruit yield of squash were obtained with potassium phosphate (28.6 K) at 0.20%. Regarding the effect of phosphorus on fruit yield and its components, Bidwell (1979) demonstrated that phosphorus may increase the efficiency of photosynthetic capacity and this in turn resulted in more accumulation of stored food in fruit squash. As well as, potassium which consists from the compound of potassium phosphate, Edmond *et. al.,* (1981) stated that potassium is the prevalent cation, in plant and may be involved in maintenance of ionic balance in cells and it bounds

Table 3: Number of leaves / plant, total chlorophyll contents and plant dry weight at 45 days from sowing as affected by phosphatic compounds and its concentrations during the two spring successive seasons of 2013 and 2014.

Characters \ Treatments	Number of leaves /plant		Total chlorophyll content (SPAD)		Plant Dry Weight (g)	
	2013	**2014**	**2013**	**2014**	**2013**	**2014**
Control (distilled water)	12.41	14.00	27.11	26.43	27.90	28.72
Potassium phosphate "KH_2PO_4. (28.6 K)" at 0.05 %	14.25	16.33	29.39	27.38	28.24	29.23
Potassium phosphate "KH_2PO_4. (28.6 K)" at 0.10 %	11.66	13.66	29.66	28.60	28.91	29.57
Potassium phosphate "KH_2PO_4. (28.6 K)" at 0.20 %	12.08	14.41	30.00	29.84	29.01	29.85
Con. Super phosphate "$Ca(H_2PO_4)_2$" at 0.05 %	11.75	13.66	29.54	29.44	27.58	29.50
Con. super phosphate "$Ca(H_2PO_4)_2$" at 0.10 %	12.33	14.66	29.73	29.70	29.72	31.91
Con. super phosphate "$Ca(H_2PO_4)_2$" at 0.20 %	14.50	16.58	30.76	29.95	31.87	33.93
Mono-ammonium phosphate "$(NH_4)H_2PO_4$" .(N=11) at 0.05 %	12.58	14.66	28.72	28.60	25.89	27.80
Mono-ammonium phosphate "$(NH_4)H_2PO_4$" .(N=11) at 0.10 %	11.66	13.41	29.43	29.40	24.97	26.80
Mono-ammonium phosphate "$(NH_4)H_2PO_4$" .(N=11) at 0.20 %	12.91	14.58	29.72	29.74	24.25	23.45
F. test	*	*	*	*	*	*
L.S.D (0.05)	**0.44**	**0.43**	**0.14**	**0.13**	**0.29**	**0.25**

ionically to the enzyme pyruvate kinase, which is essential in respiration and carbohydrates metabolism and in turn on fruit yield. Obtained results are in harmony with those reported by Mulins (2009), Mady (2009).

Chemical composition in dry matter of vegetative organs at vegetative growth (45 days from sowing) of squash plants (N, P and K %):

Data given in Table 5 reveal that, N, P and K elements in dry matter of squash plants responded significantly to all the tested treatments of phosphatic compounds.

Foliar application of mono-ammonium phosphate at 0.20% was significantly increased N% in dry matter in vegetative organs of squash

Table 4: Total yield (ton/fed^{-1}) and some characters of fruits (cm) as affected by phosphatic compounds and its concentrations during the two spring successive seasons of 2013 and 2014.

Characters / Treatments	Fruit length (cm.)		Fruit diameter (cm.)		Total fruit yield (ton/fed.$^{-1}$)	
	2013	**2014**	**2013**	**2014**	**2013**	**2014**
Control (distilled water)	11.62	11.99	3.30	3.27	3.726	3.812
Potassium phosphate "KH_2PO_4. (28.6 K)" at 0.05 %	11.77	11.91	3.40	3.38	5.036	5.087
Potassium phosphate "KH_2PO_4. (28.6 K)" at 0.10 %	11.26	11.64	3.68	3.36	6.984	7.021
Potassium phosphate "KH_2PO_4. (28.6 K)" at 0.20 %	12.85	12.66	3.79	3.94	7.444	8.059
Con. super phosphate "$Ca(H_2PO_4)_2$" at 0.05 %	11.98	12.01	3.36	3.36	4.148	4.261
Con. super phosphate "$Ca(H_2PO_4)_2$" at 0.10 %	12.09	12.24	3.38	3.41	4.601	4.673
Con. super phosphate "$Ca(H_2PO_4)_2$" at 0.20 %	12.34	12.40	3.58	3.62	5.184	5.215
Mono-ammonium phosphate "$(NH_4)H_2PO_4$" .(N=11) at 0.05 %	12.21	11.97	3.09	3.14	4.822	4.702
Mono-ammonium phosphate "$(NH_4)H_2PO_4$" .(N=11) at 0.10 %	12.43	11.84	3.22	3.18	5.509	5.600
Mono-ammonium phosphate "$(NH_4)H_2PO_4$" .(N=11) at 0.20 %	12.64	12.22	3.47	3.68	7.276	7.159
F. test	*	*	*	*	*	*
L.S.D (0.05)	**0.12**	**0.06**	**0.05**	**0.04**	**0.191**	**0.214**

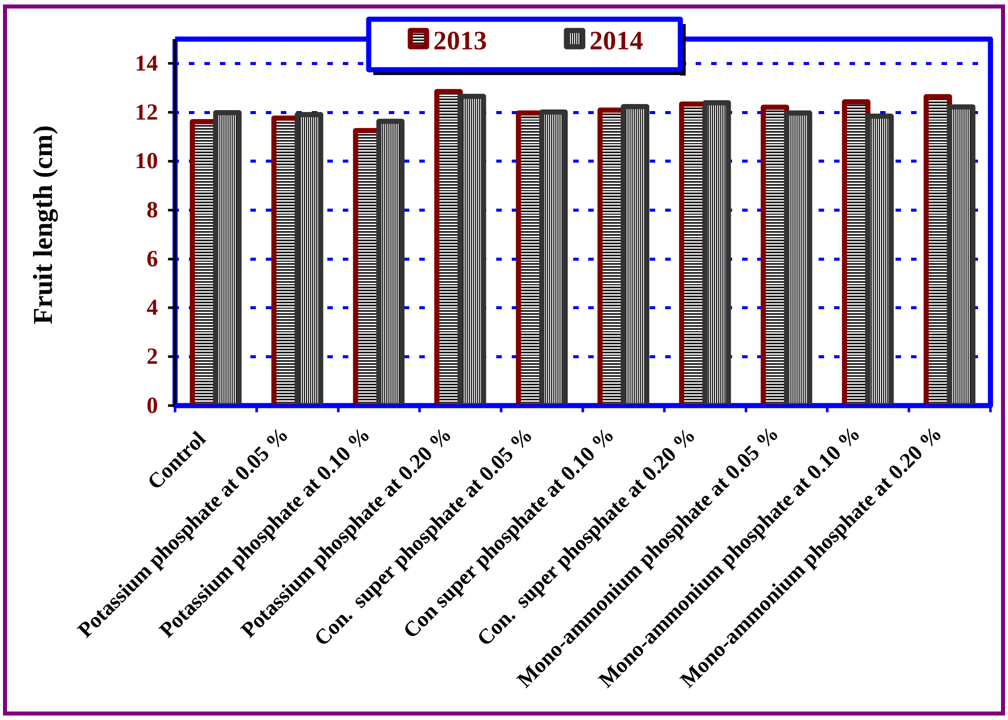

Figure 1: Fruit length (cm) as affected by phosphatic compounds and its concentrations during the two spring successive seasons of 2013 and 2014.

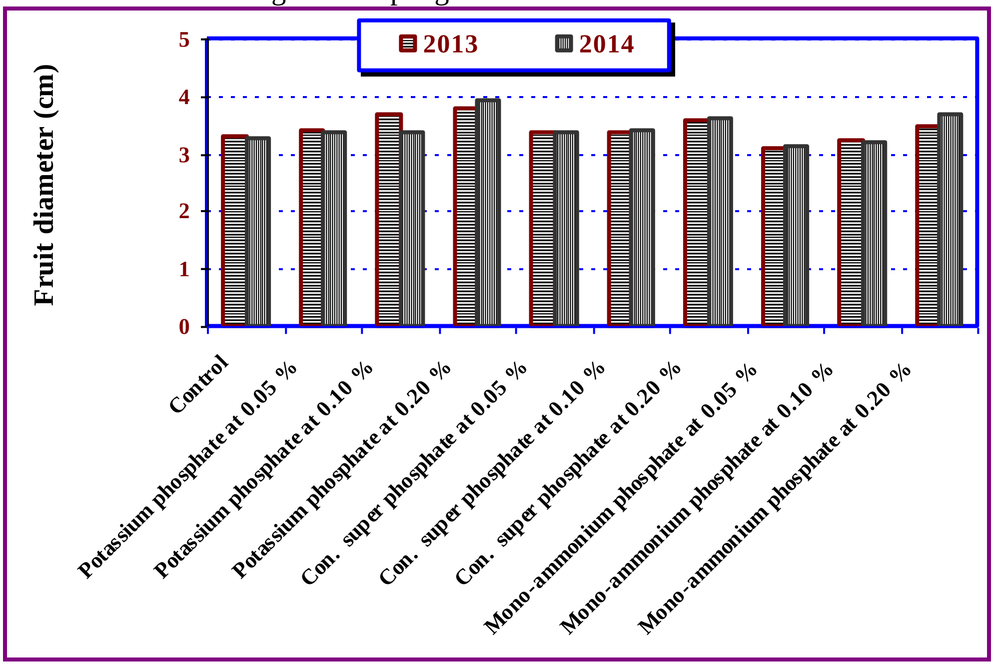

Figure 2: Fruit diameter (cm) as affected by phosphatic compounds and its concentrations during the two spring successive seasons of 2013 and 2014.

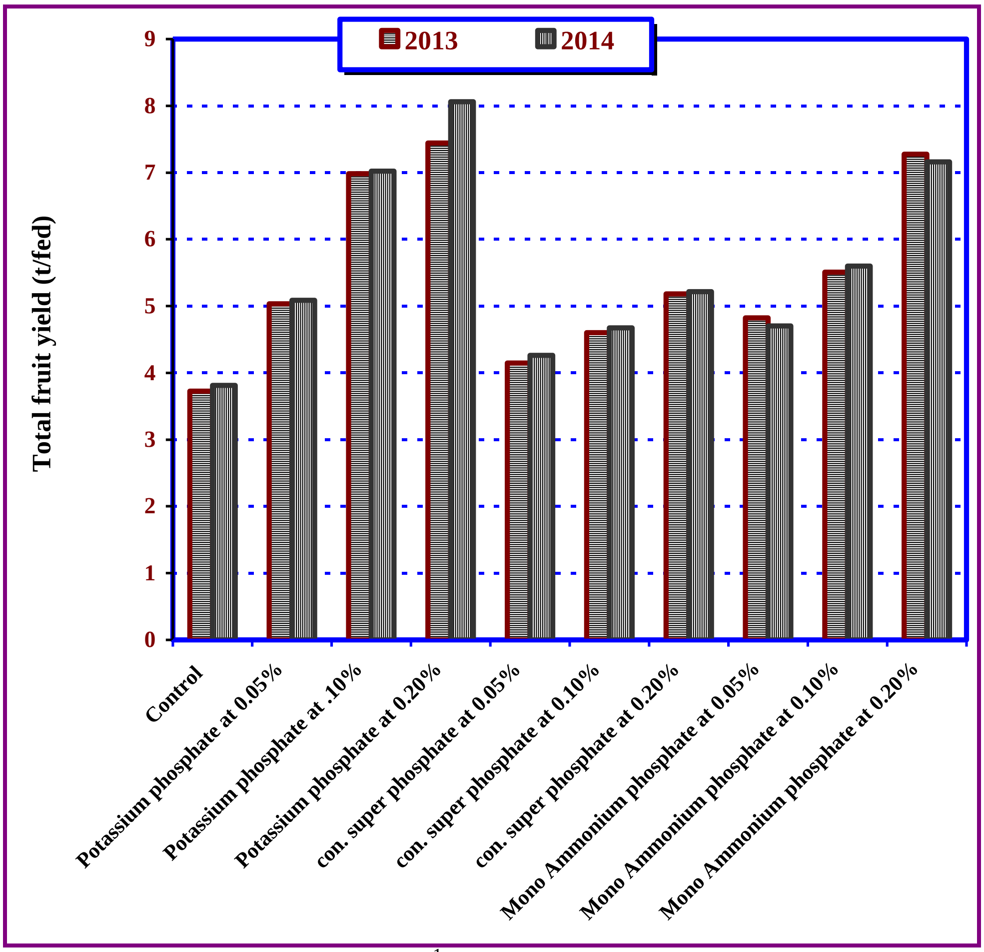

Figure 3: Total fruit yield (ton/fed^{-1}) as affected by phosphatic compounds and its concentrations during the two spring successive seasons of 2013 and 2014.

plants. As well as, the foliar application of calcium super phosphate at 0.20% led to increase P% in dry matter in vegetative organs of squash plants. In addition, the treatment of potassium phosphate at 0.20% caused a significant increase K% in dry matter in vegetative organs of squash plants. Regarding the effect of N, P and K, which consist of the phosphorus compounds, may increase the accumulation of these elements in the cells of plant, and consequently, the bioactive of nutrients increases (Mengel and Kirkby, 2001). In this direction similar conclusion were obtained by Starnes *et al.*, (2008); Tartoura *et. al.*, (2014) and Mady (2009).

Table 5: Nitrogen phosphorus and potassium percentages in dry matter of vegetative organs at 45 days from sowing of squash plant as affected by phosphatic compounds and its concentrations during the two spring successive seasons of 2013 and 2014.

Characters / Treatments	N %		P %		K %	
	2013	2014	2013	2014	2013	2014
Control (distilled water)	2.41	2.40	0.178	0.178	3.72	3.94
Potassium phosphate "KH_2PO_4. (28.6 K)" at 0.05 %	2.91	2.83	0.235	0.233	4.12	3.78
Potassium phosphate "KH_2PO_4. (28.6 K)" at 0.10 %	3.07	3.02	0.235	0.267	4.10	4.17
Potassium phosphate "KH_2PO_4. (28.6 K)" at 0.20 %	3.07	3.14	0.315	0.318	4.91	4.94
Con. super phosphate "$Ca(H_2PO_4)_2$" at 0.05 %	2.42	2.46	0.228	0.247	4.22	4.32
Con. super phosphate "$Ca(H_2PO_4)_2$" at 0.10 %	2.56	2.56	0.333	0.300	4.28	4.54
Con. super phosphate "$Ca(H_2PO_4)_2$" at 0.20 %	2.56	2.61	0.345	0.375	4.48	4.79
Mono-ammonium phosphate "$(NH_4)H_2PO_4$" .(N=11) at 0.05 %	3.01	3.04	0.233	0.235	4.18	4.20
Mono-ammonium phosphate "$(NH_4)H_2PO_4$" .(N=11) at 0.10 %	3.01	3.09	0.233	0.290	4.34	4.85
Mono-ammonium phosphate "$(NH_4)H_2PO_4$" .(N=11) at 0.20 %	3.36	3.26	0.285	0.333	4.79	4.88
F. test	*	*	*	*	*	*
L.S.D (0.05)	**0.04**	**0.07**	**0.010**	**0.012**	**0.16**	**0.25**

Dry matter %, total soluble solids and titrable acidity in fresh fruits of squash plant:

Data presented in Table 6 and Figures (4, 5 and 6) reveal that the nutritive values of squash fruits, i.e. total soluble solids and titrable acidity, as well as, dry matter percentage were significantly affected by calcium superphosphate at high concentration of 0.20% compared with other treatments and control. Such as results may be due to the favourable effect of these treatments on vegetative growth (Table 2). However P content in dry matter of vegetative organs (Table 4), could lead to the highest values of total soluble solids and titrable acidity, as well as, dry matter accumulation of fruits. These results are coincided with those of Mulins (2009) and Tarttoura *et al.,* (2014), Mady (2009).

Table 6: Dry matter, total soluble solids percentages and titrable acidity of squash fruits as affected by phosphatic compounds and its concentrations during the two spring successive seasons of 2013 and 2014.

Treatments \ Characters	Dry matter %		TSS %		Titrable acidity	
	2013	**2014**	**2013**	**2014**	**2013**	**2014**
Control (distilled water)	7.88	7.82	4.35	4.50	0.483	0.479
Potassium phosphate "KH_2PO_4. (28.6 K)" at 0.05 %	7.84	7.91	4.44	4.61	0.495	0.493
Potassium phosphate "KH_2PO_4. (28.6 K)" at 0.10 %	8.77	8.86	4.12	4.27	0.502	0.499
Potassium phosphate "KH_2PO_4. (28.6 K)" at 0.20 %	8.41	8.66	4.07	4.22	0.517	0.515
Con. super phosphate "$Ca(H_2PO_4)_2$" at 0.05 %	7.77	7.78	4.17	4.32	0.506	0.502
Con. super phosphate "$Ca(H_2PO_4)_2$" at 0.10 %	8.29	8.31	4.04	4.20	0.537	0.532
Con. super phosphate "$Ca(H_2PO_4)_2$" at 0.20 %	8.89	8.91	4.51	4.65	0.555	0.550
Mono-ammonium phosphate "$(NH_4)H_2PO_4$" .(N=11) at 0.05 %	8.62	8.93	4.31	4.46	0.521	0.516
Mono-ammonium phosphate "$(NH_4)H_2PO_4$" .(N=11) at 0.10 %	8.70	8.90	4.36	4.51	0.537	0.533
Mono-ammonium phosphate "$(NH_4)H_2PO_4$" .(N=11) at 0.20 %	8.81	8.76	4.39	4.56	0.537	0.533
F. test	*	*	*	*	*	*
L.S.D (0.05)	**0.16**	**0.12**	**0.11**	**0.08**	**0.006**	**0.006**

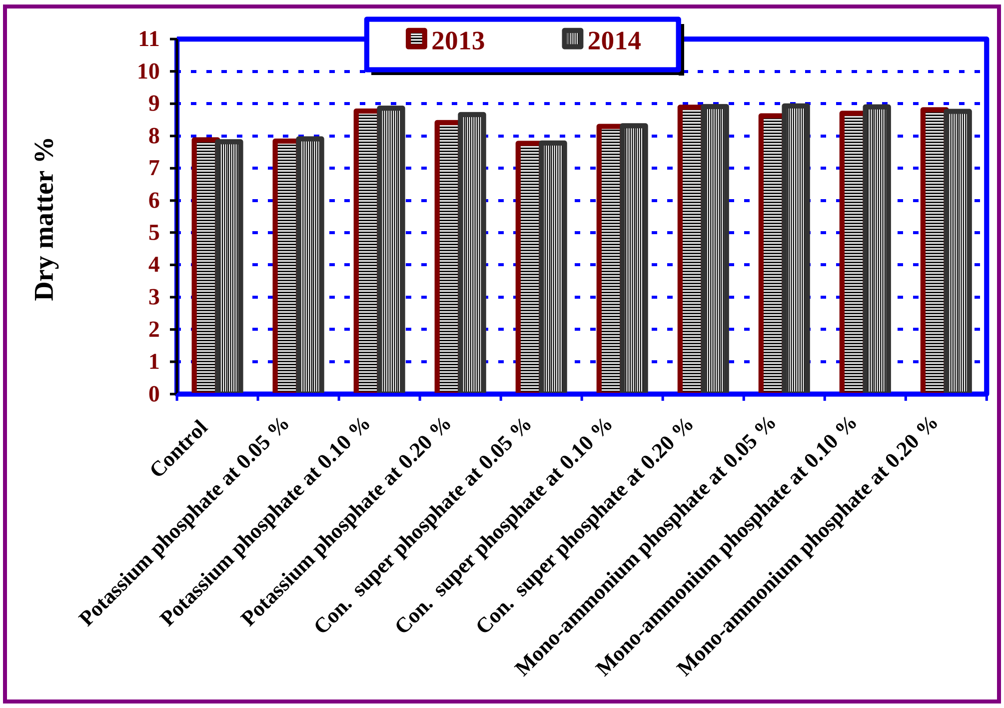

Figure 4: Dry matter % of squash fruits as affected by phosphatic compounds and its concentrations during the two spring successive seasons of 2013 and 2014.

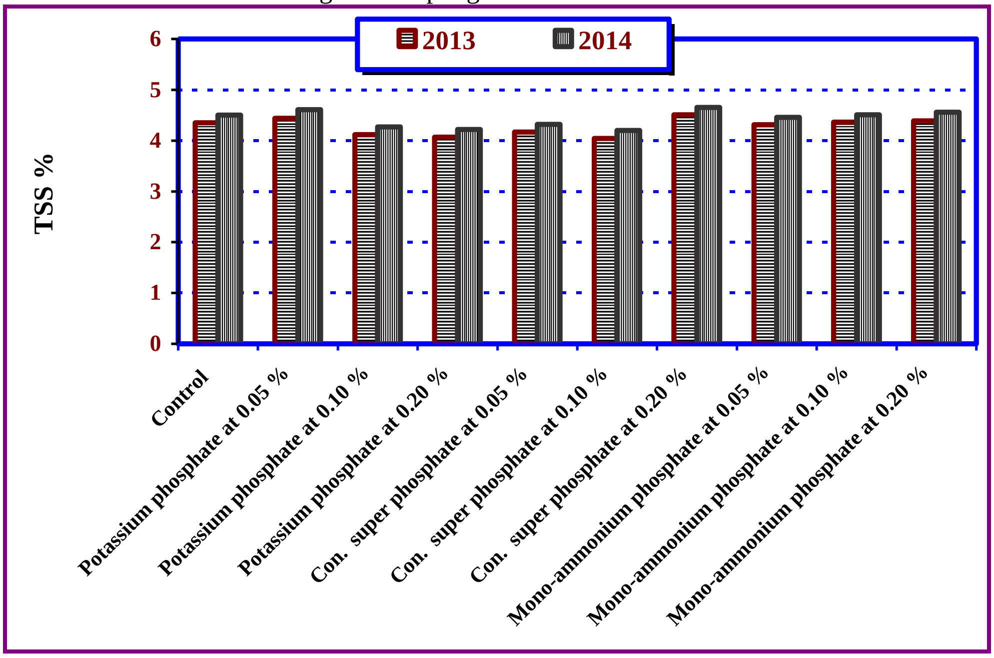

Figure 5: TSS % of squash fruits as affected by phosphatic compounds and its concentrations during the two spring successive seasons of 2013 and 2014.

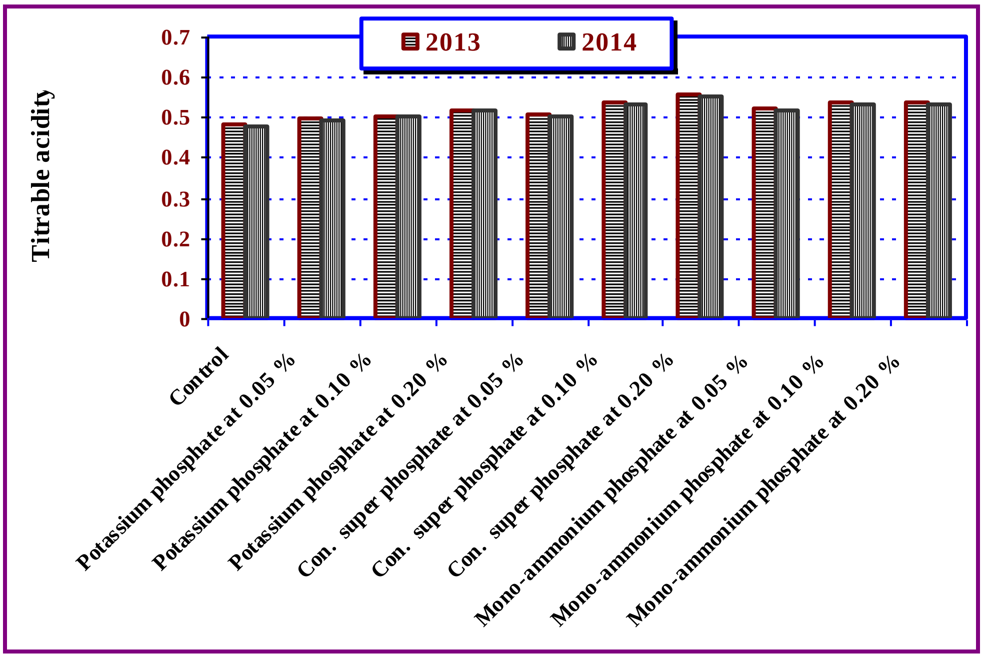

Figure 6: Titrable acidity of squash fruits as affected by phosphatic compounds and its concentrations during the two spring successive seasons of 2013 and 2014.

Conclusively, it could be concluded that foliar application of phosphorus fertilizer can improve growth and productivity of squash plant by providing additional available dose of essential macronutrients (potassium phosphate at 0.20% and calcium superphosphate at 0.20% to growing squash plant with higher yield and good quality.

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إستجابة النمو الخضري والمحصول وجودة الثمار والتركيب الكيماوي لنباتات الكوسة صنف الإسكندراني للرش بمركبات فوسفاتية مختلفة

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أجريت تجربة حقلية في ربيع موسمي ٢٠١٣ و٢٠١٤ على نباتات قرع الكوسة صنف الإسكندراني وتكونت التجربة من عشر معاملات تسعة منهم رش بمحاليل لمركبات فوسفاتية مختلفة وبتركيزات مختلفة بالإضافة لمعاملة الكنترول الرش فيها بالماء المقطر ولقد تم تصميم التجربة بطريقة القطاعات الكاملة العشوائية في أربع مكررات.

وكانت النتائج المتحصل عليها كما يلي :

- الرش بمعاملة سوبر فوسفات الكالسيوم بتركيز ٢٠ % كان أكثر فاعلية على صفات النمو الخضري ومحتوى الأوراق من الكلوروفيل خلال موسمي التجربة عند المقارنة بالمعاملات الأخرى.

- تم الحصول على أعلى محصول من ثمار قرع الكوسة وصفتي طول وقطر الثمرة عند الرش بمعاملة فوسفات البوتاسيوم بتركيز ٢٠% بالمقارنة بالمعاملات الأخرى.

- أمكن الحصول على أعلى تركيز من عنصر النتروجين بالأعضاء الخضرية لنبات قرع الكوسة من خلال الرش بمعاملة فوسفات الأمونيوم الأحادي بتركيز ٢٠ % ، وعلى أعلى تركيزمن عنصر الفوسفور بالأعضاء الخضرية عند الرش بمعاملة سوبر فوسفات الكالسيوم بتركيز ٢٠%، بينما تم الحصول على أعلى تركيز من عنصرالبوتاسيوم عند الرش بمعاملة فوسفات البوتاسيوم بالمقارنة بالمعاملات الأخرى.

- تسبب رش نباتات قرع الكوسة بمعاملة سوبرفوسفات الكالسيوم بتركيز ٢٠ % الحصول على أعلى القيم من المادة الجافة وصفات الجودة في ثمارالكوسة صنف الإسكندراني.

التوصية:

للحصول على أعلى محصول من ثمار قرع الكوسة ينصح الرش بإستخدام فوسفات البوتاسيوم بتركيز ٢٠% وكذلك للحصول على جودة عالية لثمار قرع الكوسة صنف الإسكندراني نوصي بالرش بإستخدام سوبر فوسفات الكالسيوم بتركيز ٢٠% تحت ظروف هذه التجربة.