

EFFECT OF FOLIAR APPLICATION WITH ORGANIC COMPOUNDS ON GROWTH, YIELD AND TUBERS QUALITY OF POTATO (*Solanum tuberosum* L.)

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ABSTARCT

Two field experiments were carried out during the summer seasons of 2002 and 2003 on potato cv. (Spunta) in clayey loamy soil at El-Baramoon Res .Station, Mansoura, Dakahlia Governorate, to study the effect of foliar application with organic compounds i.e. ascorbic acid ,citric acid and oxalic acid and their combinations with the nitrogenous fertilization at rate of (150 kg/fed) compared with similar rate of nitrogen fertilization alone without foliar application on vegetative growth, yield, tubers quality and some chemical contents of foliage and tubers.

Results showed that the foliar application with mixture of (ascorbic acid + citric acid) at rate of (750+750 ppm)⁻¹ twice at 7 and 9 weeks after planting was very effective on vegetative growth parameters i.e, plant height (cm) ,fresh weight of foliage/plant (g) and dry weight of foliage (%) ; as well as , average of the tuber weight (g) ,total tubers yield (ton/ feddan) , dry matter of tuber (%) and starch content of tubers (%)compared with the other treatments . On the other hand , the main stems number / plant , number of tubers/plant and tuber content of protein (%) were not affected significantly by the different treatments during the two seasons . N, P and K contents in both leaves at 90 DAP and tubers at harvest were significantly increased by applying the foliar spraying with mixture of (ascorbic acid + citric acid) at rate of (750+750 ppm)⁻¹ in the two summer seasons of 2002 and 2003 .

The results revealed that applying the foliar spraying with mixture of (ascorbic acid + citric acid at rate of 750 + 750 ppm)⁻¹ on potato plants twice at 7 and 9 weeks after planting under conditions of nitrogen fertilization at rate of 150 kg/fed. led to increase of vegetative growth parameters and increment of total tubers yield/fed by 12.88% (average of two study seasons), as well as tubers quality improvement compared with the same rate of nitrogen fertilization alone without foliar application by organic compounds (control).

INTRODUCTION

Potato (*Solanum tuberosum* L.) is the 4th most important food crop in the world, the world potato production in year of 2004 approached 327. 624. 417 metric tons, whereas potato production in Egypt was 1.950.000 metric tons (FAO, 2005).

An effecient application of nitrogen fertilization during the early stage of plant growth increased plant growth parameters i.e, plant height, number of branches/plant and fresh weight of haulm/plant (Carlos, 2000 , Juarez et al 2000 and Phillips et al, 2004).

Some investigators used the organic compounds such as ascorbic acid and citric acid to improve productivity of some vegetables. For instance Raskin (1992) indicated that citric acid and ascorbic acid as natural

components have auxinic action, antioxidant effect and as an enzyme factor. In this respect, Hemila et al (1985) and Farag (1996) reported that these compounds have synergistic effect on improving growth, flowering and productivity of fruits. Smirnoff (2000) found that convincing evidence of the involvement of ascorbate in cell division and the rapid growth. BSc and Savage (1999) and Smirnoff and Wheeler (2000) indicated that oxalic acid and its salts occur as end products of metabolism in a number of plant tissues. On the other hand, Todd and Joshua (2003) revealed that ascorbic acid is likely the primary precursor of oxalic acid in plant.

Some organic compounds were used as a foliar spraying solution or for seeds soaking before planting to improve the crops production and its quality. EL-Gamal (1985) illustrated that soaking potato seed pieces in vitamin (C) caused significant increases in both of tuber weight and total tuber yield. El-Zawahry and Hamada (1994) found that soaking seeds in ascorbic acid increased the fresh and dry weight of shoots and roots than the untreated eggplants.

Ahmed et al (1998) observed that applying two foliar sprays at growth start and at 30 days later of ascorbic acid (ascobine) or citric acid (citric) were very effective on improving yield, fruit weight and total sugar of apple. Vaser (2003) indicated that spraying of sweet cherry plants with ascorbic acid solution gave the highest dry weight of plant shoots comparing with spraying by citric acid.

Fathey et al, (2003) reported that using (ascorbic acid + citric acid) as foliar spraying was more effective than using every compound alone on plant height, number of branches/plant, dry matter of fruit, total carbohydrate, average of fruit weight and total yield, as well as N, P and K contents of eggplant.

MATERIALS AND METHODS

This investigation was carried out during two summer seasons of 2002 and 2003 at El-Baramoon Res. Station, Mansoura, Dakahlia Governorate to study the effect of foliar application with some organic compounds i.e ascorbic, citric acid and oxalic acid, as well as their combination on vegetative growth, yield, tuber quality and some chemical analysis of potato cv. Spunta. Physical and chemical analysis of the experiment soil are shown in table (1).

Experimental design and treatments :

Experimental design was a randomized complete blocks with three replications. Each plot consisted of 3 ridges; 5 m long; 75 cm wide and seed pieces were planted apart 25 cm. The experimental plot area was 11.25 m². Seed tubers were planted on 20th and 25th of January; 2002 and 2003, respectively.

Table (1): Physical and chemical properties of the experiment soil at El-Baramoon Res. Station .*

Physical properties			Chemical Properties		
Character	Depth		Character	Depth	
	0-20cm	20-40cm		0-20cm	20-40cm
Sand%	33.8	34.0	Ec dsl/m (1:5)	0.63	0.65
Silt%	23.4	23.1	Soluble anions	Meg/100 g soil	
Clay %	38.2	38.0	Co ₃ ⁻	0.0	0.0
Soil texture	Clayey	loamy	Hco ₃ ⁻	2.05	2.0
O.M%	1.8	1.8	CL ⁻	0.3	0.32
Ca Co ₃ %	2.1	2.5	So ₄ ⁻	0.8	0.93
T.S.S	0.2	0.21	Soluble cations	Meg/100 g soil	
PH	7.8	7.9	Ca ⁺⁺	2.15	2.18
Bulk density	1.18	1.15	Mg ⁺⁺	0.35	0.37
Field capacity%	43.8	42.9	Na ⁺	0.35	0.38
Available water%	23.15	22.54	K ⁺	0.30	0.32
Wilting point%	20.55	20.22	Available N ppm	29	25
			Available P ppm	16	14
			Available K ppm	384	322

*according to methods of Jackson (1973).

The experiment treatments (1 to 7) were fertilized at rate of 150 kg N/fed and sprayed twice at 7 and 9 weeks after planting with organic compounds as follows:

- 1- Ascorbic acid (1500 ppm)^{-L}
- 2- Citric acid (1500 ppm)^{-L}
- 3- Oxalic acid (1500 ppm)^{-L}
- 4- Ascorbic acid + Citric acid (750+750 ppm)^{-L}
- 5- Citric acid + Oxalic acid (750+750 ppm)^{-L}
- 6- Ascorbic acid + Oxalic acid (750+750ppm)^{-L}
- 7- Ascorbic acid + Citric acid + Oxalic acid (500 + 500 + 500 ppm)^{-L}
- 8- Ammonium nitrate at rate of 150 Kg N/fed. (without organic compounds spraying as control).

The mineral fertilizers were added as follows:

- 1- Single superphosphate (15.5% P₂O₅) was added once during the soil preparation at rate of 75 kg P₂O₅/fed.
- 2- Ammonium nitrate (33.5% N) was added on three equal portions after 4, 3 and 8 weeks from planting date at rate of 150 kg N/fed. for all treatments.
- 3- Potassium sulphate (48% K₂O) was added on twice equal portion after 4 and 6 weeks from planting date at rate of 96 kg K₂O/fed .

Other agricultural practices were carried out according to the recommendations of the Ministry of Agriculture .

Data studied:

- 1- At 90 DAP, six plants were taken randomly from each plot to determine, plant height (cm); number of main stems/plant; foliage fresh weight/plant (g) and dry weight of foliage (%) .
- 2- At harvest, number of tubers/plant; average of tuber weight (g) and total tuber yield (ton/fed) were recorded. Dry matter , starch and protein

content of tuber were determined according to the methods described by (AOAC , 1990) .

3- At harvest, total nitrogen, phosphour and potassium in the digested dry weight of both foliage at 90 DAP and tuber were determined according to Jackson methods (1973).

Data were subjected to the statistical analysis and means were compared using new L.S.D method described by Gomez and Gomez (1984).

RESULTS AND DISCUSSIONS

1- Vegetative growth parameters:

Data presented in table (2) show that the plant height (cm); foliage fresh weight/plant (g) and dry weight of foliage (%) at 90 DAP were significantly affected by different treatments, while the main stems number was not significantly affected during both seasons.

Table (2): Vegetative growth at 90 DAP as affected by foliar application with organic compounds during the summer seasons of 2002 and 2003 .

Characters	Plant height (cm)		Main stems No/ plant		Fresh weight of foliage/plant (g)		Dry weight of foliage (%)	
	1 st season	2 nd season	1 st season	2 nd season	1 st season	2 nd season	1 st season	2 nd season
1)Ascorbic acid	34.33	39.00	1.67	2.00	224.67	367.33	17.06	16.95
2) Citric acid	36.33	41.33	2.00	2.33	231.00	343.33	17.18	16.85
3) Oxalic acid	34.00	38.67	1.67	1.67	206.67	329.67	17.37	17.86
4) 1 + 2	37.00	43.00	2.00	2.33	238.33	399.67	18.02	17.90
5) 1 + 3	31.67	37.67	1.67	2.00	202.00	321.00	17.97	17.82
6) 2 + 3	31.67	37.67	1.67	1.67	202.00	317.33	16.94	17.85
7) 1 + 2 + 3	31.67	37.33	1.67	1.67	206.33	331.00	17.50	17.83
8)Control 150 kgN fed ⁻¹	30.00	36.67	1.33	1.67	201.33	314.33	17.33	17.77
F. Test	**	**	NS	NS	**	**	**	**
LSD at 0.05	1.39	2.45	--	--	12.26	5.79	0.24	0.06

The results in table (2) show that the foliar application with mixture of (ascorbic acid +citric acid) at rate of (750 + 750 ppm)⁻¹ twice at 7 and 9 weeks after planting gave highest values of plant height (cm) , fresh weight of foliage/plant (g) and dry weight of foliage (%), this effect may be due to an auxinic action of these organic compounds on potato plants (Raskin 1992). Similar conclusions were obtained by Hemila et al (1985); EL-Zawahry and Hamada (1994); Farag (1996); Smirnoff (2000); Fathey et al (2003) and Vaser (2003) who reported that using (ascorbic acid + citric acid) as foliar spraying was more effective on plant height, number of branches /plant, dry weight of plant shoots than using every compound alone .

2-Yield and its components:

Regarding the effect of foliar application with organic compounds on yield and its components; data in table (3) indicate that average of the tuber weight (g) and the total tubers yield (ton/fed) were significantly increased by

the foliar spraying with mixture of (ascorbic acid + citric acid) at rate of (750 + 750 ppm)^{-L} twice at 7 and 9 weeks after planting ,while the number of tubers/plant was not significantly affected by different treatments during the two study seasons of 2002 and 2003 .

In the same table (3), the data reported clearly increment in the yield and its components as a result of foliar spraying by organic compounds, the highest increment of tubers yield was obtained by foliar spraying with mixture of (ascorbic acid + citric acid at rate of 750 + 750 ppm)^{-L} , this increment was (12.39–13.36%) in both seasons, respectively under conditions of N fertilization (150 kg/fed) compared with same N rate alone (control).

Table (3): yield and its components at harvest as affected by foliar application with organic compounds during the summer seasons of 2002 and 2003.

Characters	Number of tubers / plant		Average of tuber weight (g)		Total yield ton/fed	
	1 st	2 nd	1 st	2 nd	1 st	2 nd
	season	season	season	season	season	season
1) Ascorbic acid	4.00	4.33	109.67	114.33	11.87	12.72
2) Citric acid	4.33	4.67	107.67	110.33	12.07	12.80
3) Oxalic acid	4.00	4.00	98.67	101.33	11.03	11.32
4) 1 + 2	4.33	4.67	116.33	119.00	12.25	12.90
5) 1 + 3	3.67	3.67	102.33	107.00	10.83	11.71
6) 2 + 3	3.33	3.67	100.33	102.00	10.93	11.45
7) 1 + 2 + 3	3.33	3.67	98.67	102.67	10.88	11.40
8) Control 150 kgN fed ⁻¹	3.00	3.33	97.33	100.33	10.90	11.38
F. Test	N.S	N.S	**	**	**	**
LSD at 0.05	--	--	5.08	4.98	0.35	0.25

Such increase in the yield might be attributed to the action of these compounds on stimulating both cell division and enlargement which caused an obvious increase in the average of tuber weight and consequently the total tubers yield / feddan. These results are in agreement with those reported by EL-Gamal (1985); Ahmed *et al* (1998); Fathey *et al* (2003) and Vaser (2003).

3- Quality parameters of tubers :

Data in table (4) illustrate that there were significant differences in tuber contents of dry matter (%) and starch (%) as affected by the different treatments in both seasons. The results show that applying the foliar spraying by mixture of (ascorbic acid + citric acid) at rate of (750 + 750 ppm)^{-L} twice at 7 and 9 weeks after planting increased the tuber dry matter (%) and starch content in tuber (%) as compared with the other treatments in the summer seasons of 2002 and 2003. A similar trend was noted by Fathey *et al* (2003) who reported that using (ascorbic acid + citric acid) as foliar spraying was more effective than using either compound alone on the total carbohydrate and dry matter of eggplant fruits.

Table (4): Tubers quality characters at harvest as affected by foliar application with organic compounds during e summer seasons of 2002 and 2003 .

Characters	Chemical compositions of leaves at 90 DAP					
	N %		P %		K %	
	1 st season	2 nd season	1 st season	2 nd season	1 st season	2 nd season
Treatments						
1) Ascorbic acid	3.19	3.18	0.372	0.387	3.41	3.20
2) Citric acid	3.17	3.16	0.368	0.370	3.38	3.49
3) Oxalic acid	2.70	2.77	0.355	0.335	2.81	2.89
4) 1 + 2	3.07	3.05	0.407	0.400	3.42	3.54
5) 1 + 3	2.91	3.01	0.323	0.320	3.36	3.41
6) 2 + 3	2.99	2.92	0.317	0.309	3.05	3.19
7) 1 + 2 + 3	3.05	3.04	0.299	0.304	3.03	3.05
8)Control 150 kgN fed ⁻¹	2.86	2.79	0.359	0.302	2.92	2.94
F. Test	**	**	**	**	**	**
LSD at 0.05	0.15	0.17	0.03	0.03	0.12	0.10

4- Chemical compositions :

Generally; the nutrients concentrations in the tuber are good reflection for content of these nutrients in the leaves and vigor of the vegetative growth. Data in table (5 a&b) revealed that applying the foliar spraying by mixture of (ascorbic acid + citric acid) at rate of (750 + 750 ppm)⁻¹ twice at 7 and 9 weeks after planting had significant effect on N, P and K contents in both of leaves and tubers during the summer seasons of 2002 and 2003 compared with control. These results proved that the organic compounds may help stimulating and increase nitrogen , phosphorus and potassium absorption. These results are in accordance with those obtained by Fathey et al (2003).

Table (5-a): Chemical compositions of leaves at 90 DAP as affected by foliar application with organic compounds during the summer seasons of 2002 and 2003 .

Characters	Dry matter (%)		Starch (%)		Protein (%)	
	1 st season	2 nd season	1 st season	2 nd season	1 st season	2 nd season
	season	season	season	season	season	season
Treatments						
1) Ascorbic acid	19.10	19.60	13.85	13.75	1.59	1.65
2) Citric acid	19.12	19.57	13.89	13.68	1.59	1.64
3) Oxalic acid	18.57	19.33	13.73	13.63	1.56	1.58
4) 1 + 2	19.17	19.80	13.96	13.81	1.65	1.66
5) 1 + 3	18.83	19.33	13.73	13.63	1.63	1.65
6) 2 + 3	18.70	19.33	13.83	13.64	1.56	1.61
7) 1 + 2 + 3	18.70	19.33	13.75	13.64	1.56	1.63
8)Control 150 kgN fed ⁻¹	18.87	19.40	13.78	13.68	1.55	1.64
F. Test	*	*	**	**	NS	NS
LSD at 0.05	0.04	0.03	0.06	0.08	--	--

Table (5-b): Chemical compositions of tubers at harvest as affected by foliar application with organic compounds during the summer seasons of 2002 and 2003.

Characters	Chemical compositions of tuber at harvest					
	N %		P %		K %	
	1 st season	2 nd season	1 st season	2 nd season	1 st season	2 nd season
1) Ascorbic acid	1.34	1.41	0.323	0.316	1.41	1.45
2) Citric acid	1.34	1.37	0.312	0.307	1.30	1.38
3) Oxalic acid	1.26	1.29	0.303	0.306	1.20	1.34
4) 1 + 2	1.39	1.43	0.327	0.318	1.44	1.57
5) 1 + 3	1.37	1.37	0.282	0.292	1.52	1.52
6) 2 + 3	1.34	1.34	0.278	0.281	1.12	1.28
7) 1 + 2 + 3	1.33	1.32	0.269	0.284	1.38	1.33
8) Control 150 kgN fed ⁻¹	1.30	1.31	0.289	0.281	1.28	1.17
F. Test	*	*	*	*	**	**
LSD at 0.05	0.02	0.05	0.01	0.01	0.12	0.08

Conclusion

This investigation indicate that applying the foliar spraying with mixture of (ascorbic acid + citric acid at rate of 750 + 750 ppm)^{-L} on potato plants twice at 7 and 9 weeks after planting led to increase of vegetative growth parameters and tubers quality, as well as recorded good increment of tubers yield reached 12.88 % (mean of two study seasons).

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تأثير الرش الورقي بالمركبات العضوية على النمو والمحصول وجودة درنات البطاطس

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أجريت تجربتان حقليتان خلال موسم الزراعة الصيفيين ٢٠٠٢، ٢٠٠٣م على البطاطس (صنف اسبونتأ) في أرض طميية طينية بمحطة بحوث البساتين بالبرامون- المنصورة- محافظة الدقهلية- مصر لدراسة تأثير الرش الورقي بالمركبات العضوية مثل حمض الأسكوربيك وحمض الستريك وحمض الأوكساليك بالإضافة الى تفاعلاتهم مع التسميد الأزوتي بمعدل ١٥٠كجم/فدان مقارنة بنفس معدل التسميد الأزوتي فقط بدون رش ورقي على قياسات النمو الخضري والمحصول وجودة الدرنات وبعض المكونات الكيماوية بالأوراق والدرنات .

وقد بينت النتائج ان الرش الورقي بخليط من (حمض الأسكوربيك + حمض الستريك) بتركيز (٧٥٠ + ٧٥٠ جزء في المليون /لتر) مرتين بعد الأسبوع السابع و الأسبوع التاسع من الزراعة مع التسميد الأزوتي بمعدل ١٥٠كجم/فدان كان فعالاً جداً على طول النبات (سم) و الوزن الطازج للعرش/نبات (جم) و المادة الجافة للعرش (%) ، كذلك متوسط وزن الدرنة(جم) و المحصول الكلي (طن/فدان) و المادة الجافة بالدرنة (%) و محتوى الدرنات من النشا مقارنة بباقي المعاملات الأخرى ، من ناحية اخرى أوضحت النتائج ان عدد الأفرع الرئيسية/نبات و عدد الدرنات / نبات و محتوى الدرنة من البروتين(%) لم تتأثر معنوياً بالمعاملات المختلفة خلال موسمي الدراسة كما أوضحت النتائج ان محتوى كل من الأوراق بعد ٩٠ يوم من الزراعة و الدرنات عند الحصاد من النيتروجين و الفوسفور و البوتاسيوم قد زادت زيادة معنوية مع استخدام الرش الورقي بخليط من (حمض الأسكوربيك + حمض الستريك) بتركيز (٧٥٠ + ٧٥٠ جزء في المليون /لتر) مرتين بعد الأسبوع السابع و الأسبوع التاسع من الزراعة في الموسمين الصيفيين ٢٠٠٢ و ٢٠٠٣.

بصفة عامة أظهرت النتائج ان استخدام الرش الورقي بخليط من حمض الأسكوربيك وحمض الستريك بتركيز (٧٥٠ جزء في المليون من كل منهما/لتر) على نبات البطاطس مرتين بعد الأسبوع السابع و الأسبوع التاسع من الزراعة تحت ظروف التسميد الأزوتي بمعدل ١٥٠ كجم/فدان أدى الى زيادة في قياسات النمو الخضري وزيادة المحصول الكلي للدرنات /فدان بمقدار ١٢,٨٨% (متوسط الزيادة في موسمي الدراسة) بالإضافة الى تحسين جودة درنات البطاطس مقارنة بنفس معدل التسميد الأزوتي فقط بدون الرش الورقي بالمركبات العضوية(الكنترول) .