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EFFECT OF FOLIAR SPRAY WITH SOME GROWTH STIMULANTS ON POTATO PLANTS UNDER DIFFERENT GROWING MEDIA

Fatma Sayed Aboud[1] and Hanaa Ali Abd-Alrahman[2]

[1]Central Laboratory for Agricultural Climate (CLAC), Agriculture Research Center, Giza, Egypt.
[2]Department of Vegetable Research, National Research Centre, Dokki, Cairo, Egypt.

Abstract

Under different substrate conditions, the suitability of four media with different mixtures of amino acids and vitamins on plant physical and chemical parameters, yield and quality of potato tubers were assessed. Mixture of tryptophan, methionine, riboflavin and vitamin C were tested at three concentrations. Among the four substrates, peatmoss + perlite treatment (1: 1 V) was the superior in terms of plant growth, yield, physical quality, leaf mineral contents and nutritional value of potato tubers. Applying mixture of tryptophan, methionine, riboflavin and vitamin C at 50 ppm for each one recorded the highest values of growth, physical quality, yield, leaf mineral contents *i.e.* N, P, K and nutritional value expressed as crude protein, P, K and total carbohydrates of potato tubers as compared with the other treatments. Moreover, the combined effect of peatmoss + perlite in spraying to tryptophan, methionine, riboflavin and vitamin C at 50 ppm for each recorded the highest values of the mentioned parameters.

Key words: Potato; Growing media; Amino acids, Vitamins; growth; Yield; Nutritional value; Mineral contents.

Introduction

Potatoes (*Solanum tuberosum* L.), Solanaceae, are rich in antioxidants (Hale and Anna Louise, 2003 and Chen *et al*., 2007), it comes in fourth highest crop after wheat, rice and corn (Haan and Rodriguez 2016). Potato is the first highest crop in energy production and the second in the production of proteins after soyabean. Potatoes are rich in vitamin C, potassium and dietary fiber (Katherine A. Beals, 2019).

Soil is the medium that provides the support for plants and provides it with the nutrients and water needed for its growth. Agricultural soil in Egypt suffers from many problems, the most crucial of which are salinity, pests, diseases and soil pollution as a result of the excessive use of pesticides and agricultural fertilizers (Soheir Mokhtar, *et al.,* 2015), which resulted in deterioration of agricultural soils, weak productivity. Hence, applying farming systems without soil has become one of the leading approaches to overcome these problems. One advantage here is that growth environment is easy to be sterilized overcoming the problem soil borne diseases. Soilless culture is a technique for growing plants in nutrient solution with or without the use of growing media (sand, peat moss, perlite, Sersa, vermiculite, etc.) to provide appropriate nutrition for the plant ((Pardossi *et al.,* 2011). Other major advantages of soilless system are steady and high-quality production (Veys, 1997), earliness, high production, cleaner production and less use of herbicides and pesticides ((Manukyan *et al.,* 2004).

Plants need amino acids and vitamins mixtures as natural bio-stimulators in small quantities. These natural stimulators play a vital alternative role in plant development instead of exogenous plant hormones, which have been proved to be carcinogenic (Iman *et al.,* 2005 and Abo Sedera *et al.,* 2010). The current study aimed to evaluate the effect of the foliar spray of different concentrations of amino acids and vitamins mixtures on potato plants grown under different growing media.

Materials and methods

This work was carried out at the Central Laboratory for Agricultural Climate Research Centre (CLAC), Dokki, Giza, Egypt. Potato plants were cultivated in four different substrate media for two successive seasons (2017/2018 and 2018/2019). The following sections explore in more details the different steps and procedures implemented throughout the two seasons.

Plant materials

Potato tubers were transplanted in terraces for two successive seasons as illustrated in table 1. Four different substrates media with different physical and chemical characteristics table 2 were used in this study. These media are clay, sand, mixture of peatmoss and perlite (1:1v/v) and mixture of sand and rice husk (1:1v/v). The media was placed in terraces with drainage and irrigation capabilities. After transplanting, the tubers were irrigated by water until it is emerged and formed true leaves. After forming true leaves, a balanced nutrient solution was used for irrigation. The nutrient solution was adapted from Cooper solution (Cooper, 1979) depending on the analysis of the local water (El-Behairy, 1994). The desired initial concentration of the nutrient solution was maintained by suitable dilution of the stock solutions with tap water. Electrical conductivity (EC) of the nutrient solution was maintained between (2-2.2 $mmhos^{-1}$) and pH maintained between (6-6.5) in table 3. Three weeks later, the plant leaves were sprayed with aqueous solution of the growth bioregulators. These bioregulators are vitamins and amino acids mixtures (tryptophan, methionine, riboflavin and vitamin C), with three different concentrations: 0 ppm for the control treatment, 100 ppm (25 ppm of each compound) and 200 ppm (50 ppm from each compound). One week after that, the plants were sprayed again with the same solution. The exact dates of bioregulator applications are given in table 1.

Three weeks later, the plant leaves were sprayed with aqueous solution of the growth bioregulators. These bioregulators are amino acids and vitamins mixtures (tryptophan, methionine, riboflavin and vitamin C), with three different concentrations:

1. 0 ppm: for the control treatment,

2. Foliar[1] treatment: with mixture of tryptophan, methionine, riboflavin and vitamin C at 25ppm for each one

3. Foliar[2] treatment: with mixture of tryptophan, methionine, riboflavin and vitamin C at 50 ppm for each one.

One week after that, the plants were sprayed again with the same solution. The exact dates of bioregulator applications are given in table 1.

Experimental design and statistical analysis

The experiment was carried out on a split piece at once design, with 36 treatments arranged in a 4 × 3 × 3 factorial scheme (four substrate, three concentrations and three replicates). Data of the experiment was statistically analyzed using Mstatic (M.S.) software. The comparison among means of the different treatments was determined as illustrated by Snedecor and Cochran (1982). Means followed by the same alphabetical letters are not statistical different at 5% level of significance according to (Duncan, 1955).

Experimental treatments

1. Clay (0, 100 and 200 ppm)

2. Peat moss+ Perlite (0, 100 and 200 ppm)

3. Sand + rice husk (0, 100 and 200 ppm)

4. Sand (0, 100 and 200 ppm)

Data sampling and analysis

After 45 days from the growth bioregulators spray, three plants were randomly selected for sampling from each replicate. The average of these three measurements was reported as the replicate value for each of the following parameters:

Vegetative growth parameters

1. Numbers of leaves per plant: all plant leaves were counted and recorded.

2. Plant height was measured by a measuring tape and reported in cm.

3. Fresh weigh (g/plant): the above ground plant shoots and leaves were collected and weighted then recorded as the plant fresh weight in grams.

4. Leaf area: Leaf area was recorded in the most recent fully expanded leaf (the fifth leaf from apex).

Dry matter (%) Dry matter was determined according to A.O.A.C. (1990).

Determination of plant total chlorophyll

Plant pigments are important indicators of plant health and nutrient status as it has a pivotal role in plant photosynthesis. In this study plant leaf total chlorophyll were measured by Minolta Chlorophyll Meter SPAD handheld device.

Determination of nitrogen, phosphorus and potassium (N, P and K) percentage of leaves

A dried sample of 0.1 g was taken in 500 ml kejldahl flask, then 10 ml of Conc. H_2SO_4 were added and digested till colorless solution appeared. The content was cooled down and diluted to about 25 ml with distilled water (solution 1).

Percentage of nitrogen

Total nitrogen was determined in solution (1) according to kejldahl method as A.O.A.C., (1990).

Percentage of phosphorus

Total phosphorus was determined colorimetrically by

ascorbic acid reductant method according to Murphy and Riley, (1962) as modified by Watanabe and Olsen, (1965).

Percentage of potassium

Total potassium was determined in solution (1) by using flame photometer according to A.O.A.C, (1990).

Physical properties of tuber

After harvesting the potato plants, total yield was collected for different measurements and assessments. These measurements were as follow:

1. Yield (kg): three plants were randomly selected per each replicate and each plant tubers were collected and weighted individually. The average of the three was calculated then multiplied by the number of plants per replicate to calculate the yield for each replicate.

2. Tubers production (kg/Fadden):

3. Number of tubers per plant: the number of tubers for the selected plants were counted and reported.

4. Tuber diameter: all tubers collected from the individual selected plants were measured using a caliper which gives diameter in cm. The average of them all was calculated and reported as the replicate tuber diameter.

5. Tuber fresh weight (g)

6. Tuber length (cm)

7. Tuber dry weight (g)

Table 1: Dates of cultivation for the two seasons.

Stage	First season	Second season
transplanting date	15th Dec 2017	12th Dec 2018
Nutrient solution addition	1st Feb 2018	1st Feb 2019
First application growth bioregulators	6th Feb 2018	9th Feb 2019
Second application growth bioregulators	14th Feb 2018	16th Feb 2019
Vegetative measurements	1st April 2018	3rd April 2019
Harvest	1st May 2018	2nd May 2019

Table 2: Physical and chemical characteristics of four commercial substrates.

Substrate	Physical				Chemical	
	Bulk density g/l	Total pore space %	water holding capacity %	Air porosity %	E.C mm-hos^{-1}	pH
Peatmoss: Perlite	392.6	62.9	47.6	15.3	0.44	7.6
Sand	1665	22	18.7	3.3	0.88	7.3
Sand+ rice husk	761.8	37.11	27.6	9.51	0.84	7.93
Clay	1249	51.56	39.65	11.91	2.31	8.15

Table 3: The chemical composition of chemical nutrient solutions.

Chemical nutrient solution				Macro nutrients (ppm)				Micro nutrients (ppm)		
N	P	K	Ca	Mg	Fe	Mn	Cu	Zn	B	Mo
200	70	300	190	50	5.0	1.0	0.039	0.044	0.17	0.1

Determination of the nutritional value of tubers in terms of

Determination of total carbohydrates

Total carbohydrates were extracted according to A.O.A.C. (1990). 0.1 g of air-dried sample was hydrolyzed with 1 N HCl by refluxing for 6 h in a boiling water bath. The obtained solution was filtered, neutralized and the total volume was made up to 100 ml with distilled water. Resulted total reducing sugars was determined colorimetrically using 1 ml of sample with alkaline potassium ferricyanide reagent. The amount of total carbohydrates was determined according to the standard curve of glucose.

Percentage of phosphorus and potassium

All of these characters were determined as mentioned in vegetative growth characteristics.

Percentage of crude protein

Crude Protein is the total protein equivalent including nitrogen from both protein and non-protein sources. Crude protein is calculated as mineral nitrogen multiplied by the protein factor, which is 6.25.

Crude protein = N × 6.25

Table 4: Effect of different growing media on vegetative growth of potato plants during 2017/2018 and 2018/2019 seasons.

Treatments	Plant length(cm)		Number of leaves/plant		Plant weight (g)		plant dry weight (%)		Leaf area (cm^2)		Chlorophyll (SPAD)	
	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
Peat moss+ Perlite	56.89^{A}	52.33^{A}	16.11^{A}	14.56^{A}	114.71^{A}	108.68^{A}	17.64^{A}	21.52^{A}	94.06^{A}	88.22^{A}	43.39^{A}	42.83^{A}
Sand+ Rice husk	48.67^{B}	40.67^{B}	13.11^{B}	12.56^{A}	88.00^{B}	75.63^{B}	13.83^{B}	17.21^{B}	77.43^{B}	76.55^{B}	41.82^{AB}	42.21^{A}
Sand	37.67^{C}	30.67^{C}	11.44^{B}	10.11^{B}	58.91^{C}	56.34^{C}	11.50^{C}	13.93^{C}	70.00^{C}	64.39^{C}	39.87^{B}	38.94^{A}
Clay	27.67^{D}	27.44^{C}	8.44^{C}	10.11^{B}	34.23^{D}	33.63^{D}	7.87^{D}	11.35^{D}	30.83^{D}	33.12^{D}	31.88^{C}	37.03^{A}

Values followed by the same letter (s) are not significantly different at 5%.

Results and Discussion

Effect of substrate media on vegetative growth

It is clear from table 4 that vegetative growth parameters (plant length, leaves number/plant, leaf area, chlorophyll content, fresh and dry weights) were affected significantly by growing media in both seasons. The highest values of vegetative growth parameters were produced by plants grown in peatmoss + perlite (1:1 V/V) as compared with the other treatments. However, the lowest values were recorded in plants produced in clay media.

Effect of substrate media on yield and physical quality

Data reported in table 5 indicated that plants produced in peatmoss+ perlite (1:1 V/V) significantly increased physical quality (diameter, length, fresh, dry weights) and total yield of potato tubers. However, the lowest values were recorded in plants produced in clay media.

Effect of growing media on leaf mineral contents and nutritional values

There were significant differences between different growing media in terms of leaf mineral contents *i.e.* N, P and K and nutritional values Fig. 1 and table 6. The highest values of leaf mineral contents and nutritional values were recorded by plants produced in peatmoss + perlite. On the other hand, the lowest values were recorded by plants produced in clay media in both seasons.

Table 5: Effect of different growing media on physical quality of potato plants and yield during 2017/2018 and 2018/2019 seasons.

Treatments	Tuber weight(cm)		Tuber diameter (cm)		Tuber length (g)		Tuber dry weight (%)		Yield (ton/fed.)	
	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
Peat moss+ Perlite	130.44^{A}	97.78^{A}	4.58^{A}	4.92^{A}	10.39^{A}	10.98^{A}	16.39^{A}	16.30^{A}	16.16^{A}	16.57^{A}
Sand+ Rice husk	86.76^{B}	83.33^{B}	4.50^{A}	4.60^{A}	8.61^{B}	9.81^{B}	13.38^{B}	13.24^{B}	14.41^{B}	14.47^{AB}
Sand	79.00^{B}	82.89^{B}	3.84^{A}	4.00^{B}	7.72^{C}	8.37^{C}	13.00^{B}	13.07^{B}	13.83^{B}	13.73^{B}
Clay	69.44^{C}	63.56^{C}	3.54^{A}	3.73^{B}	7.43^{C}	7.53^{C}	11.54^{C}	11.65^{C}	12.15^{C}	11.12^{C}

Values followed by the same letter (s) are not significantly different at 5%.

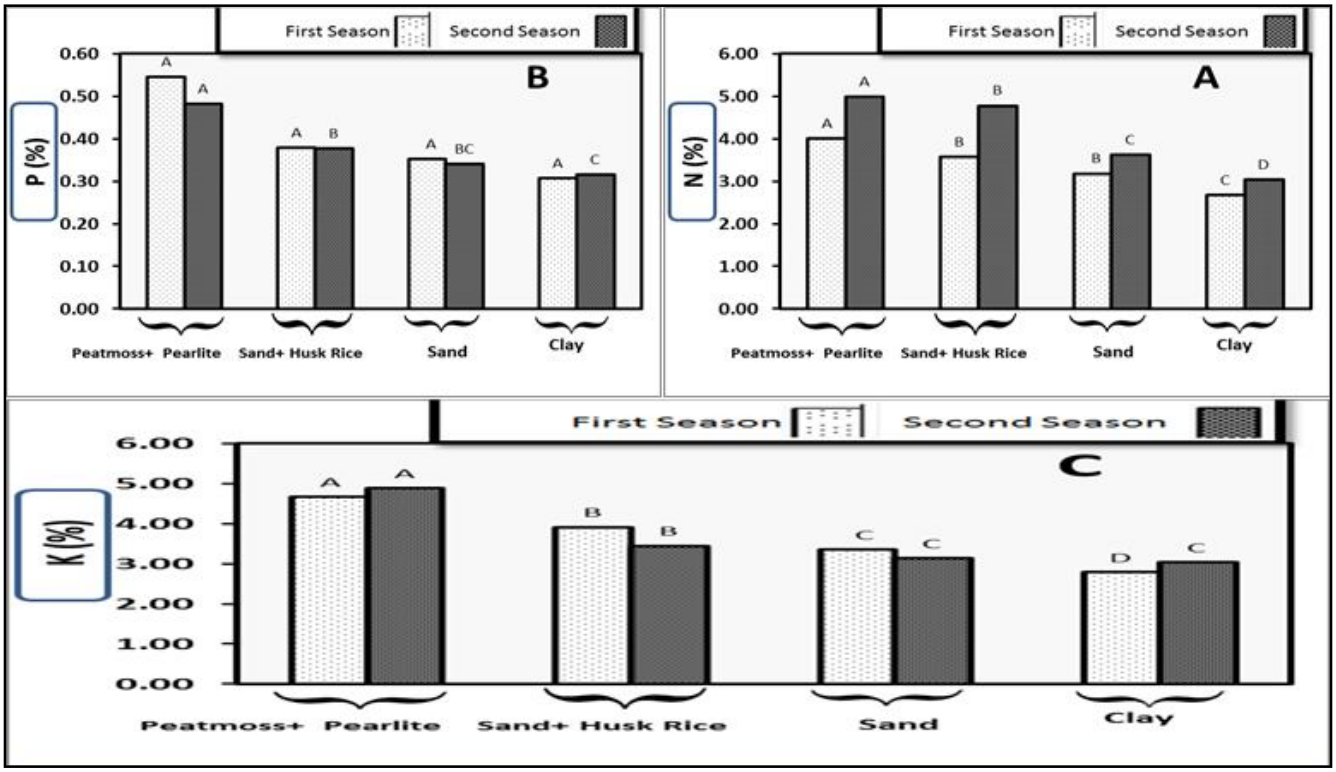

Fig. 1: Effect of different growing media on leaf mineral percentages (A, B and C) of potato plants during 2017/2018 and 2018/2019 seasons.

Values followed by the same letter (s) are not significantly different at 5%.

Table 6: Effect of different growing media on nutritional values of potato tubers during 2017/2018 and 2018/2019 seasons.

Treatments	Protein (%)		P (%)		K (%)		Carbohydrate (%)	
	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
Peat moss+ Perlite	12.20^{A}	14.58^{A}	0.38^{A}	0.28^{A}	2.11^{A}	2.55^{A}	46.33^{A}	53.20^{A}
Sand+ Rice husk	8.91^{B}	10.24^{B}	0.27^{B}	0.21^{B}	1.32^{B}	1.84^{B}	39.10^{B}	48.96^{B}
Sand	7.72^{C}	8.85^{C}	0.21^{C}	0.19^{B}	0.94^{C}	1.38^{C}	34.22^{C}	44.74^{C}
Clay	5.96^{D}	6.85^{D}	0.14^{D}	0.17^{B}	0.68^{D}	1.16^{D}	29.63^{D}	37.96^{D}

Values followed by the same letter (s) are not significantly different at 5%.

The superior performance of peatmoss+ perlite on vegetative growth and leaf minerals contents can be attributed to its good physical characteristics such as porosity, pH appropriate range and better water retention which increases its ability to retain nutrients. However, in clay media, the decreased vegetative growth, yield, physical quality, leaf mineral contents and nutritional values is probably due to the low porosity and aeration in the culture medium table 2. Our results agree to a great extent with those obtained by (Monireh *et al*., 2019). Aeration plays an important role in the growth of roots and plants, so lack of oxygen in the growing environment cause negative effects on plants and tubers will be severely damaged (Wever *et al.,* 2001). Especially in Potato, due to its shallow root system (Darvishi and Mohammadi 2015), oxygen deficiency plays a significant role. When using peatmoss+ perlite as media in potato production, enhancement of yield, physical quality and nutritional values of potato tubers may be due to the summation of the suitable conditions, consequently higher vegetative growth and photosynthetic activity, leaf mineral contents which led to more dry matter accumulation during this application table 2 and Fig. 1.

Other studies have shown that soilless systems lead to higher yields of potato mini-tubers (Nowak *et al.,* 1996; Sameei *et al*., 2005). Nowak *et al*., 1996 reported that maximum leaf area index (LAI), tuber fresh and Dry weights were reported in soilless culture as compared with soil culture. Several studies have shown the greater mini tuber FW and mean weight in hydroponic systems compared with other growing media (Abd El-Hady and

Table 7: Effect of foliar spray with some growth stimulants on vegetative growth of potato plants during 2017/2018 and 2018/2019 seasons.

Treatments	Plant length(cm)		Number of leaves/plant		Plant weight (g)		plant dry weight (%)		Leaf area (cm^2)		Chlorophyll (SPAD)	
	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
Control	35.67^{C}	30.17^{C}	9.75^{C}	8.58^{C}	63.71^{C}	54.66^{C}	9.36^{B}	13.15^{C}	55.77^{B}	61.02^{B}	34.96^{C}	37.55^{B}
Foliar^{1}	43.75^{B}	38.42^{B}	12.17^{B}	11.50^{B}	73.31^{B}	68.22^{B}	12.56^{B}	16.21^{B}	67.73^{B}	65.87^{AB}	39.15^{B}	40.61^{AB}
Foliar^{2}	48.75^{A}	44.75^{A}	14.92^{A}	15.42^{A}	84.86^{A}	82.83^{A}	14.72^{A}	18.65^{A}	71.80^{A}	69.81^{A}	43.62^{A}	42.61^{A}

Values followed by the same letter (s) are not significantly different at 5%. Control, Without Foliar Application;Foliar^{1}, Mixture of tryptophan, methionine, riboflavin and vitamin C at 25 ppm for each one; Foliar^{2}, Mixture of tryptophan, methionine, riboflavin and vitamin C at 50 ppm for each one.

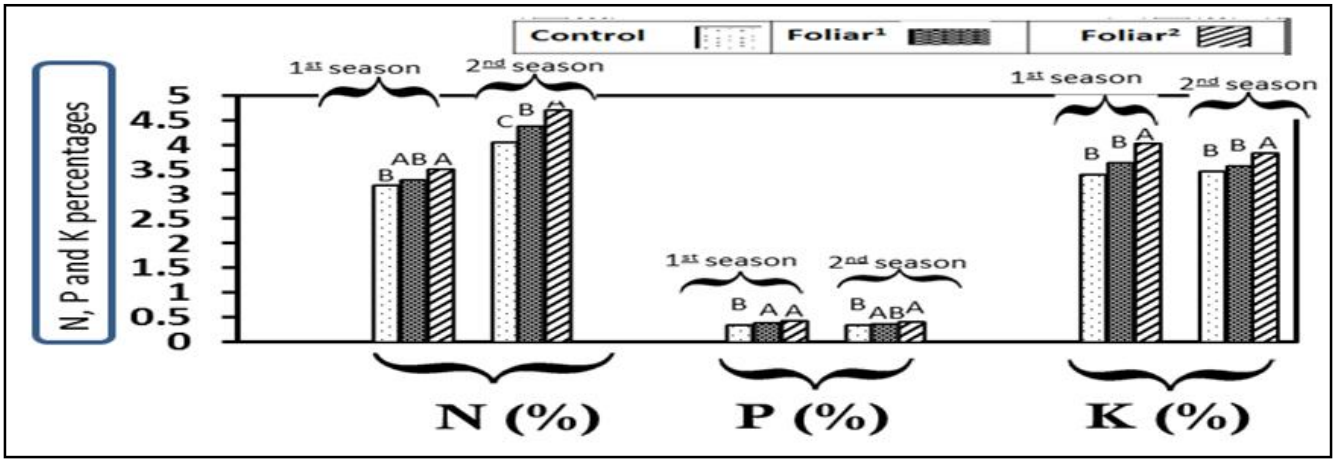

Fig. 2: Effect of foliar spray with some growth stimulants on leaf mineral percentages of potato plants during 2017/2018 and 2018/2019 seasons.

Table 8: Effect of foliar spray with some growth stimulants on physical quality and yield of potato plants during 2017/2018 and 2018/2019 seasons.

Treatments	Tuber weight(cm)		Tuber diameter (cm)		Tuber length (g)		Tuber dry weight (%)		Yield (ton/fed.)	
	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
Control	74.15^{C}	62.67^{C}	3.78^{A}	4.11^{B}	7.38^{B}	8.78^{A}	11.90^{B}	11.64^{C}	11.56^{C}	10.97^{C}
Foliar[1]	84.08^{B}	82.33^{B}	3.99^{A}	4.30^{AB}	7.89^{B}	9.08^{A}	13.89^{A}	13.85^{B}	13.71^{B}	13.74^{B}
Foliar[2]	116.00^{A}	100.67^{A}	4.58^{A}	4.55^{A}	10.35^{A}	9.67^{A}	14.95^{A}	15.21^{A}	17.13^{A}	17.21^{A}

Values followed by the same letter (s) are not significantly different at 5%. Control, Without Foliar Application; Foliar[1], Mixture of tryptophan, methionine, riboflavin and vitamin C at 25 ppm for each one; Foliar[2], Mixture of tryptophan, methionine, riboflavin and vitamin C at 50 ppm for each one.

Table 9: Effect of foliar spray with some growth stimulants on nutritional values of potato tubers during 2017/2018 and 2018/2019 seasons.

Treatments	Protein (%)		P (%)		K (%)		Carbohydrate (%)	
	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
Control	7.86^{B}	8.93^{C}	0.22^{B}	0.20^{B}	1.05^{C}	1.58^{C}	35.07^{C}	44.69^{C}
Foliar[1]	8.49^{B}	10.07^{B}	0.24^{B}	0.20^{B}	1.23^{B}	1.73^{B}	37.29^{B}	46.18^{B}
Foliar[2]	9.73^{A}	11.40^{A}	0.28^{A}	0.24^{A}	1.51^{A}	1.88^{A}	39.60^{A}	47.78^{A}

Values followed by the same letter (s) are not significantly different at 5%. Control, Without Foliar Application;Foliar[1], Mixture of tryptophan, methionine, riboflavin and vitamin C at 25ppm for each one;Foliar[2], Mixture of tryptophan, methionine, riboflavin and vitamin C at 50 ppm for each one.

Shanan 2010).

Effect of foliar application on vegetative growth

Regarding the foliar application, data indicated that using foliar application enhanced vegetative growth of potato in both seasons. Data showed also that application of foliar[2] treatment with mixture (50 ppm tryptophan + 50 ppm methionine + 50 ppm riboflavin +50 ppm vitamin C) recorded the highest values of vegetative growth (plant length, leaves number/plant, leaf area, chlorophyll content, fresh and dry weights) compared to the other treatments table 7 .

Effect of foliar application on yield and physical quality

It is clear from table 8 that yield characters were significantly increased by the foliar spray in both seasons. The highest values of physical quality and yield were

Table 10: Effect of foliar spray with some growth stimulants on vegetative growth of potato plants under different growing media during 2017/2018 and 2018/2019 seasons.

Treatments		Plant length(cm)		Number of leaves/plant		Plant weight (g)		plant dry weight (%)		Leaf area (cm^2)		Chlorophyll (SPAD)	
		1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
Peat moss+ Perlite	Control	45.00^{cd}	38.33^{cde}	13.33^{c}	11.00^{cde}	99.13^{bc}	83.40^{d}	15.28^{bc}	18.98^{b}	91.51^{a}	83.55^{abc}	38.00^{cde}	39.52^{abc}
	Foliar[1]	57.67^{b}	54.33^{ab}	16.00^{b}	14.67^{abc}	110.82^{b}	107.55^{b}	16.84^{b}	21.89^{ab}	93.41^{a}	86.79^{ab}	42.57^{abc}	43.77^{ab}
	Foliar[2]	68.00^{a}	64.33^{a}	19.00^{a}	18.00^{a}	134.17^{a}	135.11^{a}	20.79^{a}	23.69^{a}	97.25^{a}	94.32^{a}	49.60^{a}	45.20^{a}
Sand+ Rice husk	Control	42.00^{cde}	34.33^{c-g}	10.33^{de}	9.00^{de}	76.20^{de}	57.94^{f}	12.02^{c-f}	13.77^{cd}	73.36^{cd}	74.98^{bcd}	36.83^{c-f}	38.80^{abc}
	Foliar[1]	50.00^{bc}	41.33^{cd}	13.00^{c}	12.00^{cd}	87.45^{cd}	72.49^{e}	13.98^{bcd}	17.74^{bc}	76.96^{bc}	76.97^{bcd}	41.27^{bcd}	42.93^{ab}
	Foliar[2]	54.00^{b}	46.33^{bc}	16.00^{b}	16.67^{ab}	100.36^{bc}	96.46^{c}	15.49^{bc}	20.13^{ab}	81.96^{b}	77.69^{bcd}	47.37^{ab}	44.90^{ab}
Sand	Control	34.67^{ef}	25.67^{fg}	10.00^{de}	7.33^{e}	47.83^{g}	45.95^{g}	10.09^{def}	10.04^{d}	68.72^{d}	58.38^{e}	35.67^{c-f}	37.27^{abc}
	Foliar[1]	37.33^{def}	31.00^{d-g}	11.00^{cde}	10.33^{cde}	60.97^{f}	58.91^{f}	11.35^{c-f}	14.23^{cd}	69.37^{d}	64.97^{de}	40.87^{bcd}	39.03^{abc}
	Foliar[2]	41.00^{de}	35.33^{c-f}	13.33^{c}	12.67^{bcd}	67.91^{ef}	64.16^{f}	13.07^{b-e}	17.54^{bc}	71.93^{cd}	69.82^{cde}	43.07^{abc}	40.53^{abc}
Clay	Control	21.00^{g}	22.33^{g}	5.33f	7.00^{e}	31.67^{h}	31.36^{h}	5.98^{g}	9.81^{d}	25.24^{f}	27.17^{f}	29.32^{f}	34.60^{c}
	Foliar[1]	30.00^{f}	27.00^{efg}	8.67e	9.00^{de}	34.01^{h}	33.94^{h}	8.07^{fg}	10.98^{d}	31.19^{ef}	34.78^{f}	31.90^{ef}	36.70^{bc}
	Foliar[2]	32.00^{f}	33.00^{d-g}	11.33cd	14.33^{abc}	37.00^{gh}	35.59^{h}	9.54^{efg}	13.26c^{d}	36.06^{e}	37.40^{f}	34.43^{def}	39.80abc

Values followed by the same letter (s) are not significantly different at 5%. Control, Without Foliar Application; Foliar[1], Mixture of tryptophan, methionine, riboflavin and vitamin C at 25 ppm for each one; Foliar[2], Mixture of tryptophan, methionine, riboflavin and vitamin C at 50 ppm for each one.

Table 11: Effect of foliar spray with some growth stimulants on physical quality and yield of potato plants under different growing media during 2017/2018 and 2018/2019 seasons.

Treatments		Tuber weight(cm)		Tuber diameter (cm)		Tuber length (g)		Tuber dry weight (%)		Yield (ton/fed.)	
		1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
Peat moss+ Perlite	Control	98.00^{b}	72.33^{cde}	4.00^{ab}	4.57^{bc}	8.93^{cde}	10.30^{ab}	13.01^{bcd}	12.37^{bcd}	13.15^{cd}	12.66de
	Foliar^{1}	114.33^{b}	93.67^{bc}	4.60^{ab}	4.77^{b}	9.90^{bc}	10.67^{ab}	17.87^{a}	17.80^{a}	16.01^{bc}	16.39^{bc}
	Foliar^{2}	179.00^{a}	127.33^{a}	5.13^{a}	5.43^{a}	12.33^{a}	11.97^{a}	18.29^{a}	18.73^{a}	19.33^{a}	20.65^{a}
Sand+ Rice husk	Control	72.44^{c}	61.33^{e}	4.00^{ab}	4.50^{bc}	7.17^{efg}	9.53^{ab}	11.96^{cd}	11.73^{cd}	11.01^{d}	10.73^{de}
	Foliar^{1}	79.17^{c}	84.67^{bcd}	4.60^{ab}	4.60^{bc}	7.50^{d-g}	9.57^{ab}	13.17^{bcd}	13.16^{bcd}	13.85^{cd}	14.48^{cd}
	Foliar^{2}	108.67^{b}	104.00^{b}	4.90^{ab}	4.72^{b}	11.17^{ab}	10.33^{ab}	15.02^{b}	14.83^{b}	18.35^{ab}	18.20^{ab}
Sand	Control	65.67^{c}	63.00^{de}	3.87^{ab}	3.70^{d}	6.87^{fg}	8.00^{b}	11.76^{cd}	12.04^{cd}	11.49^{d}	11.03^{de}
	Foliar^{1}	70.00^{c}	84.33^{bcd}	3.43^{ab}	4.10^{cd}	7.17^{efg}	8.53^{ab}	12.95^{bcd}	12.68^{bcd}	12.25^{d}	12.43^{de}
	Foliar^{2}	101.33^{b}	101.33^{b}	4.23^{ab}	4.20^{bcd}	9.13^{cd}	8.57^{ab}	14.28^{bc}	14.48^{bc}	17.73^{ab}	17.73^{abc}
Clay	Control	60.50^{c}	54.00^{e}	3.23^{b}	3.67^{d}	6.53^{g}	7.27^{b}	10.86^{d}	10.41^{d}	10.59^{d}	9.45^{e}
	Foliar^{1}	72.83^{c}	66.67^{de}	3.33^{ab}	3.73^{d}	7.00^{efg}	7.53^{b}	11.56^{d}	11.77^{cd}	12.75^{cd}	11.67^{de}
	Foliar^{2}	75.00^{c}	70.00^{de}	4.07^{ab}	3.80^{d}	8.77^{c-f}	7.80^{b}	12.19^{cd}	12.79^{bcd}	13.13^{cd}	12.25^{de}

Values followed by the same letter (s) are not significantly different at 5%. Control, Without Foliar Application; Foliar^{1}, Mixture of tryptophan, methionine, riboflavin and vitamin C at 25 ppm for each one; Foliar^{2}, Mixture of tryptophan, methionine, riboflavin and vitamin C at 50 ppm for each one.

Table 12: Effect of foliar spray with some growth stimulants on leaf mineral percentages of potato plants under different growing media during 2017/2018 and 2018/2019 seasons.

Treatments		Protein (%)		P (%)		K (%)	
		1st season	2nd season	1st season	2nd season	1st season	2nd season
Peat moss+ Perlite	Control	3.80^{b}	5.57^{c}	0.46^{c}	0.43^{bc}	4.17^{bc}	4.53^{b}
	Foliar^{1}	3.90^{ab}	6.07^{b}	0.54^{b}	0.48^{ab}	4.47^{b}	4.85^{b}
	Foliar^{2}	4.33^{a}	6.63^{a}	0.63^{a}	0.54^{a}	5.42^{a}	5.30^{a}
Sand+ Rice husk	Control	3.47^{bcd}	4.40^{e}	0.34^{def}	0.35^{def}	3.75^{b-f}	3.24^{d}
	Foliar^{1}	3.57^{bcd}	4.80^{d}	0.40^{cd}	0.37^{cde}	3.92^{b-e}	3.31^{d}
	Foliar^{2}	3.70^{bc}	5.17^{d}	0.40^{cd}	0.41^{bcd}	4.10^{bcd}	3.82^{c}
Sand	Control	3.27^{cde}	3.47^{fg}	0.31^{ef}	0.34^{def}	3.18^{e-h}	3.12^{d}
	Foliar^{1}	3.10^{def}	3.63^{fg}	0.36^{def}	0.34^{def}	3.37^{d-g}	3.14^{d}
	Foliar^{2}	3.20^{cde}	3.80^{f}	0.39^{de}	0.34^{def}	3.55^{c-g}	3.18^{d}
Clay	Control	2.50^{g}	2.80^{i}	0.29^{f}	0.28^{f}	2.50^{h}	2.99^{d}
	Foliar^{1}	2.67^{fg}	3.07^{hi}	0.31^{f}	0.33^{ef}	2.83^{gh}	3.06^{d}
	Foliar^{2}	2.87^{efg}	3.27^{gh}	0.32^{ef}	0.34^{ef}	3.07^{fgh}	3.08^{d}

Values followed by the same letter (s) are not significantly different at 5%. Control, Without Foliar Application; Foliar^{1}, Mixture of tryptophan, methionine, riboflavin and vitamin C at 25 ppm for each one; Foliar^{2}, Mixture of tryptophan, methionine, riboflavin and vitamin C at 50 ppm for each one.

produced by foliar^{2} treatment. Whereas, the untreated plants produced the lowest values.

Effect of foliar application on leaf mineral contents and nutritional values

Data presented in Fig. 2 and table 9 indicated that leaf mineral contents *i.e.* N, P and K as well as nutritional values (crude protein, P, K and total carbohydrates) were affected significantly by foliar application treatments. Data indicates that using foliar application enhanced leaf mineral contents and nutritional values of potato plants compared to control. The highest values of leaf mineral contents and nutritional values were recorded by foliar^{2} treatment. the other hand, the lowest values were recorded by control in both seasons.

The results obtained show that higher concentration with mixture of tryptophan, methionine, riboflavin and vitamin C affected the availability of nutritional elements for potato plants as these particles act as catalysts in many physiological processes beneficial to the plant.

The stimulating effect of foliar treatment may be due to the stimulation of plant root growth, which improve water and nutrient uptake, producing higher yield (Colla *et al.,* 2017 and Rouphael *et al.,* 2017). Foliar spray with tryptophan stimulates auxin synthesis within plants, enhances the growth and yield of agricultural crops. Moreover, tryptophan contains about 14% nitrogen in its composition, which is released upon its metabolism within a plant or in the root zone and plays a role in increasing the yield (Ayesha *et al.,* 2018). Foliar application of methionine influence phytohormones, which may improve the photosynthetic activity, leading to better growth and yield (Bahari *et al.,* 2013).

Positive effects of amino acids and vitamins on the

Table 13: Effect of foliar spray with some growth stimulants on nutritional values of potato tubers under different growing media during 2017/2018 and 2018/2019 seasons.

Treatments		Protein (%)		P (%)		K (%)		Carbohydrate (%)	
		1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
Peat moss+ Perlite	Control	10.00^{bc}	12.06^{c}	0.34^{bc}	0.24^{b}	1.53^{c}	2.23^{c}	43.82^{b}	51.58^{c}
	Foliar^{1}	11.17^{b}	14.08^{b}	0.38^{ab}	0.26^{b}	1.98^{b}	2.57^{b}	45.76^{b}	52.92^{b}
	Foliar^{2}	15.44^{a}	17.58^{a}	0.42^{a}	0.35^{a}	2.82^{a}	2.85^{a}	49.41^{a}	55.11^{a}
Sand+ Rice husk	Control	8.46^{cde}	9.60^{def}	0.24^{def}	0.20^{cd}	1.21^{ef}	1.70^{f}	37.61^{d}	47.79^{f}
	Foliar^{1}	8.96^{bcd}	10.31^{de}	0.27^{cde}	0.20^{cd}	1.32^{de}	1.83^{e}	38.65^{d}	48.94^{e}
	Foliar^{2}	9.31^{bcd}	10.81^{d}	0.29^{cd}	0.23^{bc}	1.42^{cd}	1.98^{d}	41.04^{c}	50.15^{d}
Sand	Control	7.31^{def}	8.48^{fg}	0.19^{ef}	0.19^{d}	0.80^{hi}	1.30^{hi}	31.62^{f}	43.04^{i}
	Foliar^{1}	7.79^{c-f}	8.88^{fg}	0.20^{ef}	0.19^{d}	0.95^{gh}	1.38^{gh}	34.34^{e}	44.87^{h}
	Foliar^{2}	8.04^{c-f}	9.19^{efg}	0.22^{ef}	0.20^{cd}	1.08^{fg}	1.46^{g}	36.69^{d}	46.31^{g}
Clay	Control	5.69^{f}	5.56^{i}	0.12^{g}	0.16^{e}	0.64^{i}	1.09^{k}	27.22^{g}	36.34^{l}
	Foliar^{1}	6.04^{ef}	7.00^{h}	0.12^{g}	0.17^{de}	0.68^{i}	1.15^{jk}	30.43^{f}	37.97^{k}
	Foliar^{2}	6.15^{ef}	8.00^{gh}	0.18^{fg}	0.17^{de}	0.74^{i}	1.22^{ij}	31.24^{f}	39.57^{j}

Values followed by the same letter (s) are not significantly different at 5%. Control, Without Foliar Application;Foliar^{1}, Mixture of tryptophan, methionine, riboflavin and vitamin C at 25 ppm for each one; Foliar^{2}, Mixture of tryptophan, methionine, riboflavin and vitamin C at 50 ppm for each one.

vegetative growth, yield, physical quality, leaf mineral contents and nutritional values could be attributed to this bio-stimulatory effect to the increase of carbohydrates, photosynthetic pigment (chlorophyll content), dry weight tables 7 and 9, several authors have been attributed this bio-stimulatory effect to auxins and gibberellins in several plants. So, one may conclude that application of amino acid and vitamins mixtures enhance some metabolic processes. Foliar spray with Nicotinamide enhanced tomato growth and yield (Hathout *et al.,* 1993 a, b). Also, Hendawy and Azza (2010) studied the promoting effect of foliar application of thiamin, aspartic and phenylalanine on fennel, they increased growth, yield and chemical composition.

Interaction between growing media and foliar application on vegetative growth

Data in table 10 indicated that growing media + foliar application treatments significantly affected vegetative growth. The highest values of vegetative growth were recorded by plants produced in peatmoss+ perlite with foliar^{2} treatment. On the other hand, the lowest values were recorded by plants produced in clay without foliar application in both seasons.

Interaction between growing media and foliar application on yield and physical quality

Data recorded in table 11 showed that physical quality and yield produced in peatmoss+ perlite with foliar^{2} treatment recorded the highest values of physical quality (diameter, length, fresh, dry weights) and total yield of potato tubers. However, the lowest values were recorded by plants produced in clay without foliar application in both seasons.

Interaction between growing media and foliar application on leaf mineral contents and nutritional values

The interaction effect of growing media and foliar application on leaf mineral contents and nutritional values were significant in both seasons as shown in tables 11 and 13. The highest values of leaf mineral contents (N, P and K) and nutritional values (crude protein, P, K and total carbohydrates) were recorded by applying peatmoss+ perlite in combination with foliar^{2} treatment. However, the lowest values were recorded by plants produced in clay without foliar application in both seasons.

The increase of vegetative growth, yield, physical quality, leaf mineral contents and nutritional values by the peatmoss+ perlite in combination with foliar^{2} treatment may be returned to the increase in the photosynthetic pigment (chlorophyll content), total plant fresh weight, dry matter and total carbohydrates tables 10 and 13. These results come along with those obtained by Fatma (2014) on strawberry.

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