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RESPONSE OF PEA PLANTS TO PARTIAL REPLACEMENT OF MINERAL FERTILIZERS BY FULVIC ACID

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ABSTRCAT

This experiment was carried out during the two successive winter seasons of 2009 and 2010 at El-Qanaiat Regian (Private Farm), Sharkia Governorate, Egypt, to study the effect of mineral NPK at different rates and foliar spray with fulvic acid at 0.1% on growth, productivity and anatomical traits of pea plants grown in clay loam soil. Fertilization of pea plants with 100% or 75% NPK of the recommended rate with or without foliar spray with fulvic acid at 0.1% or 50% NPK with fulvic acid at 0.1% increased stem length, number of both leaves and branches/plant, chlorophyll a, b and total (a+b), average number of pods/plant, average pod weight, yield/ plant, shelling percentage, N, P, K and total carbohydrates percentage in seeds compared to control and other treatments. As for the effect of foliar application with fulvic acid on anatomical structure of vegetative growth of pea cv. Master, it could be stated that such treatment increased stem diameter due mainly to the prominent increase in the thickness of cortex, vascular cylinder and number of vascular bundle. Likewise, spraying fulvic acid increased thickness of both midvein and lamina of leaflet blades of pea cv. Master. The increase in lamina thickness was accompaned with increment in thickness of palisade and spongy tissues. Also, the main vascular bundle of the midvein was increased in size as a result of spraying fulvic acid.

Keywords: Fulvic acid, NPK, pea, growth, anatomy, yield.

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INTRODUCTION

Pea (*Pisum sativum* L.) belongs to the family *Fabaceae*. It is grown primarily for edible pods. In addition to its nutritional value, it is rich source of protein, good source of vitamin A, B and C and also contains a high proportion of minerals (Baloch, 1994). In Egypt, it is grown in winter season where its average reached about 30,000 ha. with an annual production about 295,000 tons for 2009 year (FAO, 2009).

The balance between N, P and K and increasing their levels had an important role for enhancing plant height, number of branches/ plant, chlorophyll concentration, number of pods/plant, average pod length, number of seeds/pod, yield/ plant and total yield of pea compared with the control (Ramachandra *et al.*, 1998; Shokr, 2000; Kakar *et al.*, 2002 and Achakzal and Bangulzai, 2006).

Fulvic acid (FA) are a mixture of weak aliphatic and aromatic organic acids which are soluble in water at all pH conditions (acidic, neutral and alkaline). The required concentration of humic acid (HA) and/or FA within the foliar spray should be relatively low, generally less than 50 mg of concentrated dry humic substance per liter of water. Foliar fertilizers containing HA and FA in combination with N, P, K and various trace minerals have bean demonstrated to be from 100 to 500% more efficient compared to applications of similar fertilizers to the soil. Foliar fertilizers are also more economical because smaller quantities of fertilizer are required to obtain significant plant response. Plant nutrients within foliar fertilizers are rapidly absorbed by plant leaves. Within 8 hours after application of humic substances are applies, changes in many different metabolic process are detected (Pettit, 2009).

Application of HA or FA in combination with trace elements and other plant nutrient, as foliar sprays, improved the growth of plant foliage, roots and fruits (Pettit, 2009).

When HA or FA are applied to plant leaves, the chlorophyll content of those leaves increased. Consequently, as the chlorophyll concentration increased there was an increase in the uptake of oxygen. Chlorophyll development within plant leaves was more pronounced when FA was present in the foliar fertilizer (Pettit, 2009). Moreover, uptake of major plant nutrients was mediated by humic substances, one stimulative effect

of humic substances on plant growth is enhancing the uptake of major plant nutrients (N, P and K). When adequate humic substances were present within the soil, the requirement for N-P-K fertilizer application was reduced (Pettit, 2009).

Therefore, the objective of this work was to reduce the quantity of N, P and K fertilizers by using foliar spray of pea plants with fulvic acid in combination with N, P and K fertilizers.

MATERIALS AND METHODS

This work was carried out during the two successive winter seasons of 2009 and 2010 at El-Qanaiat Region (Private Farm), Sharkia Governorate, Egypt, to study the effect of mineral N, P and K at different rates and foliar spray with fulvic acid (FA) on growth of pea plants, chemical composition and yield as well as anatomy of stem and leaves of pea cv. Master grown in clay loam soil.

The physical and chemical analysis of the experimental soil are presented in Table 1.

This experiment included 10 treatments as shown in Schedule 1.

These treatments were arranged in a randomized complete block design with three replicates.

The seeds of pea cv. Master were sown on 20th November in both growing seasons, after inoculation with root nodules bacteria (*Rhizobium leguminosarum*) and spaced at 10 cm apart on both sides of row (2 seeds/hill), then thinned to one plant/ hill.

Plot area was 11.2 m^2. It contains four rows with 4 m length each and 70 cm distance. One row was left between each two experimental units as a gourd row to avoid the overlapping of spraying solution of fulvic acid. One row was used for samples to measure vegetative growth and the other three rows were used for yield determination. The source of pea cv. Master was Hort. Res. Inst., Agric. Res. Center, Egypt. The source of root nodule bacteria was the General Organization for Agriculture Equalaization Found (G.O.A.E.F.), Ministry of Agriculture, Egypt.

Pea plants were sprayed with solution of fulvic acid at 0.1% two times each at 30 and 50 days after sowing. Each plot received 2l of fulvic acid solution using spreading agent in all treatments. The untreated plants (check) were sprayed with tap water with spreading agent.

Table 1. Physical and chemical properties of the experimental soil (season 2009)

Properties					
Mechanical		**Chemical (mg/100 g soil)**			
Sand %	27.70	pH	7.30	Ca^{++}	0.07
Silt%	34.92	EC mmohs/cm	1.71	Mg^{++}	0.04
				Na^{+}	0.35
Clay%	37.38	N%	0.03	CO_3^{-}	-
Soil texture	Clay loam	P%	0.04	HCO_3	0.17
				Cl^{-}	0.16
F.C%*	30.13	K%	0.026	SO_4^{-}	0.13

* field capacity

Schedule 1. The combinations between mineral N, P and K and fulvic acid

Treatments	Amounts (kg/fed.)			Fulvic acid (FA %)
	N	P	K	
100% NPK +FA	40.0	30.0	50.0	0.1
100% NPK	40.0	30.0	50.0	0.0
75% NPK +FA	30.0	22.5	37.5	0.1
75% NPK	30.0	22.5	37.5	0.0
50% NPK +FA	20.0	15.0	25.0	0.1
50% NPK	20.0	15.0	25.0	0.0
25% NPK +FA	10.0	7.5	12.5	0.1
25% NPK	10.0	7.5	12.5	0.0
0% NPK +FA	0.0	0.0	0.0	0.1
0% NPK	0.0	0.0	0.0	0.0

The chemical analysis of fulvic acid according to Lgagro Co. are as follows.

Property	Content
Appearance	Dark brown powder
pH	Netural
Fulvic	80-85%
N	3-5%
P	0.5 – 1%
K	6 – 8%
Amino acids	2 – 3%
Solubility	>99%

The source of nitrogen, phosphours and potassium were ammonium sulphate (20.5%N), calcium superphosphate (15.5% P_2O_5) and potassium sulphate (48% K_2O), respectively. These fertilizers were divided into five equal portions and added weekly as soil application beginning ten days after complete emergence. The other normal agricultural treatments of growing pea plants were practiced the data recorded were as following.

Plant Growth

A random sample of five plants was randomly taken from each plot at 60 days after sowing and the following data were recorded:

Morphological characters

Stem length (cm) and number of both leaves and branches/ plant.

Dry weight

The different plant parts ; i.e., branches and leaves were oven dried at 70°C till constant weight, then dry weight of branches and leaves and total dry weight (leaves +branches)/plant (g) were recorded by A.O.A.C. (1970).

Photosynthetic Pigments

Disk samples from the fourth upper leaf were taken at 60 days after sowing to determine chlorophyll a and b as well as carotenoids according to the method described by Wettestein (1957).

Anatomical Studies

The anatomical studies were carried out only in the second season to follow the changes occuring in pea plants as affected by full dose of fertilizer (100% NPK), half dose of fertilizer (50% NPK) and 50% NPK + fulvic acid. Samples were taken from the fourth internode and the fourth compound leaf after 60 days from sowing.

In the laboratory, samples were cleaned with tap water, cutted into suitable parts, killed and fixed in F.A.A. solution (10 ml.formalin , 5 ml. acetic acid and 85 ml. ethyl alcohol 75%), dehydrated in

ascending different concentrations of ethyl alcohol, clearing in different concentrations of ethyl alcohol + xylene, infiltrated and embedded in pure paraffin wax (M.P.58-60°C) (Johansen, 1940). Sectioning at thickness of 14μ. was performed by using a rotary microtome. Paraffin ribbons were mounted on slides and sections stained with safranin and fast green (Sass, 1961). Sections were mounted in canda balsam, then examined microscopically and microphotographed.

Yield and its Components

Green pods of each plot were harvested at proper maturity stage (90 days after sowing), counted and weighed in each harvest and the following data were recorded:

1. Average number of green pods/ plant,
2. Average green pod weight (g),
3. Yield of green pods / plant (g), and
4. Total yield of green pods/ feddan (Ton).

Pod Quality

Twenty green mature pods were randomly taken from each plot at 3rd harvest and the following data were recorded:

1. Pod length 2. Pod width
3. No. of seeds/pods

Shelling Percentage

It was calculated as follows:

$$\text{Shelling percentage} = \frac{\text{Seeds fresh weight}}{\text{Green pods weight}} \times 100$$

Seed Chemical Constituents

Nitrogen, phosphorus and potassium percentage

They were determined in the seeds on the basis of dry weight according to Bremner and Mulvaney (1982), Olsen and Sommers (1982) and Jackson (1970), respectively.

Total carbohydrates

It was determined according to the method described by Bernfeld (1955) and Miller (1959).

Statistical analysis

All the data were subjected to statistical analysis of variance according to Snedecor and Cochran (1980). Means separation were done by Duncan (1958).

RESULTS AND DISCUSSION

Plant Growth

Presented data in Table 2 show that fertilization of pea plants with

Table 2. Effect of mineral NPK and foliar spray with fulvic acid (FA at 0.1%) on plant growth parameters of pea plants during winter seasons of 2009 and 2010 at 60 days after sowing

Treatments	Stem length (cm)		Leaves No./plant		branches No. /plant		Dry weight (g)	
	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
100% NPK*+FA	39.50 a	39.00 a	12.66 a	12.33 a	4.00 a	3.66 a	4.53 a	3.70 a
100% NPK	38.66 abc	38.60a	12.00 ab	12.00 ab	3.33 ab	3.33 ab	4.06 a	3.26 a
75% NPK +FA	35.83 abc	37.50 a	11.66 ab	11.00 abc	4.00 a	3.66 a	4.36 a	3.46 a
75% NPK	35.00 abc	35.80 ad	11.33 ab	11.33 abc	3.00 ab	3.00 abc	3.53 a	3.00 a
50% NPK +FA	37.00 ab	37.50 a	12.33 a	12.00 ab	3.33 ab	3.33 ab	3.86 a	3.13 a
50% NPK	30.33 abc	32.33 b	10.66 bcd	10.33 cde	2.33 bc	2.33 bc	3.20 a	2.60 a
25% NPK +FA	32.33 abc	32.60 b	10.33 cde	10.66 bcd	2.66 abc	2.33 bc	2.73 a	2.40 a
25% NPK	28.00 bcd	27.30 c	10.00 de	9.66 de	2.66 abc	2.33 bc	2.50 a	2.30 a
0% NPK +FA	24.00 cd	24.43 c	9.66 e	9.33 de	2.00 bc	2.00 d	2.26 a	2.23 a
0% NPK	27.33 d	24.16 c	10.00 de	9.00 e	1.33 c	1.00 e	1.83 a	1.90 a

*; 100% of N, P_2O_5 and K_2O were 40,30 and 50 kg./fed. respectively.
Values having the same letters in the same column are not significantly different at $P < 0.05$

NPK at different rates single or in combinations with foliar spray with fulvic acid (FA) at 0.1% reflected a significant effect on stem length and number of both leaves and branches / plant after 60 days from sowing in both seasons.

Concerning stem length, fertilization with 100% NPK + spraying with FA at 0.1% in both seasons, 100% NPK individual, 75% NPK + spraying with FA at 0.1% and 50% NPK + spraying with FA at 0.1% in the 2nd season gave the tallest plants with no significant differences with 75% NPK, in both seasons and 100% NPK and 75% NPK + spraying with FA at 0.1% in the 1st season only.

As for number of leaves, the obtained results in Table 2 indicate that 100% NPK + spraying with FA at 0.1% in both seasons and 50% NPK + spraying with FA at 0.1% in the 1st season recorded the maximum values of number leaves/plant with no significant differences with 100% NPK, 75%

NPK + spraying with FA at 0.1% and 75% NPK individual in both seasons and 50% NPK + spraying with FA at 0.1% in the 2nd season.

Concerning number of branches/ plant, data in Table 2 show that NPK at 100% or 75% in combination with FA at 0.1% increased number of branches/ plant in both seasons with no significant differences with NPK at 100% individual and NPK at 50% + foliar spray with FA at 0.1%.

With respect to dry weight of shoots, data in Table 2 indicate that mineral N, P and K at different rates with or without foliar spray with FA at 0.1% did not reflect any significant effect on shoot dry weight of pea plants.

From forgoing results, it could be concluded that, fertilization of pea plants with 100% (40, 30 and 50 kg /fed of N,P and K, respectively) or 75% NPK (30,22.5 and 37.5 kg /fed of N,P and K, respectively) single or in combination with foliar spray with FA at 0.1% or 50% NPK of (20,155 and 25 kg/fed of N,P and K, respectively) + foliar spray with FA at 0.1% increased stem length and number of both leaves and branches/ plant.

The stimulative effect of NPK on growth parameters may be due to that N is an essential element for building up protoplasm, amino acids and proteins which induce cell division and initiate meristematic activity. Phosphours is a part of molecular structure of the plant nucleic acids (DNA and RNA), the energy transfer compounds and phosphoproteins. Moreover, potassium is very important in overall metabolism of plant enzymes activity, it was found to serve a vital role in photosynthesis by direct increasing in growth and leaf area and hence CO_2 assimilation. Potassium also has a beneficial effect on water consumption (Mengel and Kirkby, 1978 and Gardenr *et al.*, 1985). These results agree with those reported by Ramachandra *et al.* (1998); Shokr (2000); Kakar *et al.* (2002); Achakzal and Baragulzai (2006) and Pettit (2009).

Photosynthetic Pigments

The obtained data in Table 3 show that mineral NPK at different rates with or without spraying with FA at 0.1% showed a significant effect on chlorophyll a, b and total chlorophyll a+b, except carotenoids in leaf tissues of pea plants.

In general, fertilization of pea plants with N , P and K at 100 or 75% with or without FA at 0.1% and NPK at 50% with FA at 0.1% increased concentration of chlorophyll

Table 3. Effect of mineral NPK and foliar spray with fulvic acid (FA at 0.1%) on photosynthetic pigments of pea plants during winter season 2010 at 60 days after sowing

Treatments	Photosynthetic pigments (mg/ g fresh weight)			
	Chl a	Chl b	Chl (a+b)	Carotenoids
100% NPK*+FA	1.29 ab	1.09 abc	2.38 a	0.61 a
100% NPK	1.29 ab	1.13 ab	2.42 a	0.56 a
75% NPK +FA	1.29 ab	1.15 a	2.45 a	0.60 a
75% NPK	1.24 abc	1.03 bcd	2.27 a	0.42 a
50% NPK +FA	1.30 a	1.08 abc	2.38 a	0.49 a
50% NPK	1.22 bcd	0.97 cd	2.20 ab	0.42 a
25% NPK +FA	1.09 d	0.94 d	1.70 b	0.41 a
25% NPK	1.08 cd	0.92 d	1.73 b	0.40 a
0% NPK +FA	1.13 cd	0.92 d	1.72 b	0.48 a
0% NPK	1.13 cd	0.91 d	1.71 b	0.41 a

*; 100 % of N,P_2O_5 and K_2O were 40,30 and 50 kg /fed. respectively.
Values having the same letters in the same column are not significantly different at $P < 0.05$

a, b and total chlorophyll (a+b), except N, P and K at 75% with respect to chlorophyll b compared to the control and other treatments.

The enhancing effect of NPK on photosynthetic pigments might be due to that N is a constituent of chlorophyll molecule. Moreover, nitrogen is the main constituent of all the amino acids and hence of proteins and lipids as glactolipids, acting as structural components of the cholorplast. Correspondingly, and enhancement of protein synthesiz and cholorplasts formation leads to an increase in chlorophyll as well as carotene (Marschner, 1995). Also, when FA was applied to plant leaves, the chlorophyll content of these leaves increased (Pettit, 2009).

Anatomical Studies

Anatomy of the main stem

Microscopical measurements of certain histological characters of

the fourth internode which resembled the median internode of the main stem of pea cv. Master of control plants (100% NPK) and those of the half dose of fertilizer (50% NPK) and sprayed with fulvic acid on plants grown under the half dose of fertilizers (50% NPK + fulvic acid) are given in Table 4. Likewise, microphotographs depict these treatments are shown in Figure 1.

It is noted that the half dose of fertilizer reduced the area of the main stem of pea cv. Master by 38.7% less than the control. The decrease in stem area could be attributed mainly to the decrease in all included tissues except that of epidermis. The thickness of cortex, vascular cylinder and number of vascular bundle were 15.1, 13.2 and 21.6% less than the control. It is clear that the decrease which was observed in the thickness of vascular cylinder could be attributed, mainly, to the decrease in thickness of fibrous tissue, phloem tissue, xylem tissue, number of vessels per vascular bundle and vessel diameter by 21.3, 6.2, 17.3, 20.4 and 17.9% less than those of the control, respectively.

As the action of foliar spraying with fulvic acid on pea plants grown under the half dose of fertilizer induced by slight increase in all included tissues except that of epidermis. Foliar application with fulvic acid increased the area of stem by 17.5% more than the control. The increase in stem area, due to foliar application with fulvic acid, could be attributed to slight increase in thickness of cortex, vascular cylinder and number of vascular bundle were 4.6, 15 and 2.4% more than those of the control, respectively. It is clear that the increase in the thickness of vascular cylinder could be attributed mainly to the increase in thickness of phloem tissue, xylem tissue, number of vessels per vascular bundle and vessel diameter by 68, 5.7, 3.6 and 7.1% more than those of the control, respectively.

Anatomy of the leaf

Microscopical counts and measurements of certain characters in transverse sections through the blade of leaflet of the fourth compound leaf developed on the main stem of control plants (100% NPK) of pea cv. Master and those of the half dose fertilizer (50% NPK) and (50% NPK + fulvic acid) are given in Table 5. Likewise, microphotographs illustrating these treatments in transverse sections are shown in Figure 2.

Table 4. Counts and measurements in microns of certain histological features in transverse sections through the middle part of the fourth internode of the main stem of pea cv. Master, at the age of 60 days, as affected by (100% NPK, 50% NPK and 50% NPK + fulvic acid)
(Mcans of three sections from three specimens)

Characters	Treatments				
	100% NPK* (control)	50% NPK + fulvic acid (0.1%)	± % to control	50% NPK	± % to control
Stem area	175386.9	206210.4	+ 17.5	107429.3	-38.7
Thickness of epidermis	9.9	9.9	-	9.9	-
Thickness of cortex	85.9	89.9	+4.6	72.9	-15.1
Thickness of vascular cylender	219.7	252.7	+15.0	186.4	-13.2
Thickness of fibrous tissue	49.9	39.9	-21.3	39.9	-21.3
Thickness of phloem tissue	53.3	89.6	+68.0	50.0	-6.2
Thickness of xylem tissue	116.5	123.2	+5.7	96.5	-17.3
Number of vascular bundle	16.6	17.0	+2.4	13.0	-21.6
Number of vessels	8.3	8.6	+3.6	6.6	-20.4
Vessel diameter	27.9	29.9	+7.1	22.9	-17.9

*; 100 % of N,P_2O_5 and K_2O were 40,30 and 50 kg /fed. respectively.

Table 5. Counts and measurements in microns of certain histological features in transverse sections through the blade of the leaflet of the fourth leaf developed on the main stem of pea cv. Master, at the age of 60 days, as affected by (100% NPK, 50% NPK and 50% NPK + fulvic acid)
(Means of three sections from three specimens)

Characters	Treatments				
	100% NPK* (control)	50% NPK + fulvic acid (0.1%)	± % of control	50% NPK	± % of NPK
Thickness of midvein	445.5	449.5	+0.89	349.7	-21.5
Thickness of lamina	278.0	284.4	+2.30	201.6	-27.4
Thickness of palisade tissue	115.8	109.8	+5.20	75.9	-34.5
Thickness of spongy tissue	122.8	139.8	+13.80	95.9	-22.0
Dimensions of the main vascular bundle of midvein:					
Length	122.8	132.8	+8.10	109.8	-10.6
Width	119.8	122.8	+2.50	66.5	-44.4
Number of vessels/midvein bundle	5.0	6.0	+20.00	5.0	-
Vessels diameter	22.9	24.9	+8.70	15.9	-30.5
Thickness of upper epidermis	21.5	24.9	+15.80	19.9	-7.44
Thickness of lower epidermis	17.9	9.9	-44.60	9.9	-44.6

*; 100 % of N,P_2O_5 and K_2O were 40,30 and 50 kg /fed. respectively.

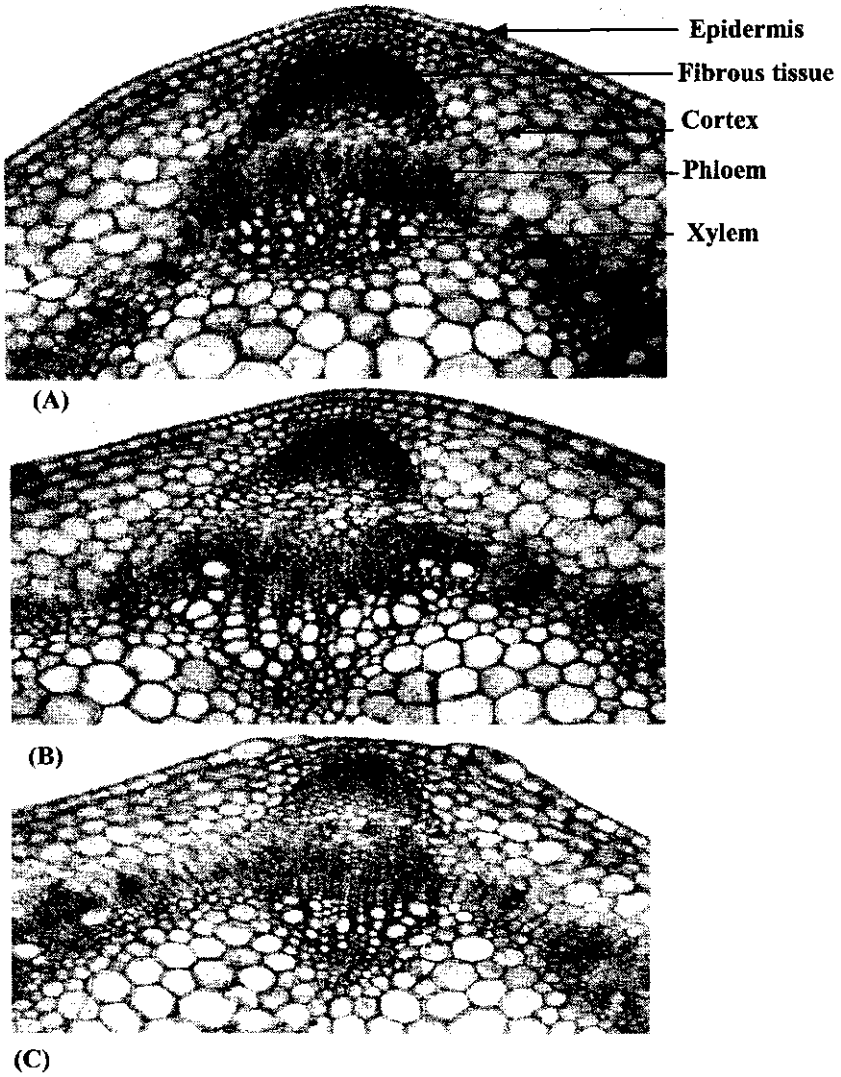

Fig. 1. Transverse sections through the fourth internode of the main stem of pea cv. Master at the age of 60 days, as affected by 100% NPK, 50% NPK + fulvic acid at 0.1% and 50% NPK (100 x)

A- Plant treated with 100% NPK (40, 30 and 50 kg/fed., respectively)

B- Plant treated with 50% NPK + fulvic acid

C- Plant treated with 50% NPK (20, 15 and 25 kg/fed., respectively)

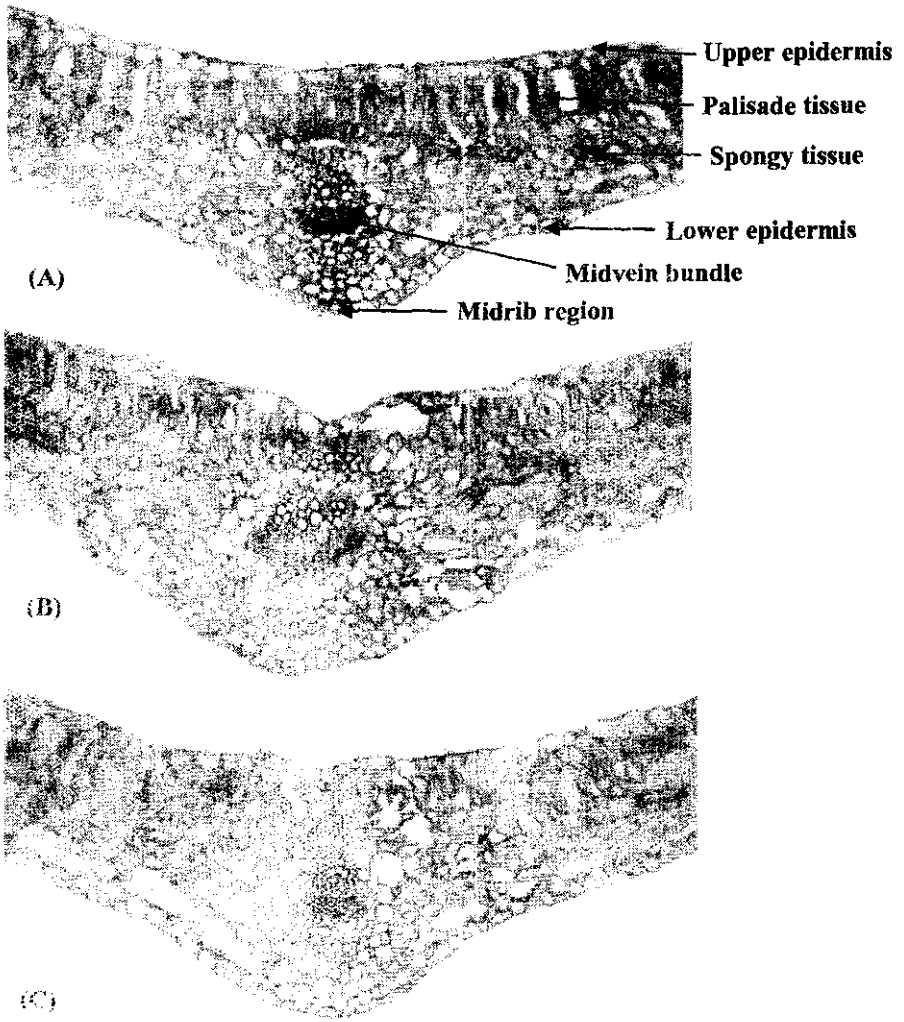

Fig. 2. **Transverse sections through the leaflet blade of the fourth compound leaf developed on the main stem of pea cv. Master at the age of 60 days, as affected by 100% NPK, 50% NPK + fulvic acid at 0.1% and 50% NPK (100x)**

A- Plant treated with 100% NPK (40, 30 and 50 kg/fed., respectively)

B- Plant treated with 50% NPK + fulvic acid

C- Plant treated with 50% NPK (20, 15 and 25 kg/fed., respectively)

It is realized that the half dose of fertilizer reduced the thickness of both midvein and lamina of leaflet blades of pea cv. Master by 21.5 and 27.4% less than the control, respectively. The thinner leaflets induced by 50% NPK could be attributed to the decrease in thickness of epidermis as well as the thickness of mesophyll tissues. The decrements below the control were 7.44, 44.6, 34.5 and 22% for thickness of upper epidermis, lower epidermis, palisade tissue and spongy tissue, respectively. Such treatment decreased the dimensions of midvein bundle below the control by 10.6% in length and by 44.4% in width. Also, the mean diameter of vessel for leaves was decreased by 30.5% less than the control.

As for the action of foliar spraying with fulvic acid on pea plants grown under the half dose of fertilizer induced by increasing in all tissues except that of lower epidermis which showed decrease of 44.6% less than the control. Slight increase in the thickness of midvein and lamina of leaflet blades by 0.89 and 2.3% more than the control, respectively. It is clear that the increase in lamina thickness was accompanied with 15.8, 5.2 and 13.8% increments in thickness of upper epidermis, palisade and spongy tissues compared with the control. The main vascular bundle of the midvein increased in size, the increment was mainly due to the increase in length by 8.1% and in width by 2.5% more than the control. Also, average number of vessels per midvein bundle was increased by 20% over the control. The mean diameter of vessel was increased by 8.7% more than the control.

As for as the author is aware, previous information about the effect of foliar application with fulvic acid on anatomical structure of stem and leaves of pea plants or other species grown under mineral fertilizer (NPK) are not available in the literature.

Yield and its Components

As for average number of green pods/ plant, average pod weight and yield/ plant, presented data in Table 6 show that fertilization of pea plants with different rates of NPK with or without FA at 0.1% increased average number of green pods/plant, average pod weight and yield/ plant in both seasons. In general, fertilization with mineral NPK at 100% (40, 30 and 50 kg/ fed. of N, P and K, respectively) or 75% (30, 22.5 and 37.5 kg/fed. of

Table 6. Effect of NPK and foliar spray with fulvic acid (FA at 0.1%) on yield and its components of pea plants during winter seasons of 2009 and 2010

Treatments	Average number of pods/plant		Average pod weight (g)		Yield / plant (g)		Total yield / fed (Ton)	
	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
100% NPK*+FA	15.70 a	15.80 a	3.49 b	3.17 c	54.80 ab	50.10 a	6.263 a	5.726 a
100% NPK	14.80 ab	14.60 a	3.33 bc	3.19 c	49.36 ab	46.55 ab	5.641 ab	5.310 ab
75% NPK +FA	14.90 a	14.90 a	3.84 a	3.48 a	57.15 a	51.83 a	6.532 a	5.924 a
75% NPK	14.30 ab	14.00 ab	3.17 c	3.17 c	45.28 b	44.33 ab	5.175 b	5.066 b
50% NPK +FA	14.60 ab	14.40 ab	3.65 b	3.33 b	53.33 ab	48.01 ab	6.095 a	5.487 ab
50% NPK	13.08 b	12.60 b	3.53 b	3.35 b	46.23 b	42.33 b	5.285 b	4.838 b
25% NPK +FA	10.70 c	10.50 c	2.11 de	2.36 d	22.60 c	24.73 c	2.583 c	2.826 c
25% NPK	3.90 d	4.07 d	1.83 e	2.17 e	7.16 d	8.85 d	0.818 d	1.011 d
0% NPK +FA	2.60 de	2.90 de	2.43 d	2.31 d	6.33 d	6.70 d	0.743 d	0.768 d
0% NPK	1.80 e	1.90 e	2.79 d	2.44 d	5.03 d	4.63 d	0.723 d	0.697 d

*; 100% of N, P_2O_5 and K_2O were 40, 30 and 50 kg /fed. respectively.
Values having the same letters in the same column are not significantly different at $P < 0.05$

N, P and K, respectively) with or without FA at 0.1% and NPK at 50% (20, 15 and 25 kg/fed. of N, P and K, respectively) with FA at 0.1% recorded the maximum values of average number of pods/ plant, average pod weight and yield/ plant followed by NPK at 50% in both seasons.

The use of NPK +FA at 1% resulted in a corresponding increase in the total yield per plant as well as per faddan and all yield components. This might be related to the favourable effects of NPK and FA at 0.1% on the vegetative growth (Table 2) and photosynthetic pigments (Table 3). That possibly increased the efficiency of photosynthsis and resulted in more pod yield of pea. These results agree with those reported by Ramachandra *et al.* (1998), Shokr (2000), Kakar *et al.* (2002) and Achakzal and Baragulzai (2006).

Pod Quality

Presented data in Table 7 show that mineral fertilization with NPK at different rates with or without FA at 0.1% increased number of seeds/ pod, pod length and pod width compared to the control or spraying with FA at 0.1. In general, NPK at 100 or 75% with or without

Table 7. Effect of mineral NPK and foliar spray with fulvic acid (FA at 0.1%) on green pods quality of pea plants during winter seasons of 2009 and 2010

Treatments	No. of seeds/pod		Pod length (cm)		Pod width (cm)	
	1st season	2nd season	1st season	2nd season	1st season	2nd season
100% NPK*+FA	7.23 a	6.90 a	8.25 a	8.23 a	1.22 a	1.12 a
100% NPK	6.63 ab	6.60 a	7.28 ab	7.70 ab	1.03 bc	1.03 a
75% NPK +FA	6.80 ab	6.86 a	7.64 ab	8.08 a	1.11 ab	1.04 a
75% NPK	6.43 ab	6.13 a	7.31 ab	7.13 b	1.02 bc	0.98 ab
50% NPK +FA	6.63 ab	6.43 a	7.41 ab	7.36 b	0.98 bc	1.03 a
50% NPK	6.16 b	5.80 a	7.25 b	7.25 b	1.00 bc	1.02 a
25% NPK +FA	3.83 c	4.43 b	5.37 c	5.91 c	0.83 e	0.87 bc
25% NPK	3.50 de	3.46 bc	5.33 c	5.33 cd	0.89 de	0.86 bc
0% NPK +FA	3.16 de	3.00 c	4.93 cd	5.16 d	0.83 e	0.81 c
0% NPK	2.70 e	2.60 c	4.35 d	4.28 e	0.80 e	0.80 c

*; 100 % of N, P_2O_5 and K_2O were 40,30 and 50 kg /fed. respectively.
Values having the same letters in the same column are not significantly different at $P < 0.05$

FA at 0.1% and NPK at 50% with FA at 0.1% recorded the maximum values of number of seeds/ pod, pod length and pod width in both seasons.

Shelling Percentage

The obtained results in Table 8 show that fertilization of pea plants with NPK at 100 or 75% with or without FA at 0.1% and NPK at 50% with FA at 0.1% increased seeds fresh weight/10 pods, fresh weight/10 pods, husk fresh weight/ 10 pods and shelling percentage in both seasons.

Seed Chemical Constituents

N, P and K percentage

The obtained results in Table 9 show that fertilization of pea plants with N, P and K at different rates and foliar spray with FA at 0.1% reflected a significant effect on N, P and K contents in seeds.

Fertilization of with 100% NPK or 75% NPK with FA at 0.1% recorded the maximum values of N percentage in seeds with no significant differences with 100% NPK without spraying with FA at 0.1% and 50% NPK with FA at

Table 8. Effect of mineral NPK and foliar spray with fulvic acid (FA at 0.1%) on fresh weight/10 pods (g) seed fresh weight / 10 pods (g), husk fresh weight/10 pods and shelling percentage during winter seasons of 2009 and 2010

Treatments	Fresh weight / 10 Pods (g)		Seed fresh weight / 10 Pods (g)		Husk fresh weight/10 pods		Shelling percentage	
	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
100% NPK*+FA	36.00 a	34.00 a	21.00 a	23.00 a	15.00 ab	11.00 ab	58.33 b	67.65 a
100% NPK	34.00 a	33.00 b	23.00 a	23.00 a	11.00 abc	10.00 abc	67.65 a	69.69 a
75% NPK +FA	41.00 a	33.00 b	25.00 a	23.00 a	16.00 a	11.00 ab	60.98 b	69.69 a
75% NPK	33.00 a	31.00 b	23.00 a	21.00 a	10.00 b	10.00 abc	69.70 a	67.74 a
50% NPK +FA	36.00 a	38.00 a	25.00 a	25.00 a	11.00 abc	13.00 a	69.44 a	65.79 a
50% NPK	36.00 a	34.00 a	23.00 a	23.00 a	13.00 abc	11.00 ab	63.89 b	67.65 a
25% NPK +FA	21.33 b	22.00 c	14.00 b	16.00 b	7.33 cd	6.00 bc	65.64 b	72.73 a
25% NPK	17.00 c	20.00 c	7.00 c	10.00 c	10.00 b	10.00 abc	41.18 c	50.00 b
0% NPK +FA	13.00 c	13.00 d	5.67 c	5.67 cd	7.33 cd	7.33 bc	43.62 c	43.62 c
0% NPK	10.33 d	9.67 d	4.66 c	4.6 d	5.67 d	5.00 c	45.11 c	48.29 bc

*; 100 % of N,P_2O_5 and K_2O were 40,30 and 50 kg /fed. respectively.
Values having the same letters in the same column are not significantly different at P <0.05

Table 9. Effect of mineral NPK and foliar spray with fulvic acid (FA at 0.1%) on Seed chemical constituents of pea during winter seasons of 2009 and 2010

Treatments	Nitrogen %		Potassium %		Phosphorus%		Carbohydrate%	
	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
100% NPK*+FA	1.99 a	2.09 a	1.91 a	1.90 a	0.18 a	0.19 a	54.31 a	52.64 a
100% NPK	1.82 ab	2.01 ab	1.68 b	1.91 a	0.14 c	0.18 ab	52.37 a	50.44 a
75% NPK +FA	1.94 a	2.09 a	1.71 b	1.91 a	0.16 b	0.18 ab	53.52 a	50.44 a
75% NPK	1.80 ab	1.98 bc	1.49 c	1.79 ab	0.14 c	0.17 ab	47.16 b	49.25 ab
50% NPK +FA	1.89 ab	2.04 ab	1.49 c	1.90 a	0.16 b	0.18 ab	49.23 ab	49.76 ab
50% NPK	1.72 bc	1.97 bc	1.49 c	1.55 bc	0.14 c	0.15 b	46.55 b	45.99 bc
25% NPK +FA	1.51 d	1.80 c	1.43 c	1.59 bc	0.13 c	0.16 b	40.34 c	44.02 c
25% NPK	1.57 cd	1.87 bc	1.32 c	1.45 cd	0.14 c	0.16 b	40.10 c	39.12 c
0% NPK +FA	1.21 e	1.18 d	1.11 d	1.24 de	0.11 d	0.11 c	31.96 d	32.24 e
0% NPK	1.02 f	1.00 e	1.10 d	1.01 e	0.10 d	0.10 c	30.96 d	30.12 e

*; 100 % of N, P_2O_5 and K_2O were 40,30 and 50 kg /fed. respectively.
Values having the same letters in the same column are not significantly different at P <0.05

0.1% in both seasons and NPK at 75% without FA at 0.1% in the 1st season.

As for P and K percentage in seeds, the data in Table 7 illustrate that mineral NPK at 100% with FA at 0.1% gave the highest values of P and K content in seeds in both applied seasons without significant differences could be detected with 100% NPK, 75% with or without FA at 0.1% and 50% NPK with FA at 0.1% in the 2nd season only.

Total carbohydrates

Fertilization of pea plants with mineral NPK at different rates with or without foliar spray with FA showed a significant effect on total carbohydrates in seeds as compared to the control (Table 9).

Mineral NPK at 100% with or without FA at 0.1% and NPK at 75% with FA at 0.1% were the best treatments for enhancing total carbohydrates in seeds with no significant differences with NPK at 75 % in the 2nd season and NPK at 50% in both seasons.

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استجابة نباتات البسلة للإحلال الجزئى للتسميد المعدنى بواسطة حمض الفولفيك

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أجريت تجربة خلال موسمين شتويين متتاليين لعامى ٢٠٠٩ و٢٠١٠ فى مزرعة خاصة بمنطقة القنايات، محافظة الشرقية، مصر. وذلك لدراسة تأثير التسميد المعدنى النتروجينى والفوسفاتى والبوتاسى بمعدلات مختلفة والرش بحمض الفولفيك بتركيز ٠,١% على النمو والإنتاجية والصفات التشريحية لأوراق وسيقان نباتات البسلة المنزرعة فى أرض طينية طميية. أدى تسميد نباتات البسلة بمعدل ١٠٠% أو ٧٥% من الموصى به من النتروجين والفوسفور والبوتاسيوم مع الرش أو بدون الرش بحمض الفولفيك (٠,١%) أو بمعدل ٥٠% من الموصى به من النتروجين والفوسفور والبوتاسيوم مع الرش بحمض الفولفيك (٠,١%) إلى زيادة طول النبات، وعدد كل من الأوراق والأفرع على النبات، وتركيز كل من الكلورفيل أ ، ب والكلورفيل الكلى (أ + ب) والكاروتينويدات فى الأوراق، ومتوسط عدد القرون على النبات، ومتوسط وزن القرن، ومحصول النبات، وكذلك نسبة التصافى فى القرون، ومحتوى البذور من النتروجين والفوسفور والبوتاسيوم والكربوهيدرات الكلية مقارنة بالكنترول (بدون تسميد) وكذلك بالمعدلات الأخرى. أما بالنسبة لتأثير الرش بحمض الفولفيك على التركيب التشريحى للمجموع الخضرى لنبات البسلة صنف ماستر، فقد أظهر الرش بهذا الحمض زيادة فى قطر الساق الرئيسية نتيجة حدوث زيادة واضحة فى سمك كل من القشرة والاسطوانة الوعائية وكذلك عدد الجزم الوعائية، كما أدى الرش بحمض الفولفيك إلى حدوث زيادة فى سمك كل من العرق الوسطى، ونصل الوريقة، وقد صاحب الزيادة فى سمك النصل زيادة فى سمك كل من النسيج العمادى والأسفنجى، وكذلك كانت هناك زيادة فى حجم الحزمة الوعائية الرئيسية للعرق الوسطى.