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ORIGINAL ARTICLES

Response of Mungbean Plant (*Vigna radiata* (L.) Wilczek) to Foliar Spray with Ascorbic Acid

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ABSTRACT

Field experiments were carried out at the Agricultural Experiments and Researches Station, Faculty of Agriculture, Cairo University, Giza, Egypt during the two growing seasons of 2010 and 2011 in order to study the influence of foliar spray with various concentrations of ascorbic acid (0, 150, 300, 450 and 600 ppm) on morphological and anatomical characters of vegetative growth, photosynthetic pigments, yield characters and seed quality of mungbean cv. Kawmy 1. The obtained results revealed that foliar application with the relatively low tested concentration of 150 ppm ascorbic acid showed no significant effect on all studied characters of vegetative growth and yield components as well as on photosynthetic pigments and seed quality of mungbean cv. Kawmy 1. By contrast, foliar application with any of the other used three concentrations of ascorbic acid especially higher used ones (450 or 600 ppm) induced significant promotive effects on morphological and yield characters as well as on photosynthetic pigments and on seed protein and total carbohydrates. The maximum significant promotion was obtained when plants of mungbean cv. Kawmy 1 were sprayed twice with 450 ppm ascorbic acid. Such treatment elicited beneficial changes in both vegetative and reproductive characters as well as on photosynthetic pigments and some chemical constituents of the seed, which resulted in higher yield of seeds per plant with high quality. These plants were characterized by longer main stem, which developed more lateral branches and a higher number of pods having more number of seeds of high specific weight and high protein and carbohydrate contents. Also, such plants showed favourable changes in anatomical structure of their stems and leaves. Foliar application with 450 ppm ascorbic acid induced prominent increase in stem diameter due mainly to the increase in thickness of stem wall. The increase in stem wall thickness could be attributed mainly to the prominent increase in thickness of xylem tissue and of parenchymatous area of the pith. Moreover, phloem tissue was increased and xylem vessels had wider cavities, which amounted to more total active conducting area to cope with vigorous growth resulting from treatment with 450 ppm ascorbic acid. Likewise, such treatment increased thickness of both midvein and lamina of leaflet blades of mungbean cv. Kawny1. It was found that the thicker lamina induced by ascorbic acid was mainly due to increase induced in thickness of both palisade and spongy tissues. Also, the main vascular bundle of the midvein was increased in size as a result of spraying ascorbic acid.

Key words: Mungbean, Ascorbic acid, Vegetative growth, Morphology, Anatomy, Photosynthetic pigments, Yield, Seed quality.

Introduction

Pulses are important world food crops because they provide an inexpensive source of vegetable dietary protein. In Egypt, most of pulse crops are grown in winter season such as faba bean (*Vicia faba* L.), lentil (*Lens esculenta* L.), chick pea (*Cicer arietinum* L.), Egyptian lupine (*Lupinus termis* Forssk.) and pea (*Pisum sativum* L.). Some pulses are grown in summer season such as bean (*Phaseolus vulgaris* L.), cow pea (*Vigna sinensis* Savi.) and soybean (*Glycine max* (L.) Merrill). Local production of pulses is not sufficient to meet the increasing demand for human utilization. Therefore, introducing high yielding pulse crops with short growing season is considered as an effective tool for narrowing the food gap in Egypt.

The mungbean (*Vigna radiata* (L.) Wilczek) is a new introduced summer pulse crop in Egypt with short growing season (almost three months) grown principally for its protein – rich edible seeds (Ashour *et al.*, 1992, 1993 and 1995). The mungbean is native to the India. Burma area of Southeast Asia. From Asia, it spread into the Middle East, the pacific Islands, East Africa, Australia and the Americas, but Asia continues to be the region for major production. Protein in the seeds averages around 24% (Poehlman, 1991). Fruitful efforts have been made by Egyptian investigators to benefit from mungbean as a pulse crop to be cultivated under local conditions. These efforts resulted in producing the local mungbean cv. Kawmy 1 being registered and certified

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in 1997 by the Egyptian Ministry of Agriculture. It needs a lot of work to enhance its productivity under local conditions through choosing the optimal agricultural practices.

Recently, a great attention has been focused on the possibility of using natural and safety substances in order to improve plant growth, flowering and fruit setting. In this concern, antioxidants has synergistic effect on growth, yield and yield quality of many plant species. These compounds have beneficial effect on catching the free radicals or the active oxygen (singlet oxygen, superoxide anion, hydrogen peroxide, hydroxyl radicals and ozone) that producing during photosynthesis and respiration processes (Zhang and Klessing, 1997). Leaving these free radicals without chelating or catching leads to lipids oxidation and the loss of plasma membrane permeability and the death of cell within plant tissues. Antioxidants have also an auxinic action. One of the most familiar antioxidants is ascorbic acid which being synthesized in higher plants and affects plant growth and development. It is a product of D-glucose metabolism which affects some nutritional cycles activity in higher plants and play an important role in the electron transport system (Givan, 1979). Many investigators reported that ascorbic acid application resulted in enhancement of growth, yield and chemical constituents of some different plant species. Among of them, Rabie and Negm (1992) and Abdel-Messih and Eid (1999) on wheat, Zahran (1993) and Abdel-Aziz (1999) on lentil, Mahmoud (1994) and Nofal *et al.* (1996) on faba bean, Anton *et al.* (1999) and Abdo and El-Moselhy (2004) on barley, El-Kobisy *et al.* (2005) on pea and Nassar and Abdo (2009) on Egyptian lupine.

Thus, the present investigation is an attempt to through to light more information about the effect of foliar application with different concentrations of ascorbic acid on morphology and anatomy of vegetative growth as well as on photosynthetic pigments, yield characters and seed quality of mungbean cv. Kawmy 1. This would be an effort to trace the beneficial effect for ascorbic acid on productivity of mungbean, if any.

Materials and Methods

The current investigation was carried out at the Agricultural Experiments and Researches Station, Faculty of Agriculture, Cairo University, Giza, Egypt during the two summer seasons of 2010 and 2011 in order to study the response of mungbean plants to foliar application with different concentrations of ascorbic acid.

Seeds of mungbean cv. Kawmy 1 were procured from Field Crops Research Institute, National Research Center, Dokki, Giza, Egypt.

Ascorbic acid was sprayed at concentrations of 150, 300, 450 and 600 ppm. The control plants were sprayed with tap water.

Field work procedure:

Field experiment was carried out in each of the two growing seasons. Seeds of mungbean were sown on 12th May 2010 in the first season and replicated on 8th May 2011 in the second one to provide the experimental plant materials. The experiment was made in a randomized complete block design with three replicates. The four levels of ascorbic acid beside the control required that the experimental land of each replicate be divided into five plots, each contained one treatment. The plot was six ridges, four meters long, 60 cm apart, and hills were spaced at 20 cms distance. Seeds were hand sown in the two sides of the ridge with four seeds per hill. Three weeks after sowing, the plants were thinned to two plants per hill. Land preparation, fertilizer application and cultural operations followed the normal practices of mungbean cultivation.

Ascorbic acid was applied by means of an atomizer sprayer after five weeks from sowing (the age of 6-7 leaf stage) and repeated two weeks later (plants at the beginning of flowering stage). Volume of spraying solution was 2.5 liters per plot in the first application and it was 3.5 liters per plot in the second one. This volume was adequate to wet the plants of the plot thoroughly, and excess solution was dripping. Tween 20 at 0.5% as wetting agent was added to the ascorbic acid solutions.

Recording of data:

Investigations involved data pertaining to morphology and yield performance of mungbean cv. Kawmy 1 as affected by different concentrations of ascorbic acid in both studied seasons. Investigations involved also data pertaining to stem and leaf anatomy of the studied cultivar in addition to photosynthetic pigments of leaves and certain biochemical constituents of seeds yielded from treated and untreated plants. Anatomical and physiological studies were carried out on specimens taken from plants of the second season. The procedure of recording the various data was carried out in the following manner:

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A- Morphological characters:

A random sample of five plants was taken for investigation in each plot, *i.e*., a total number of 15 plants was fixed for each treatment at the age of 75 days from sowing date. Data on morphological characters were recorded on individual plants as follows:
1- Plant height (cm), measured from the cotyledonary node up to the upper most point of the plant.
2- Main stem length (cm), measured from the cotyledonary node up to the shoot apex.
3- Number of internodes of the main stem.
4- Number of branches / plant.
5- Number of leaves / plant.
6- Total leaf area $(cm)^2$ / plant, measured by means of LI-3000 A portable area meter.
7- Dry weight of shoot (g) / plant. All above ground parts of the plant were chopped and placed in paper bag. The bages with their contents were dried in the oven at 70^oC till constant weight was reached.

B- Anatomical studies:

It was intended to carry out a comparative microscopical examination on plant material, which showed the most prominent response of plant growth to investigated treatments. Specimens of mungbean cv. Kawmy 1 were taken from the eighth internode which resembled the median internode of the main stem as well as from the terminal leaflet of the corresponding leaf. Plants used for examination were taken throughout the second season of 2011 at the age of 75 days from sowing date. Specimens from the stem and leaves were killed and fixed for at least 48 hrs. in F.A.A. (10 ml formalin, 5 ml glacial acetic acid and 85 ml ethyl alcohol 70%). The selected materials were washed in 50% ethyl alcohol, dehydrated in a normal butyl alcohol series, embedded in paraffin wax of melting point 56^oC, sectioned to a thickness of 20 microns, double stained with crystal violet-erythrosin, cleared in xylene and mounted in Canada balsam (Nassar and El-Sahhar, 1998). Sections were read to detect histological manifestations of noticeable responses resulted from spraying with ascorbic acid compared to control and photomicrographed.

C- Determination of photosynthetic pigments:

Photosynthetic pigments were determined quantitatively in upper most leaves developed on the main stem and on lateral branches of treated and untreated plants in the second season of 2011 at the age of 75 days from sowing date. For this purpose, a random sample of two plants was taken for investigation in each plot; *i.e*., a total number of six plants was fixed for each treatment. Photosynthetic pigments (chlorophyll a, chlorophyll b and carotenoids) were extracted by using dimethyl formamide and determined according to Nornai (1982) as mg/g fresh weight of mungbean leaves.

D- Yield characters:

A random sample of ten plants was assigned for investigation in each plot; *i.e*., a total number of 30 plants was fixed for each treatment. The plants were taken from the middle region of the plot at harvest time, 95 days from sowing date, in both studied seasons. Data on yield characters were recorded on individual plants as follows:
1- Number of mature dried pods / plant.
2- Number of seeds / plant.
3- Specific weight of seeds (g), using ten random samples from each of the three replicates, each comprised of 1000 seeds.
4- Yield of seeds (g) / plant.

E- Biochemical studies:

Chemical analysis of seeds (seed quality) was performed at harvest time on seeds obtained from untreated and treated plants of mungbean cv. Kawmy 1 in the second season of 2011. Percentages of crude protein and total carbohydrates were determined as follows:

1- Determination of crude protein:

Total nitrogen content was determined using the modified micro-Kjeldhahl method described by Pregl (1945). Nitrogen content of seeds was multiplied by 6.25 to calculate the crude protein content (Anon., 1999).

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2- Determination of total carbohydrates:

Total carbohydrates were determined spectrophotometrically (as glucose) after acid hydrolysis using phenol sulphuric acid reagent (Dubois *et al*., 1956).

Statistical analysis:

Data on morphological and yield characters as well as on photosynthetic pigments and seed quality were subjected to conventional methods of analysis of variance according to Snedecor and Cochran (1982). The least significant difference (L.S.D.) for each character was calculated at 0.05 level of probability.

Results and Discussion

I- Morphological characters:

Data on morphological characters of vegetative growth of mungbean cv. Kawmy 1 as affected by foliar application with different concentrations of ascorbic acid in two growing seasons are given in Table (1).

1- Plant height:

Data presented in Table (1) clearly show that all adopted concentrations of ascorbic acid, except that of 150 ppm, promoted significantly height of mungbean plant in both studied seasons. The maximum height was achieved at 450 ppm ascorbic acid (Fig. 1), being 29.8 and 32.0% more than height of untreated plants in the first and second season; respectively.

Table 1: Morphological characters of vegetative growth of mungbean cv. Kawmy 1, at the age of 75 days from sowing date, as affected by foliar application with different concentrations of ascorbic acid in two growing seasons (2010 and 2011)

Treatments	Conc.	Morphological characters						
	Ppm	Plant height (cm)	Main stem length (cm)	No. of internodes	No. of branches/plant	No. of leaves /plant	Total leaf area (cm^2)/plant	Shoot dry weight (g)/plant
First season of 2010								
Control	0	109.2 c	77.8 c	14.9	9.3 c	36.2 c	5183.5 c	118.6 c
Ascorbic acid	150	111.4 c	76.2 c	15.1	9.6 c	37.1 c	5323.8 c	120.4 c
	300	128.1 b	90.4 b	14.9	10.6 b	40.4 b	5894.5 b	131.9 b
	450	141.7 a	99.5 a	14.8	11.4 a	42.8 a	6517.2 a	145.2 a
	600	140.5 a	99.1 a	15.4	11.2 ab	42.8 a	6492.7 a	143.1 a
L.S.D. (0.05)		10.4	7.9	n.s.	0.62	2.19	473.1	10.8
Second season of 2011								
Control	0	114.6 c	81.9 c	15.6	8.4 c	34.7 c	4695.2 c	101.4 c
Ascorbic acid	150	112.8 c	78.5 c	15.2	8.5 c	34.5 c	4716.6 c	102.1 c
	300	132.5 b	91.6 b	15.8	9.6 b	38.2 b	5312.2 b	113.2 b
	450	151.3 a	101.8 a	15.6	10.2 a	40.5 a	5783.5 a	122.9 a
	600	145.9 a	99.5 ab	16.1	10.2 a	40.4 a	5739.2 a	121.7 ab
L.S.D. (0.05)		12.1	8.8	n.s.	0.56	2.08	392.5	9.2
Means having the same letter are not significantly different at 0.05 level.								

2- Length of the main stem:

It is realized from Table (1) that foliar application with the relatively low used concentration of 150 ppm ascorbic acid showed no significant effect on main stem length of mungbean plant in both studied seasons. By contrast, any of the other three sprayed concentrations of ascorbic acid (300, 450 and 600 ppm) induced significant promotion in this concern. The maximum increase in main stem length was recorded at 450 ppm ascorbic acid, being 27.9 and 24.3% more than that of the control in the first and second season; respectively.

3- Number of internodes of the main stem:

Results in Table (1) reveal that all tested concentrations of ascorbic acid had no significant effect on number of internodes of the main stem in both studied seasons.

4- Number of branches / plant:

It is clear from Table (1) that all assigned concentrations of ascorbic acid, except that of 150 ppm, increased significantly the number of branches developed per mungbean plant in both studied seasons. The maximum increase was observed at 450 ppm ascorbic acid, being 22.6 and 21.4% more than that of the control in the first and second season; respectively.

5- Number of leaves / plant:

Data given in Table (1) indicate that foliar application with the relatively low used concentration of 150 ppm ascorbic acid had no significant effect on number of leaves per mungbean plant in both studied seasons. Whereas, all other tested concentrations of ascorbic acid showed significant increase in this respect. The maximum increase in number of leaves per plant was detected at 450 ppm ascorbic acid, being 18.2 and 16.7% over the control plants in the first and second season; respectively.

Fig. 1: Habit of mature plants, 75 days old, of mungbean cv. Kawmy 1 as affected by foliar application with ascorbic acid.
A- Control plant.
B- Plant treated with 450 ppm ascorbic acid.

6- Total leaf area / plant:

It is clear from Table (1) that the effect of foliar application with the assigned concentrations of ascorbic acid on total leaf area per mungbean plant showed the same trend that previously mentioned about the effect of ascorbic acid on number of leaves developed per the same plant. The relatively low sprayed concentration of 150 ppm had no significant effect on total leaf area per plant in both studied seasons. By contrast, any of the other three sprayed concentrations (300, 450 and 600 ppm ascorbic acid) induced significant increase in this concern. The maximum increase in total leaf area per mungbean plant was recorded at 450 ppm, being 25.7 and 23.2% more than total leaf area per untreated plant in the first and second season; respectively.

7- Dry weight of shoot (g)/plant:

It is realized from Table (1) that all sprayed concentrations of ascorbic acid, except that of 150 ppm, showed significant promotive effect on shoot dry weight per mungbean plant in both studied seasons. The maximum increase was detected at 450 ppm ascorbic acid, being 22.4 and 21.2% more than shoot dry weight per untreated plant in the first and second season; respectively.

From the above mentioned results about the effect of foliar application with different concentrations of ascorbic acid on morphological characters of vegetative growth of mungbean cv. Kawmy 1, it could be stated that most of the applied concentrations especially high used ones (450 and 600 ppm) promoted significantly morphological characters (plant height, main stem length, number of branches/plant, number of leaves/plant, total leaf area/plant and dry weight of shoot/plant). The maximum promotion was achieved at 450 ppm ascorbic acid.

These results are in agreement with those reported by Mahmoud (1994) on wheat and faba bean, who stated that foliar application with 500 ppm ascorbic acid showed significant positive effect on most of the growth characters. In this respect, Nofal *et al.* (1996) pointed out that shoot and root of faba bean plant responded significantly to ascorbic acid application as seed soaking and / or foliar spray. Likewise, Abdel-Aziz (1999) on lentil reported that foliar application with 500 ppm ascorbic acid increased significantly plant height, number of branches and dry weight of plant. Also, Anton *et al.* (1999) and Abdo and El-Moselhy (2004) on barley stated that ascorbic acid especially at 500 ppm increased plant height and number of tillers/m^2. In this concern, El-Kobisy *et al.* (2005) found that ascorbic acid at concentration of 200, 400 or 800 ppm induced significant promotive effect on vegetative growth characters (main stem length, number of internodes of the main stem and number of branches/plant) of pea cv. Little Marvel. Likewise, Nassar and Abdo (2009) on Egyptian lupine found that foliar application with ascorbic acid especially at 400 or 600 ppm induced significant promotive effect on vegetative growth characters (plant height, main stem length, number of internodes of the main stem and number of branches/plant). All, being in accordance with the present findings.

II- Anatomical studies:

It was aimed in this investigation to follow up the internal structure of vegetative growth which exhibited the most noticeable response to tested treatments. The aforementioned findings concerning the morphological characters of vegetative growth of mungbean cv. Kawmy1 proved that foliar application with 450 ppm ascorbic acid achieved the most remarkable effects among various tested concentrations of ascorbic acid. This may justify a further study on the spraying effect with 450 ppm ascorbic acid on the internal structure of mungbean cv. Kawmy 1.

Microscopical characters were examined through specimens of the eighth internode of the main stem as well as of the terminal leaflet of the corresponding leaf. Sampling was carried out during the second season of 2011 at the age of 75 days.

1- Anatomy of the main stem:

Microscopical measurements of certain histological characters in transverse sections through eighth internode of the main stem of mungbean cv. Kawmy 1 sprayed with 450 ppm ascorbic acid and those of control are given in Table (2). Likewise, microphotographs illustrating these treatments are shown in Figure (2).

Table 2: Measurements in microns of certain histological characters in transverse sections through the middle part of the eighth internode of the main stem of mungbean cv. Kawmy 1, at the age of 75 days from sowing date, as affected by foliar application with 450 ppm ascorbic acid (Means of three sections from three specimens).

Histological characters	Treatments		
	Control	450 ppm ascorbic acid	± % to control
Stem diameter	8625.9	9755.7	+ 13.1
Stem wall thickness	2803.6	3842.1	+ 37.0
Epidermis thickness	21.4	23.6	+ 10.3
Cortex thickness	164.9	145.8	- 11.6
Fiber strands thickness	109.8	97.2	- 11.5
Phloem tissue thickness	264.2	281.7	+ 6.6
Xylem tissue thickness	1089.4	1531.5	+ 40.6
Vessel diameter	53.8	64.2	+ 19.3
Parenchymatous pith thickness	1154.5	1742.8	+ 51.0
Hollow pith diameter	3013.7	2059.6	- 31.7

It is clear from Table (2) and Figure (2) that foliar application with 450 ppm ascorbic acid increased stem diameter by 13.1% over the control. This increment in stem diameter was mainly due to the prominent increase in thickness of stem wall by 37.0% over the control. Nevertheless, a noticeable decrease of 31.7% in diameter of hollow pith was recorded below the control. The increase in stem wall thickness could be attributed mainly to the prominent increase in thickness of xylem tissue by 40.6% over the control and in thickness of parenchymatous area of the pith by 51.0% more than that of the control. Moreover, xylem vessels had wider cavities, being 19.3% more than the control, which amounted to more total active conducting area to cope with vigorous growth resulting from treatment with 450 ppm ascorbic acid. Likewise, the thickness of epidermis and of phloem tissue were increased by 10.3 and 6.6% over those of the control; respectively. However, a decrement of 11.6% in thickness of cortex and of 11.5% in thickness of fiber strands below the control was observed as a result of ascorbic acid treatment.

In this respect, El-Kobisy *et al*. (2005) recorded favourable anatomical effects for ascorbic acid at concentration of 400 ppm when sprayed twice to pea plants. Such favourable effects resulted in increasing stem diameter due mainly to increasing in thickness of stem wall which resulted from increasing in thickness of cortex as well as in number and size of vascular bundles. Moreover, a prominent increase in vessel diameter of treated plants over the control was recorded. Likewise, Nassar and Abdo (2009) studied the effect of foliar application with 400 ppm ascorbic acid on anatomy of the main stem of Egyptian lupine cv. Giza 2. They stated that such treatment induced prominent increase in stem diameter due mainly to the increase in thickness of stem wall and in diameter of hollow pith. The increase in stem wall thickness could be attributed to the prominent increase in thickness of all included tissues (epidermis, cortex, fiber strands, vascular tissue and parenchymatous area of the pith), being partially in agreement with the present findings.

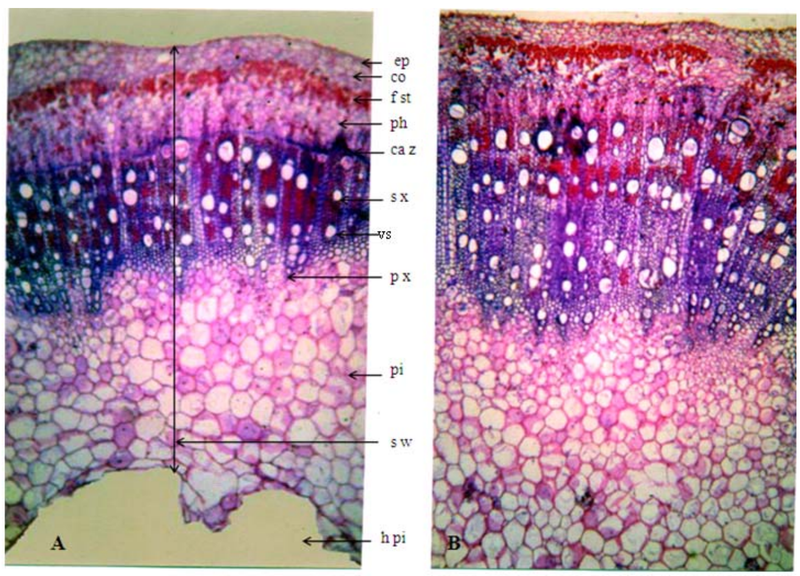

Fig. 2: Transverse sections through eighth internode of the main stem of mungbean cv. Kawmy 1, at the age of 75 days, as affected by foliar application with ascorbic acid. (x 52)

A- From untreated plant (control).

B- From plant sprayed with 450 ppm ascorbic acid.

Details: ca z, cambium zone; co, cortex; ep, epidermis; f st, fiber strands; h pi, hollow pith; ph, phloem; pi, pith; p x, primary xylem; s w, stem wall; s x, secondary xlem and vs, vessel.

2- Anatomy of the leaflet blade:

Microscopical counts and measurements of certain histological characters in transverse sections through the blade of the terminal leaflet of the eighth compound leaf developed on the main stem of control plants of mungbean cv. Kawmy 1 and of those sprayed with 450 ppm ascorbic acid are presented in Table (3). Likewise, microphotographs illustrating these treatments are shown in Figure (3).

It is obvious from Table (3) and Figure (3) that ascorbic acid at 450 ppm resulted in leaflets thicker than that of the control. This effect was attributed to the increase induced in thickness of both midvein and lamina of leaflet blades by 30.8 and 32.2% more than those of the control; respectively. It is clear that the thicker lamina induced by ascorbic acid treatment was mainly due to increase in thickness of both palisade and spongy tissues by 33.7 and 24.9% over the control; respectively. Data also indicated that the main vascular bundle of the midvein was increased in size as a result of spraying ascorbic acid. The increment was mainly due to the increase in length by 5% and in width by 4.2% as well as in its number of vessels by 12.5% over the control.

Moreover, xylem vessels had wider cavities, being 15.4% more than the control, which amounted to more total active conducting area to cope with vigorous growth resulting from treatment with 450 ppm ascorbic acid.

Table 3: Counts and measurements in microns of certain histological features in transverse sections through the blade of terminal leaflet of the eighth compound leaf developed on the main stem of mungbean cv. Kawmy 1, at the age of 75 days from sowing date, as affected by foliar application with 450 ppm ascorbic acid (Means of three sections from three specimens).

Histological characters	Treatments		
	Control	450 ppm ascorbic acid	± % to control
Midvein thickness	1298.4	1697.9	+ 30.8
Lamina thickness	199.8	264.2	+ 32.2
Palisade tissue thickness	84.2	112.6	+ 33.7
Spongy tissue thickness	75.9	94.8	+ 24.9
Dimensions of the main vascular bundle of midvein:			
Length	398.6	418.5	+ 5.0
Width	479.5	499.4	+ 4.2
Number of vessels / midvein bundle	32.0	36.0	+ 12.5
Vessel diameter	27.2	31.4	+ 15.4

In this concern, El-Kobisy *et al.* (2005) on pea as well as Nassar and Abdo (2009) on Egyptian lupine found that foliar application treatment with 400 ppm ascorbic acid resulted in leaflets thicker than those of the control. Such effect was attributed to the increase induced in thickness of both leaflet lamina and midvein, being in accordance with the present findings.

III- Photosynthetic pigments:

Results concerning the effect of foliar application with different concentrations of ascorbic acid on chloroplast pigments in leaves of mungbean plants aged 75 days in the second growing season of 2011 are presented in Table (4).

It is noted from Table (4) that the relatively low used concentration of 150 ppm ascorbic acid had no significant effect on concentration of chlorophyll a, chlorophyll b and carotenoids. The other three rest concentrations of ascorbic acid (300, 450 and 600 ppm) showed significant promotive effect on photosynthetic pigments, except the effect of 300 ppm ascorbic acid on carotenoids which proved insignificant. The maximum significant increase in concentration of photosynthetic pigments was detected at 450 ppm ascorbic acid, being 28.7% more than the concentration of chlorophyll a in leaves of control plants, 25.5% more than the concentration of chlorophyll b in leaves of control plants and 13.5% more than the concentration of carotenoids in leaves of control plants.

Table 4: Photosynthetic pigments (mg/g fresh weight) in leaves of mungbean cv. Kawmy 1, at the age of 75 days from sowing date, as affected by foliar application with different concentrations of ascorbic acid in the second growing season of 2011.

Treatments	Conc.	Photosynthetic pigments (mg/g F.W.)		
	ppm	Chlorophyll a	Chlorophyll b	Carotenoids
Control	0	3.407 c	1.096 b	0.836 c
Ascorbic acid	150	3.512 c	1.108 b	0.844 bc
	300	3.947 b	1.293 a	0.887 abc
	450	4.385 a	1.376 a	0.949 a
	600	4.279 a b	1.358 a	0.921 ab
l.s.d. (0.05)		0.346	0.125	0.084
Means having the same letter (s) are not significantly different at 0.05 level.				

The previous report of Abdo and El-Moselhy (2004) stated that photosynthetic pigments (Chl.a, Chl.b, Chl. a+b and carotenoides) in leaves of barley plants showed significant positive response to ascorbic acid application at 300 or 600 ppm, being in agreement with the present findings.

IV- Yield characters:

Data on yield characters of mungbean cv. Kawmy 1 as influenced by spraying various concentrations of ascorbic acid in two growing seasons are given in Table (5). The investigated traits included number of pods/plant, number of seeds/plant, weight of 100 seeds (g) and yield of seeds (g)/plant.

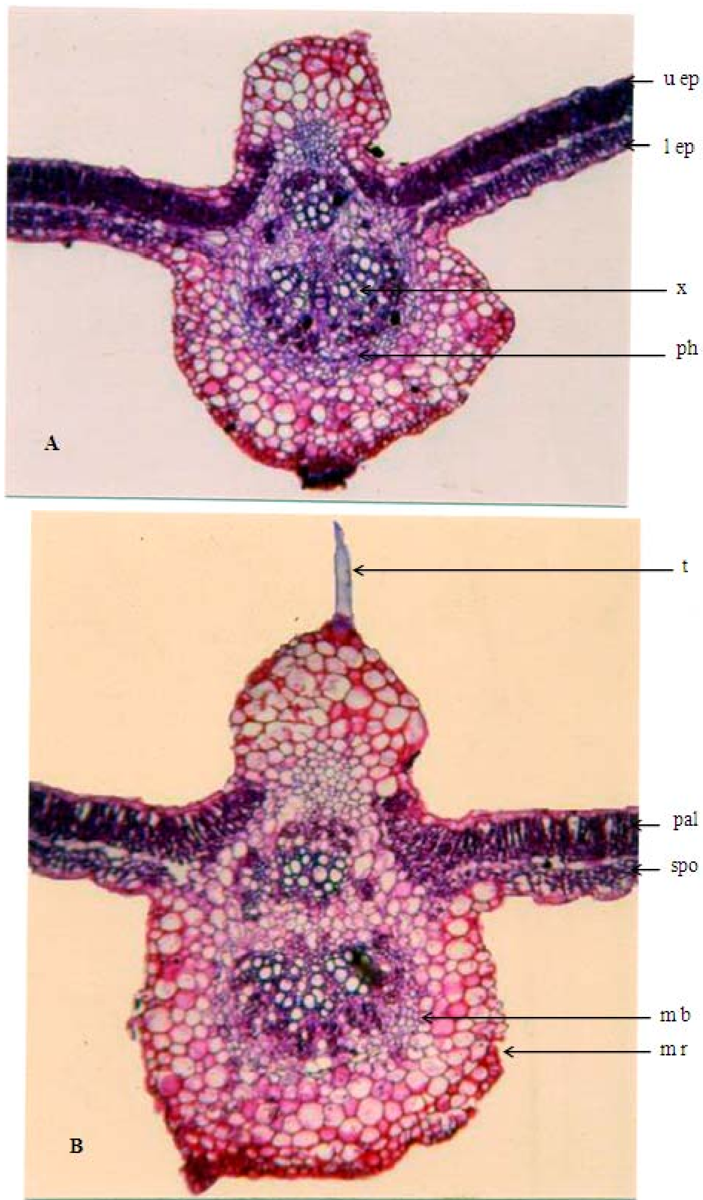

Fig. 3: Transverse sections through the blade of terminal leaflet of the eighth compound leaf developed on the main stem of mungbean cv. Kawmy 1, at the age of 75 days, as affected by foliar application with ascorbic acid. (X 52)

A- From untreated plant (control).

B- From plant sprayed with 450 ppm ascorbic acid.

Details: l ep, lower epidermis; m b, midvein bundle; m r, midrib region; pal, palisade tissue; ph, phloem; spo, spongy tissue; t, trichome; u ep, upper epidermis and x, xylem.

1- Number of pods / plant:

It is realized from Table (5) that the untreated plants recorded a number of 94.6 pods in the first season and of 85.2 pods in the second one which was differed significantly with most of the investigated treatments. The relatively low used concentration of 150 ppm ascorbic acid showed no significant effect on number of pods developed per mungbean plant in both studied seasons. On the other hand, any of the other three sprayed concentrations of ascorbic acid (300, 450 and 600 ppm) increased significantly the number of pods per plant. The highest number (121.8 pods/plant in the first season and 113.1 pods/plant in the second one) was obtained at 450 ppm ascorbic acid, being 28.8% more than the number of pods per untreated plant in the first season and 32.8% more than the number of pods per untreated plant in the second one.

Table 5: Yield characters of mungbean cv. Kawmy 1, at the harvest time (95 days from sowing date), as affected by foliar application with different concentrations of ascorbic acid in two growing seasons (2010 and 2011).

Treatments	Conc. ppm	Yield characters			
		No. of pods / plant	No. of seeds / plant	Weight of 100 seeds (g)	Yield of seeds (g) / plant
First season of 2010					
Control	0	94.6 c	1115.3 c	4.91 b	53.88 c
Ascorbic acid	150	97.2 c	1136.1 c	4.83 b	54.22 c
	300	110.5 b	1271.6 b	4.94 b	61.53 b
	450	121.8 a	1412.9 a	5.36 a	72.41 a
	600	119.3 ab	1377.4 a	5.29 a	69.85 a
L.S.D. (0.05)		9.2	103.7	0.34	6.76
Second season of 2011					
Control	0	85.2 c	964.7 c	4.78 c	46.25 c
Ascorbic acid	150	81.7 c	935.3 c	4.74 c	43.18 c
	300	96.5 b	1104.7 b	4.81 bc	54.24 b
	450	113.1 a	1289.2 a	5.19 a	64.62 a
	600	109.7 a	1263.6 a	5.08 ab	62.83 a
L.S.D. (0.05)		8.7	99.4	0.28	5.69
Means having the same letter are not significantly different at 0.05 level.					

2- Number of seeds per plant:

It is obvious from Table (5) that the effect of foliar application with the assigned concentrations of ascorbic acid on number of seeds per mungbean plant showed the same trend that previously mentioned about the effect of such antioxidant on number of pods per the same plant. The relatively low sprayed concentration of 150 ppm ascorbic acid had no significant effect on number of seeds per plant in both studied seasons. Whereas, any of the other three sprayed concentrations induced significant increase in this respect. The maximum increase in number of seeds per mungbean plant was achieved at 450 ppm ascorbic acid, being 26.7 and 33.6% more than that of the control in the first and second season; respectively.

3- Specific weight of seeds (average weight of 100 seeds):

Data presented in Table (5) clearly show that the first two sprayed concentrations of ascorbic acid (150 and 300 ppm) showed no significant effect on specific weight of mungbean seeds in both studied seasons. By contrast, the rest two sprayed concentrations of ascorbic acid (450 and 600 ppm) increased significantly average weight of 100 seeds and the difference between these two used concentrations was insignificant in both studied seasons. The maximum increase in specific weight of seeds was recorded at 450 ppm ascorbic acid, being 9.2% more than the control in the first season and 8.6% more than the control in the second one.

4- Yield of seeds per plant:

It is noted from Table (5) that the effect of foliar application with the adopted concentrations of ascorbic acid on seed yield per mungbean plant showed the same trend that previously mentioned for number of pods and seeds per plant. The relatively low tested concentration of 150 ppm ascorbic acid showed no significant effect on seed yield per plant of mungbean cv. Kawmy 1 in both studied seasons. By contrast, any of the other three sprayed concentrations of ascorbic acid (300, 450 and 600 ppm) induced significant increase in this respect. The maximum increase in seed yield per plant was detected at 450 ppm ascorbic acid, being 34.4 and 39.7% more than seed yield per control plant in the first and second season; respectively.

From the aforementioned results concerning the effect of foliar application with various concentrations of ascorbic acid on yield characters of mungbean cv. Kawmy 1, it could be stated that seed yield per plant, being the outcome of various components; *i.e.,* number of pods per plant, number of seeds per plant and specific weight of seeds showed high response to most of the investigated treatments especially when ascorbic acid was foliary sprayed at relatively high used concentration of 450 or 600 ppm. It was found that ascorbic acid at 450 ppm gave a maximum significant promotive effect on yield and yield components of mungbean cv. Kawmy 1. Similar results were also reported by Zahran (1993) and Abdel-Aziz (1999) on lentil and by Mahmoud (1994) and Nofal *et al.* (1996) on faba bean as well as by Anton *et al.* (1999) and Abdo and El-Moselhy (2004) on barley and by El-Kobisy *et al.* (2005) on pea. Likewise, Nassar and Abdo (2009) stated that ascorbic acid at 400 ppm induced maximum significant promotive effect on yield characters of Egyptian lupine plant. The treated plants had higher number of pods and higher number of seeds of high specific weight compared to the untreated ones, being in agreement with the present findings.

V- Seed quality:

Chemical analysis was performed on mature dried seeds, at harvest time of the second season, of mungbean cv. Kawmy 1 as affected by foliar application with various concentrations of ascorbic acid. For each treatment, chemical analysis was done to determine the percentage of crude protein and of total carbohydrates(Table 6). Such quantitative determinations were used to disclose the qualitative changes in mungbean seeds as a result of spraying plants with ascorbic acid.

1- Crude protein:

It is realized from Table (6) that foliar application with the relatively low used concentration of 150 ppm ascorbic acid showed no significant effect on the percentage of crude protein in seeds of mungbean. Whereas, any of the other three used concentrations of ascorbic acid 300, 450 and 600 ppm increased significantly the percentage of crude protein. Worthy to note that the highest percentage of crude protein (23.92%) was recorded in seeds of plants treated with 450 ppm ascorbic acid against 21.08% crude protein in seeds of untreated plants.

In this connection, El-kobisy *et al.* (2005) stated that foliar application with ascorbic acid at concentration of 200, 400 or 800 ppm on pea cv. Little Marvel increased significantly the percentage of crude protein in seeds of sprayed plants. Likewise, Nassar and Abdo (2009) found that ascorbic acid at concentration of 400 or 600 ppm increased significantly the percentage of crude protein in seeds of Egyptian lupine cv. Giza 2. All, being in harmony with the present findings.

Table 6: Percentages of crude protein and total carbohydrates in mature dried seeds of mungbean cv. Kawmy 1 as affected by foliar application with different concentrations of ascorbic acid in the second growing season of 2011.

Treatments	Conc. ppm	Crude protein %	Total carbohydrates %
Control	0	21.08 c	59.73 b
Ascorbic acid	150	20.95 c	61.02 b
	300	23.67 a	64.94 a
	450	23.92 a	65.28 a
	600	22.31b	63.47 a
L.S.D. (0.05)		1.15	2.39
Means having the same letter are not significantly different at 0.05 level.			

2- Total carbohydrates:

Data presented in Table (6) clearly show that the relatively low tested concentration of 150 ppm ascorbic acid had no significant effect on the percentage of total carbohydrates in seeds of mungbean cv. Kawmy 1. On the other hand, any of the other three sprayed concentrations of ascorbic acid (300, 450 and 600 ppm) induced significant increase in this respect and the differences among the three tested concentrations proved insignificant. The highest percentage (65.28%) was recorded in seeds of plants sprayed with 450 ppm ascorbic acid compared to 59.73% total carbohydrates in seeds of untreated plants.

In this respect, Abdo and El-Moselhy (2004) found that ascorbic acid when foliary sprayed on barley plants at concentration of 600 ppm resulted in significant increase in the percentage of total carbohydrates in grains of sprayed plants, being in line of the present findings. By contrast, El-Kobisy *et al.* (2005) stated that foliar application with ascorbic acid at concentrations of 100, 200, 400 and 800 ppm on pea plants cv. Little Marvel showed no significant effect on the percentage of total carbohydrates in seeds of treated plants when compared to the control, being in contradiction with the present findings.

References

Abdel-Aziz, E.A., 1999. Response of two lentil varieties to foliar spray with micronutrients mixture and ascorbic acid. J. Agric. Sci., Mansoura Univ., 24(10): 5575-5585.

Abdel-Messih, S.G. and M.A.M. Eid, 1999. Response of wheat crop to different levels of nitrogen fertilizer and foliar spray with ascorbic acid. Egypt. J.Appl. Sci., Zagazig Univ., 14(2): 132-142.

Abdo, Fatma A. and M.A. El-Moselhy, 2004. Response of barley plant to foliar spray with ascorbic acid under different levels of nitrogen application. Egypt. J. Appl., Zagazig Univ., 19(2): 111-128.

Anon., 1995. Official Methods of Analysis of the Association of the Official Analytical Chemists (A.O.A.C.). 16th Edit., Published by A.O.A.C., Washington D.C.

Anton, N.A., A.S. Abdel-Nour and E.A. Abdel-Aziz, 1999. Response of barley to ascorbic, citric acids and micronutrients mixture under sandy soil condition. Zagazig J. Agric. Rec., 26(6): 1553-1563.

Ashour, N.I., T.G. Behairy, M.M. Selim and E.M. Abdel-Lateef, 1992. Mungbean (*Vigna radiata* Roxb.)-A new introduced crop in Egypt. 2- Varietal differences in growth and yield. Proc. 5th Conf. Agron., Zagazig 13-15 Sept., 1: 361-370.

Ashour, N.I., T.G. Behairy, E.M. Abdel-Lateef and M.M. Selim, 1993. Mungbean (*Vigna radiata* (L.) Wilczek) a new introduced crop in Egypt. 1- Effect of planting date on growth and yield. Bull. NRC, Egypt, 18: 298-304.

Ashour, N.I., S.H. Abou-Khadrah, M.E. Mosalem, G.M. Yakout, M.E. Zedan, E.M. Abdel-Lateef, T.G. Behairy, M.W. Hassan, G.G. Darwish and M.Z. El-Hifny, 1995. Introduction of mungbean (*Vigna radiata* (L.) Wilczek) in Egypt. 2- Effect of genotype, planting density and localization on mungbean yield. Egypt. J. Agron., 20: 99-108.

Dubois, M., K.A. Gilles, J.K. Hamilton, P.A. Rebers and F. Smith, 1956. Colorimetric method for determination of sugars and related substances. Analytical Chemistry, 28(3): 350-356.

El-Kobisy, O.S., K.A. Kady, R.A. Medani and R.A. Agamy, 2005. Response of pea plant (*Pisum sativum* L.) to treatment with ascorbic acid. Egypt. J. Appl. Sci., Zagazig Univ., 20(6A): 36-50.

Givan, G.V., 1979. Metabolic detoxification of ammonia in tissues of higher plants. Phytochemistry, 18: 375-382.

Mahmoud, M., 1994. Physiological studies on the nutrition of some economic plants. M.Sc. thesis, Fac. Agric., Cairo Univ.

Nassar, Dalia M.A. and Abdo, Fatma A., 2009. Response of Egyptian lupine plant (*Lupinus termis* Forssk.) to foliar application with ascorbic acid. Egypt. J. Appl. Sci., Zagazig Univ., 24(4B): 415-434.

Nassar, M.A. and K.F. El-Sahhar, 1998. Botanical Preparations and Microscopy (Microtechnique). Academic Bookshop, Dokki, Giza, Egypt, 219 pp. (In Arabic).

Nofal, M.A., K.M. Khalil, K.G. Assy and I.A. Ibrahim, 1996. Effect of ketoglutaric, malic and ascorbic acid applied as seed soaking and / or foliar spray on growth and nutrients composition of faba bean plant. Egypt. J. Appl. Sci., Zagazig Univ., 11(7): 340-352.

Nornai, R., 1982. Formulae for determination of chlorophyllous pigments extracted with N.N. Dimethyl Formamide. Plant Physiol., 69: 1371-1381.

Poehlman, J.M., 1991. The Mungbean. Westview Press, USA, p. 1-11.

Pregl, F., 1945. Quantitative Organic Microanalysis. 4th Edit., J. and A. Churchill Ltd., London.

Rabie, M.H. and A.Y. Negm, 1992. Effect of ascorbic acid and nickel on wheat production. Proc. 5th Conf. Agron. Zagazig, 13-19 Sept., 1: 29-36.

Snedecor, G.W. and W.G. Cochran, 1982. Statistical Methods. The Iowa State University Press. 7th Edit., 2nd Printing, 507.

Zahran, F.A., 1993. Studies on fertilization in lentil. Ph. D. Thesis, Fac. Agric., Al-Azhar Univ., Cairo, Egypt.

Zhang, S. and D.F. Klessing, 1997. Salicylic acid activities a 48-KOMAP Kinase in tobacco. Plant Cell, 9: 409-424.