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EFFECT OF SOIL TREATMENT WITH EFFECTIVE MICRO-ORGANISMS AS BIOFERTILIZER ON MORPHOLOGICAL CHARACTERS, YIELD AND ANATOMICAL STRUCTURE OF POTATO PLANT (*Solanum tuberosum* L.)

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ABSTRACT

The present study was conducted on potato plant (*Solanum tuberosum* L. cv. Spunta) during the two successive seasons of 2002 and 2003, using five concentrations of EM1 stock solution (1, 5, 10, 15 and 20 ml/L) compared with control plants. The first three concentrations of EM1 induced significant increases in plant height, number of stems/plant, number of leaves/plant, total leaf area / plant, number of tubers / plant and weight of tubers / plant, in both studied seasons. Treatment 5 ml EM1/L gave the highest values in most of the investigated morphological and yield characters compared to control plants. While, the other used two concentrations of 15 and 20 ml EM1/L induced significant decrease in all of the previous studied characters.

Anatomical studies were made on plants treated with 5 and 15 ml EM1/L which gave the extreme differences in morphological characters compared with control. Treatment of 5 ml EM1/L gave the thickest roots, stems and leaves.

INTRODUCTION

Potato (*Solanum tuberosum* L.) is one of the most important vegetable crops grown in Egypt, belongs to the family Solanaceae which includes about 90 genera and 2000 species (Cobley, 1976), distributed in the tropical and temperate regions. Potato plant is an annual herbaceous and succulent with branched stem. The plants have two types of stems; aerial stems and subterranean ones (Stolons and tubers) which are rich in starch and vitamins (B and C), and used for human food and livestock feed (Cutter, 1992).

Using biofertilizers in potato production in Egypt to produce safety yield and free of harmful chemicals and toxic materials is well recommended to take place in European market, and to have the consumer who is willing to pay high price for healthy safe product. Effective Microorganisms Stock Solution (EM1) is one of many biofertilizers used in this concern. EM1 as a biofertilizer was first used in Japan by Teuro Higa (1995), it contains a group of benificial microorganisms (primarily photosynthetic and lactic bacteria, yeast, actinomycetes and fermenting fungi) which are cultured and used for many purposes; a) promotes germination, flowering, fruiting and ripening in plants, b) improves physical, chemical and biological environments of the soil and suppresses soil borne pathogens and pests; c) enhances the photosynthetic capacity of crops; d) ensures better germination and establishment, and e) increases the efficacy of organic matter as fertilizer.

EM1does not contain any genetically modified microorganisms, as it is prepared from made up of mixed cultures of microbial species that are

found in natural environments worldwide. Effective Microorganisms Stock Solution EM1 is one of EM group (EM1 stock solution, EM5 solution, EM Bokaski and EM fermented plant extract) can be applied by two ways; watering into the soil and foliar spray.

Generally, biofertilizers are microbial preparations containing, primarily, sufficient numbers of potent strains of microorganisms, having a definite beneficial role in furnishing a proper rhizosphere for plant growth (Abou-Hussein, *et al.,* 2002). Quastel (1965) reported that soil microorganisms known as phosphate solubilizing bacteria (PSB) play a fundamental role in converting P fixed form to be soluble and available for plant nutrition. As well as the microbial breakdown of soil organic matter is associated with an increased CO_2 production which possibly increases the solubility of soil phosphate. Kundu and Gaur (1980) concluded that potato inoculated with culture suspensions of *Bacillus polymyxa* and *Pseudomonas straite* gave the higher yield. Rabinovich *et al.,* (1999) reported that increased doses of biofertilizers for potato raised high concentration of denitrificating microorganisms. Chettri *et al.*, (2003) observed that the growth and tuber yield of potato increased significantly due to the effect of plant growth promoting bacteria (PGPB).

This study was carried out to investigate the effect of Effective Microorganisms Stock Solution (EM1) on morphology, yield and anatomy of potato plants.

MATERIALS AND METHODS

The current investigation was conducted at the Agricultural Experiments and Research Station, Faculty of Agriculture, Cairo University, Giza, Egypt, during the two successive growth seasons of 2002 and 2003 to study the effect of Effective Microorganisms Stock Solution (EM1) on the morphological, anatomical and yield of *Solanum tuberosum* L. cv. Spunta. Tuber seeds of potato were obtained from the Co-operative Society of Potato Growers, Egypt.

The stock solution of EM1 was introduced from Japan by Department of Pharmacology, Faculty of Pharmacy, Cairo University.

Planting dates of tuber seeds were at the first of February in both seasons (2002 and 2003). The type of soil of the experimental field was loamy clay soil. The layout of the experiment was randomized complete block design in three replicates for each treatment. The experimental plot comprised 5 rows, 4 meters long and 80 cm in width. The soil was inoculated by five EM1 concentrations, i.e., 1, 5, 10, 15 and 20 ml EM1/L, at the time of sowing; thereafter whole potato tubers weighing 45-60g. were sown in hills 30 cm apart and covered with soil. Beside the control treatment where no inoculation was carried for the soil. Thereafter, three inoculations of EM1 were carried out at the ages of 30, 45 and 60 days from sowing date. Normal fertilization and irrigation recommended for potato plants were applied.

Recording of data:

The current investigation involved studies pertaining to morphological and yield characters as well as anatomical characteristics of potato plant cv. Spunta as affected by EM1. A random sample of five plants was assigned for investigation in each plot; i.e., a total of 15 plants was fixed for each treatment at harvest time (120 days from sowing date). Plants were chosen from the median region of the plot. The following morphological and yield characters were investigated.

1- Plant height (cm), measured from the soil surface to the uppermost point of the plant.
2- Number of stems / plant.
3- Stem diameter (mm), at the median internode of the tallest stem, was measured by using a callipper.
4- Number of leaves / plant.
5- Leaf area (cm^2) / plant, measured by using leaf area meter (L1-3000 mod.).
6- Number of tubers / plant.
7- Weight of tubers (g) / plant.

Statistical analysis:

Data on morphological and yield characters of potato cv. Spunta in both studied seasons were subjected to conventional methods of analysis of variance according to Snedecor and Cochran (1982). The least significant difference of each character was calculated.

Anatomical studies:

Specimens were taken at the second season, from plants 60 days old, for treatments 5 and 15 ml EM1 / L as well as control ones for comparison.

Specimens were taken from adventitious roots, second internode below the shoot apex, basal internode, petiole and leaflet lamina of the third foliage leaf. Stolon and mature tubers at harvest, 120 days from sowing, were also studied.

All specimens were killed and fixed for at least 48 hours in F.A.A. (10 ml formalin, 5 ml glacial acetic acid, 85 ml ethyl alcohol 70%), washed in 50% alcohol, dehydrated in a normal butyl alcohol series and embedded in paraffin wax of melting point 58^{o} C (Sass, 1958).

Cross sections of 20 μ thick were cut and stained by crystal violet / erythrosine combination, and mounted in Canada balsam (Nassar and El-Sahhar, 1998).

Sections were microscopically analysed and photomicrographed.

RESULTS AND DISCUSSION

1- Morphological and yield characters:

The mean values of morphological and yield characters of potato cv. Spunta as affected by different levels of EM1 in two seasons are given in Table (1).

Table (1) : Morphological and yield characters, at maturity (120 days from sowing date), of *Solanum tuberosum* L. cv. Spunta as affected by different concentrations of Effective Microorganisms Stock Solution (EM1) in two successive seasons of 2002 and 2003.

Characters	First season of 2002							Second season of 2003						
	EM1 concentrations (ml/L)						L.S.D. (0.05)	EM1 concentrations (ml/L)						L.S.D. (0.05)
	0.0	1	5	10	15	20		0.0	1	5	10	15	20	
Plant height (cm)	74.6	83.9	86.8	84.2	63.9	63.5	7.92	78.8	89.1	92.3	88.9	67.4	66.7	8.57
No. of stems / plant	13.1	15.8	16.2	16.0	11.1	11.2	1.52	12.9	15.9	16.0	15.4	11.2	11.3	1.49
Stem diameter (mm)	12.4	12.2	12.6	12.4	11.5	11.4	Ns	12.3	12.4	12.7	12.1	11.4	11.5	Ns
No. of leaves / plant	118.2	132.4	139.8	137.1	103.9	97.2	11.97	122.7	137.9	140.6	138.4	105.2	99.8	12.83
Total leaf area (cm^2) plant	9237	11085	12114	10768	8327	8149	884.0	10481	12249	12306	11975	8752	8497	962.0
No. of tubers / plant	8.6	9.5	10.2	9.6	7.8	7.9	0.69	8.4	9.6	10.1	9.4	7.5	7.4	0.72
Weight of tubers (g)/plant	960.6	1087.8	1139.3	1074.2	836.0	845.5	94.8	915.6	1065.4	1141.3	1054.7	738.5	732.9	88.5

The investigated characters, at harvest time, included plant height (cm), number of developed aerial stems per plant, diameter of the tallest stem (mm), number of leaves per plant, total leaf area (cm^2) per plant, number of tubers per plant and yield of tuber (g) per plant.

Results presented in Table (1) clearly show that the first three assigned concentrations of EM1 induced significant increases in most of the investigated morphological characters and all yield characters of potato cv. Spunta in both studied seasons, and the differences among the first three used concentrations (1, 5 and 10 ml EM1 / L) proved almost indifferent. The highest values were detected at concentration of 5 ml EM1 / L which gave maximum significant increase over the control by 16.4 and 17.1% for plant height, 23.7 and 24.0% for number of aerial stems developed per plant, 18.3 and 14.6% for number of leaves per plant, 31.2 and 17.4% for total leaf area per plant, 18.6 and 20.2% for number of tubers per plant and 18.6 and 24.7% for yield of tubers per plant in the first and second seasons; respectively. By contrast, the other two used concentrations of EM1; i.e., the relatively two high used concentrations of 15 and 20 ml EM1 / L decreased significantly the previously mentioned characters in both studied seasons, and the difference between these two concentrations proved insignificant.

The present findings on the effect of relatively low and median assigned concentrations of EM1 on morphological and yield characters of potato cv. Spunta were in agreement with those found by Abdel-Ati, (1998) (using 15 m^3/fed. chicken manure); Abou-Hussien, (1995) (using chicken manure, 10 m^3 / fed. combined with cattle manure 30 m^3, in sandy soil) and Abou-Hussien *et al.*, (2002) [using chicken manure, compost and biofertilizer, (suspension from Yeast, *Pseudomonas* and Bacteria dissolving phosphate)]; Bhattacharya *et al.*, (2004) [using Hizyme (a biofertilizer containing essential amino acid) at the rate of 20 and 25 kg / ha combined with NPK and farmyard manure 10 t/ha]; Chettri *et al.*, (2003) [using plant growth promoting bacteria (PGPB) *Bacillus cereus* and *B. subtilis*]; El-Gamal, (1996) [using 200 kg N/ fed + HALEX2 (a mixture of N-fixing bacteria of the genera *Azotobacter, Azospirillum* and *Klebsiella*)]; Ghosh and Das, (1998) [using biofertilizers and growth regulators together (Buckup, Electra, Bioplin, Micrin and Vitormone as biofertilizers, and protein hydrolysate as plant growth regulators)]; Indiresh *et al.*, (2003) (using combined inoculation of both *Azotobacter chroococum* and *Pseudomonas striate*); Kamala and Singh, (2001) (using *Azotobacter* and phosphoinoculants culture separately); Mahendran and Kumar, (1998) (using the recommended NPK + soil inoculation with *Azospirillum* and phosphobacteria); Pandey and Kumar, (1989) (using *Azotobacter* and *Azospirillum* with or without NPK); and Singh and Sharma, (2002) (using phosphorus solubilizing biofertilizer for inoculation seed tubers prior to planting). All the previous investigators worked on potato plants.

II- Anatomical studies:

1- Anatomical structure of the root:

The anatomical structure of the adventitious roots at the age of 45 days showed obvious differences between both treatments (5 and 15 ml EM1/L) and control plants. Epidermis cells in control root were ruptured in

many places, while in treated plants, epidermis was present and complete with large cells and tangentially elongated. Epidermis thicknesses were 20.8, 45.4 and 38.9 μ for control plant, 5 ml EM1/L treatment and 15 ml EM1/L treatment; respectively. Cortex cells were compact in control plants and were large with irregular thin-walled and intercellular spaces in treated plants, their average thickness measurements recorded 111.6, 162.3 and 159.7 μ in the same order stated before. The average numbers of cortex layers were 5-6 for control plants and 6-7 for both treatments 5 and 15 ml EM1/L. The innermost layer of the cortex was the endodermis where the casparian strips were not easily detected. The stele type was pentarch and the metaxylem vessels occupied the center of the section where secondary growth was found in this age. This is in harmony with the description stated by Hayward (1938). The diameters of vascular cylinder were 1185.1, 1103.3 and 698.3 μ for control, 5 and 15 ml EM1/L treatments; respectively. The thicknesses of phloem were 103.8, 94.8 and 90.9 μ in the same sequence. The whole diameter of the root recorded 1453.5, 1571.3 and 1123.9 μ for control, 5 and 15 ml EM1/L treatments; respectively, Fig. (1 a,b and c) and Table (2).

Table (2): Means of measurements (μ) and counts of different tissues in cross sections of the adventitious roots of *Solanum tubersoum* L. treated with Effective Microorganisms Stock Solution (EM1) and control plants (Averages of 10 readings).

Characters	EM1 concentrations (ml/L)		
	0.0	5.0	15.0
Epidermis thickness	20.8	45.4	38.9
Cortex thickness	111.6	162.3	159.7
No. of cortex layers	5-6	6-7	6-7
Vascular cylinder diameter	1185.1	1103.3	698.3
Phloem thickness	103.8	94.8	90.9
Root diameter	1453.5	1571.3	1123.9

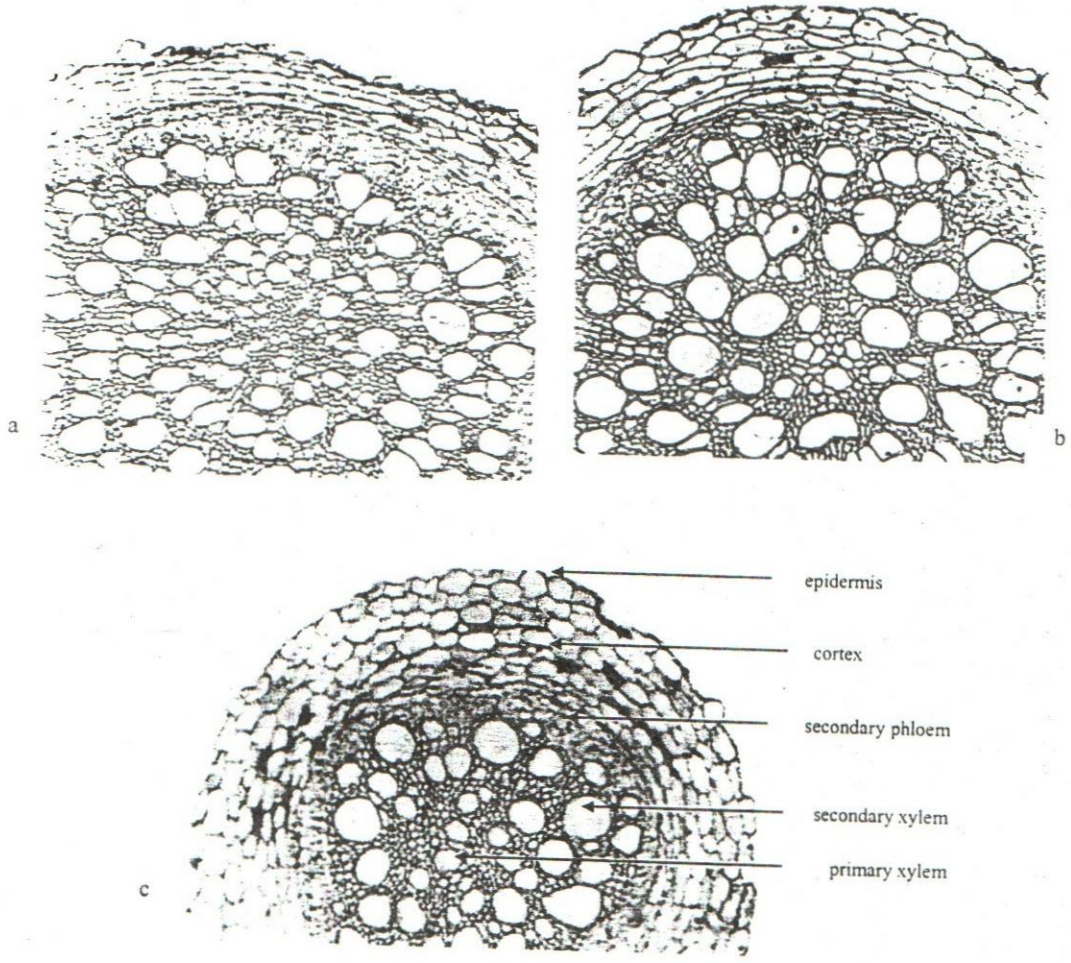

Fig. (1): Transections through the adventitious roots of potato plant cv. Spunta, at the age of 60 days, as affected by treatments with biofertilizer EM1. (X 65)
a) Control plant b) Treatment of 5 ml EM1/L,
and c) Treatment of 15 ml EM1/ L

2- Anatomical structure of the stems:

a) Aerial stem:

1- Structure of the second internode.

Fig. (2 a, b and c) and Table (3) give the details of the anatomical structure of the second internode below the shoot apex of *Solanum tuberosum* L. treated with EM1 stock solution and control plants. The cross sections in treatments and control were quadrangular in shape, and the epidermis layer was covered with a thin cuticle layer, and their cells were nearly square or slightly tangential elongated. Averages of epidermis thickness were 32.5 μ in both control and treatment of 15 ml EM1/L, while in treatment of 5 ml EM1/L it was 29.3 μ. The cortex consisted of thin-walled cells with small intercellular spaces, the outer layers were chlorenchymatous underlying the epidermis, except at the corners where angular collenchyma was present. The average numbers of chlorenchyma layers ranged between 4-6, 5-6 and 4-5 layers, and their thicknesses were 107.3, 165.8 and 117.0 μ in control, 5 and 15 ml EM1/L treatments; respectively. The average numbers of parenchyma layers ranged between 4-5 layers in both control and 5 ml EM1/L treatment, and between 7-9 in 15 ml EM1/L treatment, and their thicknesses were 204.8, 442.0 and 344.5 μ in the same order stated before. Cortex thickness was 308, 612.7 and 466.2 μ in the same sequence.

The vascular cylinder consisted of 5 large major bundles located opposite the corners of the stem, with some minor ones between each two major bundles. The bundles were endarch and bicollateral, forming a dictyostele. The minor bundles adjacent to the major bundles were larger than the far ones those which farer. Measurements of thickness of vascular cylinder were 820.7, 958.8 and 715.0 μ, in control, 5 and 15 ml EM1/L treatments, respectively. Averages of external and internal phloem thicknesses of the major bundles were 175.5 and 240.5 μ for control, 182.0 and 344.5 μ for 5 ml EM1/L and 204.8 and 195.0 μ for 15 ml EM1/L treatment. Xylem thickness of major bundle recorded 383.5, 419.5 and 276.3 μ, in the same sequence. Measurements of minor bundles for external and internal phloem were 117.0 and 240.5, 130.0 and 182.0, and 107.3 and 139.8 μ, in control, 5 and 15 ml EM1/L treatments; respectively, while xylem thickness recorded 269.8, 240.5 and 250.3 μ, in the same order.

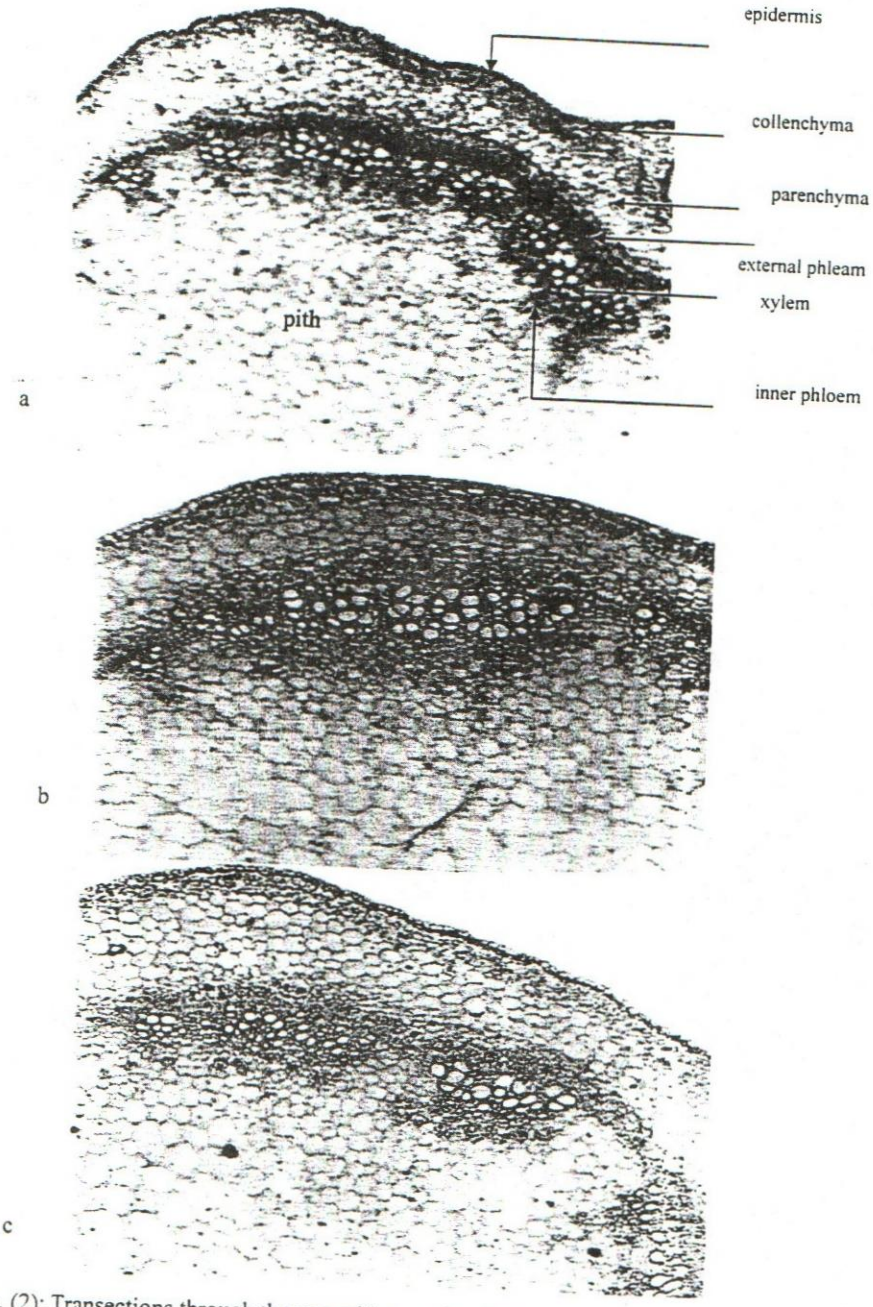

Fig. (2): Transections through the second internodes directly below the shoot apex of potato plant cv. Spunta, at the age of 60 days, as affected by treatments with biofertilizer EM1. (X 35)
a) Control plant b) Treatment of 5 ml EM1/L, and
c) Treatment of 15 ml EM1/ L

Table (3): Means of measurements (μ) and counts of different tissues of the second internode below the shoot apex of *Solanum tuberosum* L. treated with EM1 stock solution and control plants (Averages of 10 readings)

Characters	EM1 concentrations (ml/L)		
	0.0	5.0	15.0
Epidermis thickness	32.5	29.3	32.5
Chlorenchyma thickness	107.3	165.8	117.0
Parenchyma thickness	204.8	442.0	344.5
Cortex thickness	308.8	612.7	466.2
Vascular cylinder thickness	820.7	958.8	715.0
Thickness of external phloem of major bundle	175.5	182.0	204.8
Thickness of internal phloem of major bundle	240.5	344.5	195.0
Thickness of xylem of large bundle	383.5	419.3	276.3
Thickness of external phloem of minor bundle	117.0	130.0	107.3
Thickness of internal phloem of minor bundle	240.5	182.0	139.8
Thickness of xylem of small bundle	269.8	240.5	250.3
Pith diameter	3412.5	3900.0	4030.0
Stem diameter	5741.8	7120.2	6465.5
No. of large vascular bundles	5	5	5
No. of small vascular bundles	9-10	6-7	8-9
No. of chlorenchyma layers of the cortex	4-6	5-6	4-5
No. of parenchyma layers of the cortex	4-5	4-5	7-9
No. of xylem rows of large bundle	27.8	22.0	28.3
No. of xylem vessels of large bundle	140.0	145.7	211.7
No. of xylem rows of small bundle	7.4	8.0	8.3
No. of xylem vessels of small bundle	39.5	28.4	61.0

The average numbers of xylem rows in major bundles were 27.8, 22.0 and 28.3 rows; and their average numbers of vessels were 140.0, 140.7 and 211.7 vessels, in control, 5 and 15 ml EM1/L treatments; respectively. On the other hand, the average numbers of xylem rows of minor bundles were 7.4, 8.0 and 8.3 rows, and their average numbers of vessels were 39.5, 28.4 and 61.0 vessels, in the same sequence. Measurements of pith diameter were 3412.5, 3900.0 and 4030.0 μ in control, 5 and 15 ml EM1/L treatments; respectively. The whole diameter of the second internode recorded 5741.8, 7120.2 and 6465.5 μ, in the same order. The description for the structure of the second internode is in harmony with that of Hayward (1938) and McCauley and Evert (1988).

2- Structure of the basal internode

Fig. (3 a,b and c) and Table (4) show the average measurements of tissues of basal internode for control and treatments with 5 and 15 ml EM1/L stock solution. The results indicated that, the average of epidermis thickness was 32.5 μ for both control and EM1 treatments. The average numbers of chlorenchyma layers ranged between 4-5, 6-7 and 4-6 layrs, and their average thicknesses were 149.5, 243.8 and 217.8μ, in control, 5 and 15 ml EM1/L treatments; respectively.

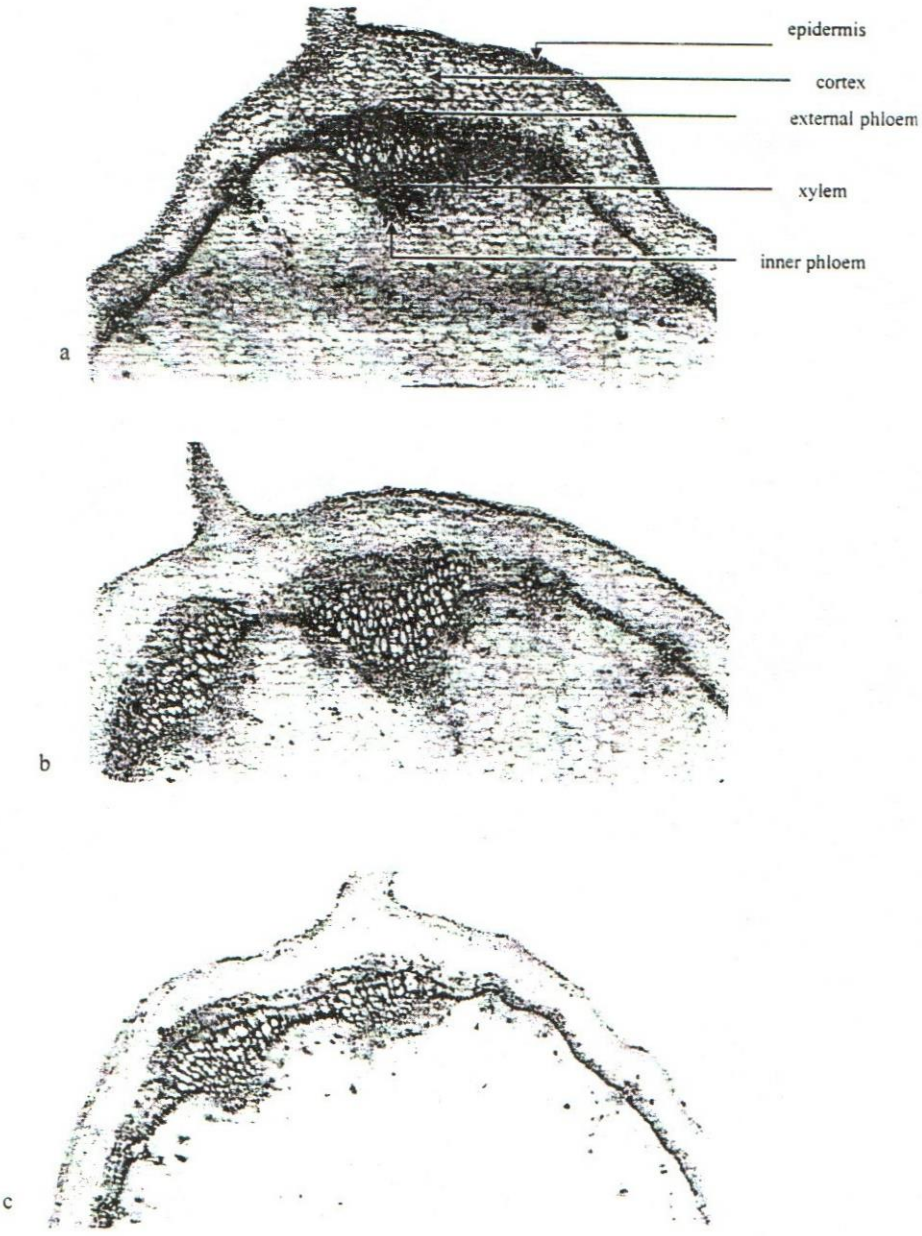

Fig. (3): Transections of the basal internodes of 60 days old plants of potato cv. Spunta as affected by treatments with biofertilizer EM1. (X 15)
a) Control plant b) Treatment of 5 ml EM1/L, and
c) Treatment of 15 ml EM1/ L

Numbers of parenchyma layers ranged between 4-6, 5-7 and 5-7 layers and their thicknesses recorded 312.0, 383.5 and 464.8 μ in the same order. Concerning cortex thickness, it reached 480.3, 649.7 and 692.5 μ, in the same order stated before. As for vascular cylinder, a continuous cylinder of vascular tissues are formed by the development of intervascicular cambium, the secondary growth includes in addition to the increase in number of minor bundles, increasing in size of major ones. Averages of thickness of vascular cylinder recorded 1268.5, 2106.0 and 1368.5 μ, for control, 5 and 15 ml EM1/L treatments; respectively. External and internal phloem thicknesses recorded 269.8 and 299.0 for control; 399.8 and 650.0 for 5 ml EM1/L and 315.3 and 351.0 μ for 15 ml EM1/L. While, xylem thicknesses were 692.3, 1033.5 and 692.3 μ in the same sequence. The previous description for the basal internode is in accordance with those given by Hayward (1938) and Cutter (1992).

Table (4): Means of measurements (μ) and counts of different tissues of the basal internodes of *Solanum tuberosum* L. plants treated with EM1 Stock Solution and control (Averages of 10 readings).

Characters	EM1 concentrations (ml/L)		
	0.0	5.0	15.0
Epidermis thickness	32.5	32.5	32.5
Chlorenchyma thickness	149.5	243.8	217.8
Parenchyma thickness	312.0	383.5	464.8
Cortex thickness	480.3	649.7	692.5
Vascular cylinder thickness	1268.5	2106.0	1368.5
External phloem thickness	269.8	399.8	315.3
Internal phloem thickness	299.0	650.0	351.0
Xylem thickness	692.3	1033.5	692.3
No. of collenchyma layers of the cortex	4-5	6-7	4-6
No. of parenchyma layers of the cortex	4-6	5-7	5-7

b) Subterranean stems:

1- Structure of the stolon.

Fig. (4 a,b and c) and Table (5) show the microscopical measurements (μ) and counts of different tissues of stolon and mature tuber. It is clear that, the stolon shape was round and the epidermal cells were round or slightly elongated towards the cortex tissue and was covered with thin cuticle layer. Epidermis thicknesses were 32.5, 28.6 and 27.3 μ in control, 5 and 15 ml EM1 / L treatments; respectively. Measurements of cortex thickness were 389.4, 369.9 and 324.5 μ in the same order. Cells of cortex and pith tissues had thin walls, small intercellular spaces and had many starch grains. Vascular cylinder type was bicollateral, external and internal phloem thicknesses recorded 94.8 and 81.8 for control, 134.9 and 71.4 for 5 ml EM1/L and 83.1 and 72.7 μ for 15 ml EM1/L. While, xylem thicknesses were 79.2, 63.6 and 80.5 μ in control, 5 and 15 ml EM1 / L treatments; respectively.

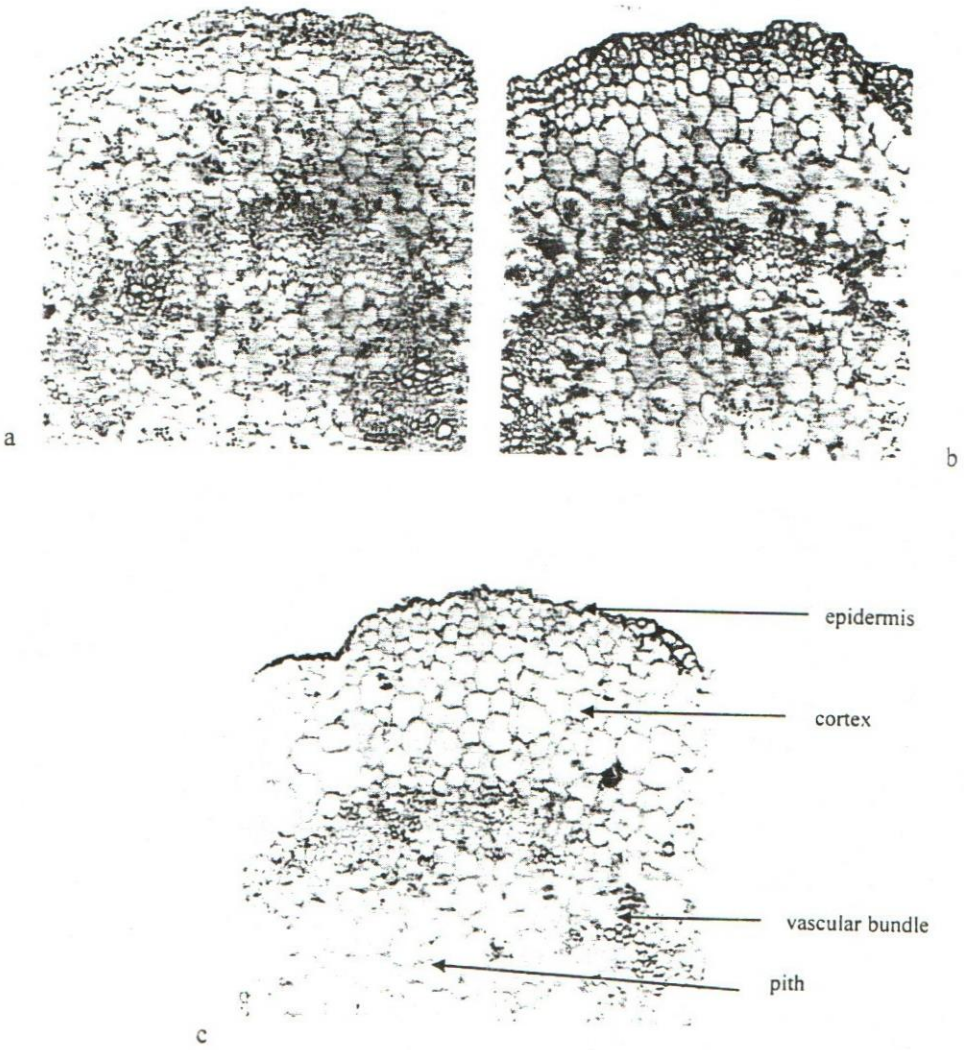

Fig. (4): Transections of the stolon of potato plants cv. Spunta, aged 60 days . as affected by treatments with biofertilizer EM1.(X 55)
a) Control plant b) Treatment of 5 ml EM1/L, and
c) Treatment of 15 ml EM1/ L.

Measurements of vascular cylinder thickness were 267.5, 289.4 and 248.4 μ in the same sequence. Concerning pith diameter it was 778.8, 1168.2 and 973.5 μ, while total diameter of stolon recorded 2189.8, 2588.3 and 2206.6 μ in the same order stated before.

Table (5): Means of measurements (μ) and counts of different tissues of stolon and mature tuber of *Solanum tuberosum* L. treated with EM1 Stock Solution and control plants (Averages of 10 readings).

Characters	EM1 concentrations (ml/L)		
	0.0	5.0	15.0
Stolon:			
Epidermis thickness	32.5	28.6	27.3
Cortex thickness	389.4	369.9	324.5
Vascular cylinder thickness	267.5	289.4	248.4
External phloem thickness	94.8	134.9	83.1
Internal phloem thickness	81.8	71.4	72.7
Xylem thickness	79.2	63.6	80.5
Pith diameter	778.8	1168.2	973.5
Stolon diameter	2189.8	2588.3	2206.6
Mature tuber:			
Thickness of phellem	246.6	166.1	237.5
Thickness of phelloderm	486.8	415.4	404.9
No. of phellem layers	16-18	9-11	9-14
No. of phelloderm layers	9-11	9-11	10-12

2- Structure of the mature tuber:

Fig. (5 a, b and c) and Table (5) show the structure of a sector of mature tuber. The principel zones in the mature tuber from the periphery inward are the periderm, cortex, vascular cylinder, perimedullary zone and central pith. The periderm acts as a protective zone over the entire tuber and consists of 16-18, 9-11 and 9-14 of pressed layers of cork cells, and their thicknesses reached 246.6, 166.1 and 237.5 μ for control, 5 and 15 ml EM1/L treatments, respectively. Average numbers of phelloderm layers ranged between 9-11 in both control and 5 ml EM1/L treatment, while 15 ml EM1/L treatment recorded 10-12 layers, and their thicknesses were 486.8, 415.4 and 404.9 μ in the same order. Cortex zone consists of storage tissue below the periderm, the peripheral layers are arranged in rows due to the tangential division of phellogen cambium. These layers had a limited amount of starch grains. The cells of the innermost layers of cortex are rounded or slightly elongated with small intercellular spaces in between, and the cells are filled with many starch grains.

The anatomical structure of the tuber is in harmony with that mentioned by Hayward (1938).

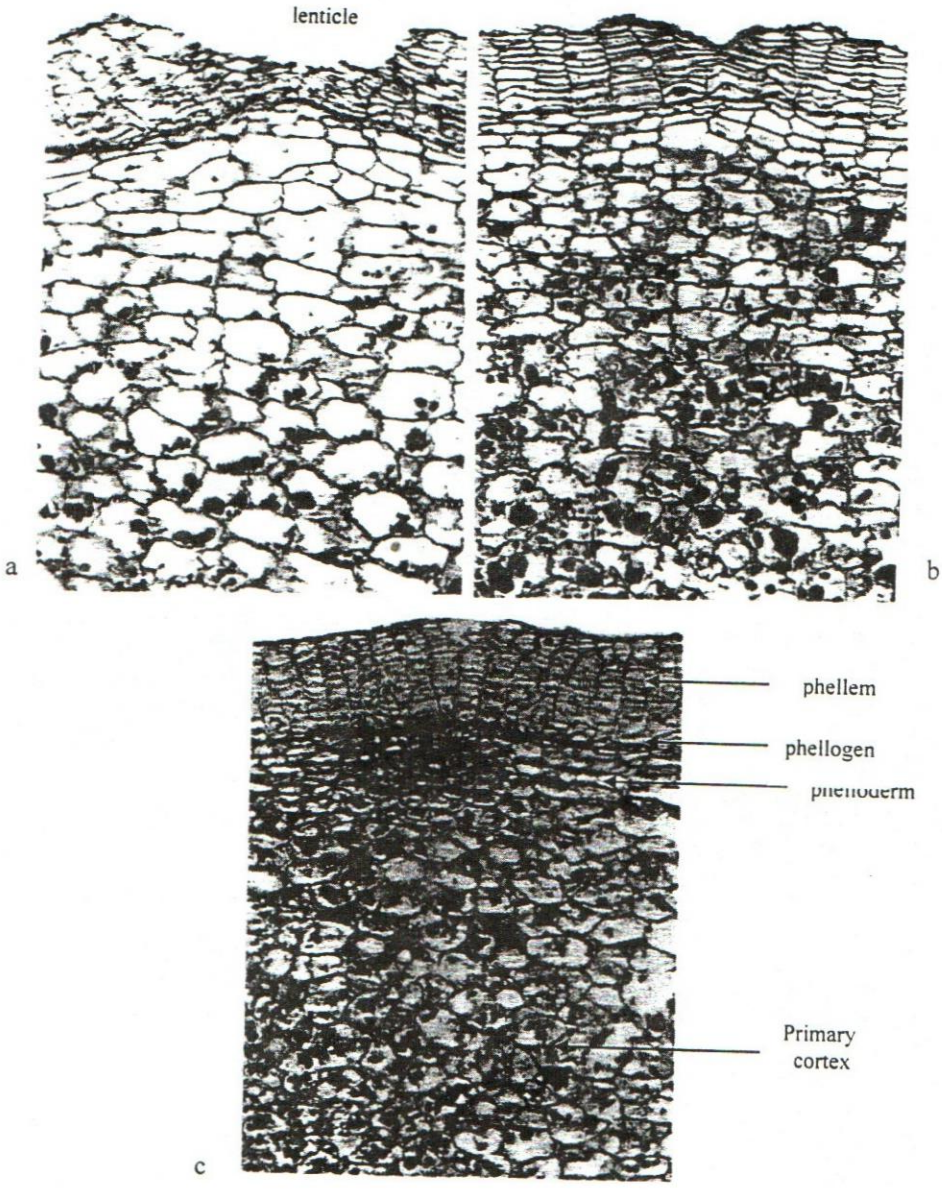

Fig. (5): Transections of mature tubers, 120 days old, of potato plant (X 50)
a) Control plant b) Treatment 5 ml EM1/L, and
c) Treatment 15 ml EM1/ L

3- Anatomical structure of the foliage leaf:

a) Structure of the petiole.

The petiole was reniform in shape in control and treatments plants, Fig. (6 a,b and c). The petiole was bounded by an epidermis of a uniseriate layer covered with a thin cuticle layer. The thichnesses of upper epidermis were 32.5, 32.5 and 35.8 μ, while the lower ones were 32.5, 35.8 and 29.3 μ, in control, 5 and 15 ml EM1/L treatments; respectively. The ground tissue consisted mainly of parenchyma cells, with 2-3 layers of chlorenchyma present sub-upper epidermal layer, in both control and 5 ml EM1/L treatment, and 1-2 layers in 15 ml EM1/L treatment. The number of chlorenchymatous sub-lower epidermal layers recorded 3-4, 4-5 and 3-4 layers in the same order stated before. The vascular bundles embedded in the ground tissue, their numbers were 3 in the control and treatments. The median bundle in all was the largest and the bundles were bicollateral. External and internal phloem thicknesses of the median bundles were 143.0 and 185.3 for control; 120.3 and 104.0 for 5 ml EM1/L; and 110.5 and 87.8 μ for 15 ml EM1/L. While, xylem thicknesses were 217.8, 204.8 and 143.0 μ, for control, 5 and 15 ml EM1/L treatments; respectively. The thicknesses of median bundle regions were 3282.5, 3194.8 and 2496.0 μ, and their widths were 5778.5, 4020.3 and 4244.5 μ, in the same sequence (Fig. (6 a, b and c) and Table (6). The structure of the petiole was in harmony with those stated by Metcalf and Chalk (1957).

Table (6): Means of measurements (μ) and counts of different tissues of petiole of *Solanum tuberosum* L. treated with EM1 Stock Solution and control plants (Averages of 10 readings).

Characters	EM1 concentrations (ml/L)		
	0.0	5.0	15.0
Thickness (μ) of :			
Upper epidermis	32.5	32.5	35.8
Lower epidermis	32.5	35.8	29.3
External phloem of the central bundle	143.0	120.3	110.5
Internal phloem of the central bundle	185.3	104.0	87.8
Xylem of the central bundle	217.8	204.8	143.0
Region of median bundle	3282.5	3194.8	2496.0
Width of region of median bundle (μ)	5778.5	4020.3	4244.5
No. of vascular bundles	3	3	3
No. of chlorenchyma layers present sub-upper epidermal layer	2-3	2-3	1-2
No. of chlorenchyma layers present sub-lower epidermal layer	3-4	4-5	3-4

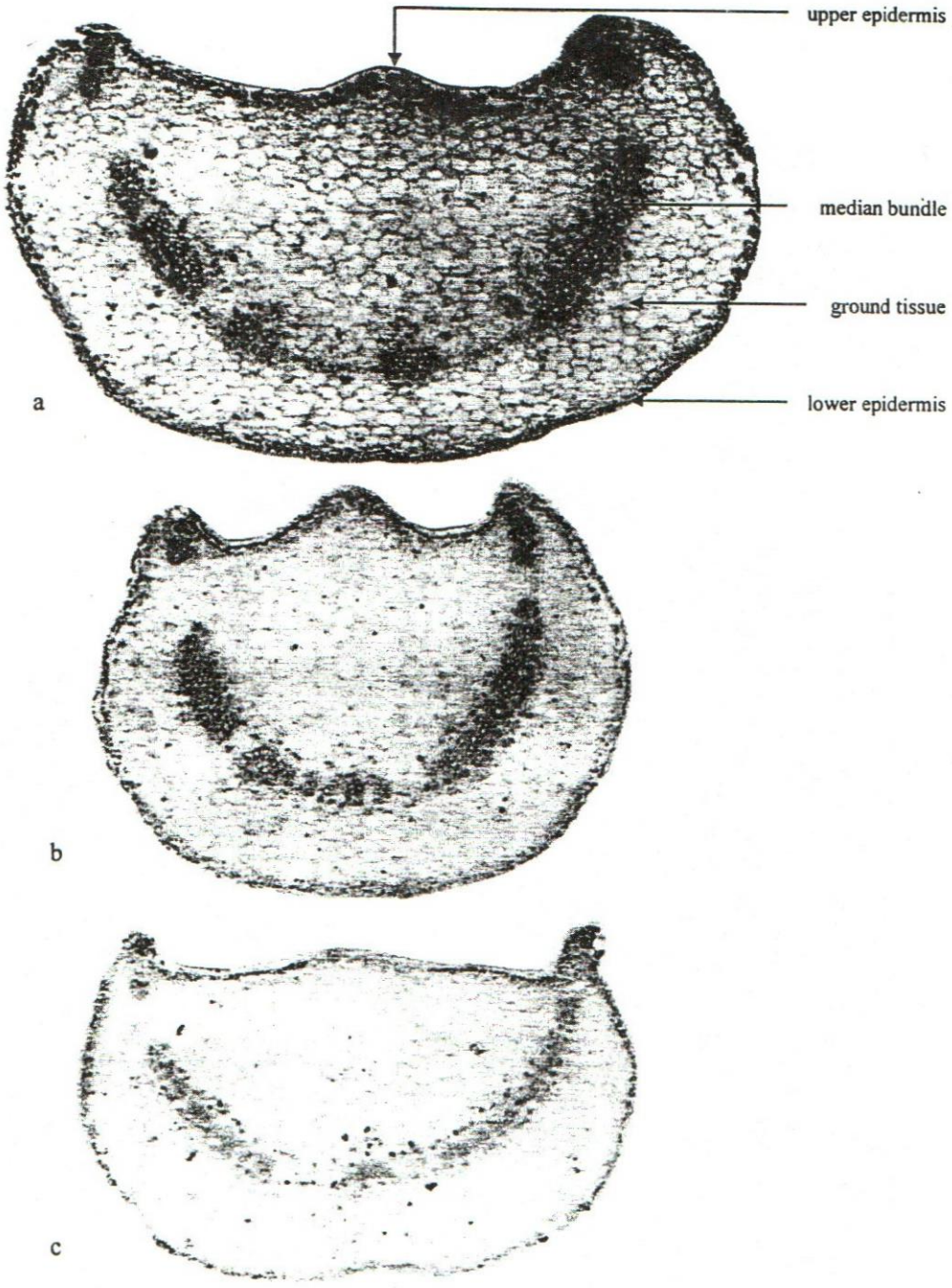

Fig. (6): Transections of the leaf petiols of potato plant (X 25)
a) Control plant b) Treatment 5 ml EM1/L,
and c) Treatment 15 ml EM1/ L

b) Structure of the leaflet blade.

Fig. (7 a,b and c) and Table (7) give the details of the anatomical structure of the leaflet blade of *Solanum tuberosum* L. treated with EM1 bio-fertilizer and control plants. It is clear that, the thicknesses of upper epidermis were 23.4, 24.7 and 23.4 μ, in control, 5 and 15 ml EM1/L treatments; respectively, while those of the lower ones were 14.3μ in all treatments and control. Mesophyll thicknesses were 174.7, 192.4 and 183.2 μ, in the same order. The palisade tissue consisted of one layer in all studied plants. Measurements of the palisade tissue thickness were 62.3, 72.7 and 84.4 μ, while the spongy ones recorded 99.9, 112.9 and 89.6 μ, in control, 5 and 15 ml EM1/L treatments; respectively.

Table (7): Means of measurements (μ) and counts of different tissues of leaflet of *Solanum tuberosum* L. treated with EM1 Stock Solution and control plants (Averages of 10 readings).

Characters	EM1 concentrations (ml/L)		
	0.0	5.0	15.0
Thickness (μ) of :			
Upper epidermis	23.4	24.7	23.4
Lower epidermis	14.3	14.3	14.3
Mesophyll	174.7	192.4	183.2
Palisade tissue	62.3	72.7	84.4
Spongy tissue	99.9	112.9	89.6
Lamina	219.3	237.2	225.6
External phloem of midrib bundle	46.7	48.0	73.9
Internal phloem of midrib bundle	61.0	42.8	51.9
Xylem of midrib bundle	72.7	55.8	120.7
Midrib region	815.1	745.1	848.9
Width of midrib region (μ)	771.0	694.4	1031.9
No. of xylem rows of midrib bundle	11.8	13.5	23.4
No. of xylem vessels of midrib bundle	50.3	67.9	112.0

Lamina thicknesses were 219.3, 237.2 and 225.6 μ, in the same sequence. External and internal phloem of midrib bundle thicknesses recorded 46.7 and 61.0 for control; 48.0 and 42.8 for 5 ml EM1/L and 73.9 and 51.9μ for 15 ml EM1/L. While, xylem thicknesses recorded 72.2, 55.8 and 120.7 μ, in the same order stated before.

Lengths of midrib region were 815.1, 745.1, and 848.9 μ, while their widths were 771.0, 694.4 and 1031.9 μ, for control, 5 and 15 ml EM1/L treatments; respectively. The average numbers of xylem rows in the midrib bundle were 11.8, 13.5 and 23.4 rows, and their average numbers of vessels were 50.3, 67.9 and 112.0 vessels, in the same order. The description of the leaflet agrees with that given by Metcalf and Chalk (1957).

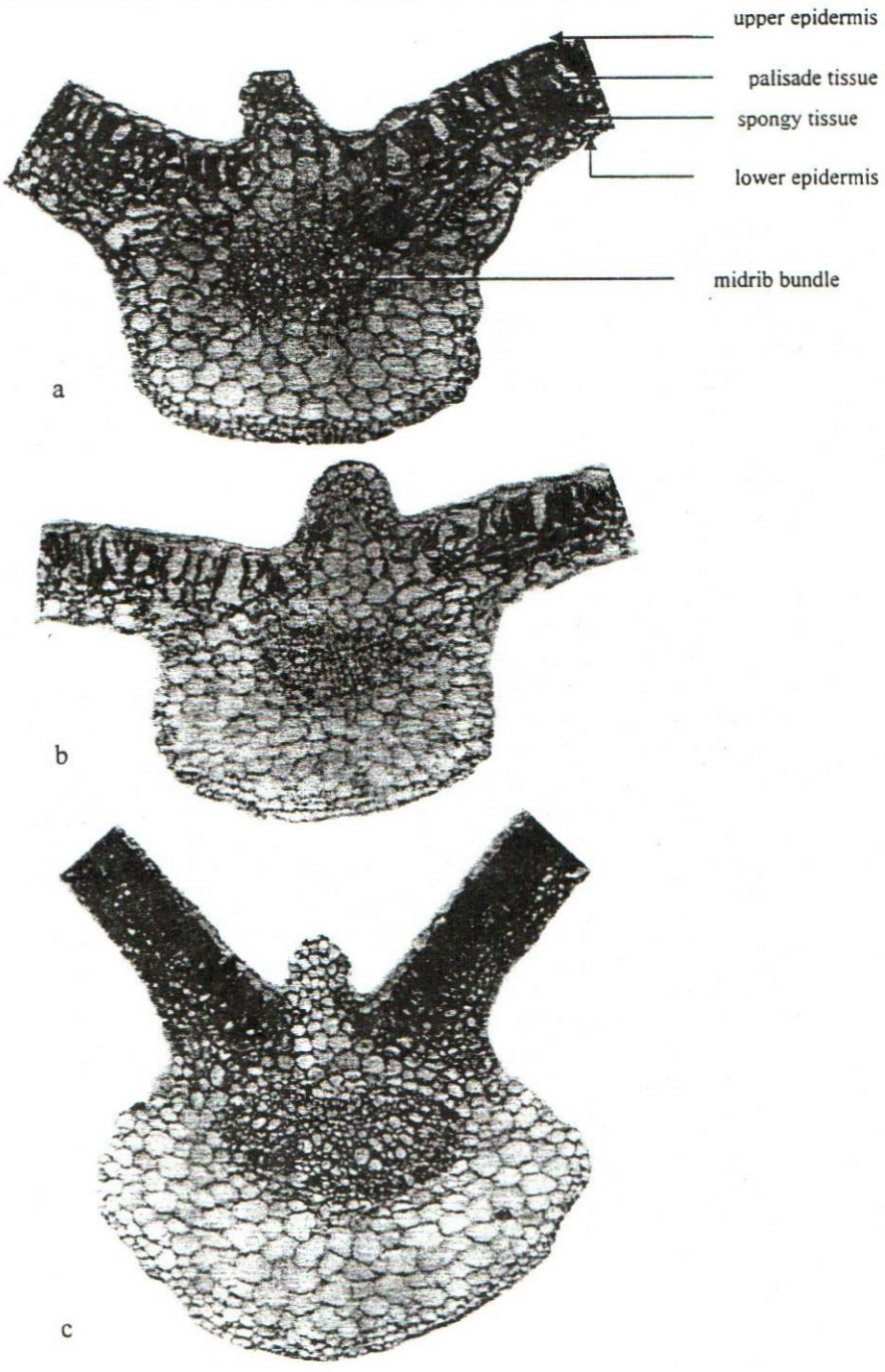

Fig. (7): Transections of the leaflet blades of potato plant (X 60)
a) Control plant b) Treatment 5 ml EM1/L,
and c) Treatment 15 ml EM1/ L

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تأثير معاملة التربة بالكائنات الدقيقة المؤثرة كسماد حيوى على الصفات المورفولوجية والمحصول والتركيب التشريحى لنبات البطاطس

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أجريت هذه الدراسة على نبات البطاطس صنف سبونتا خلال موسمى ٢٠٠٢، ٢٠٠٣ باستخدام خمسة تركيزات من المحلول الميكروبى النشط EM1 (١، ٥، ١٠، ١٥، ٢٠ مللى /لتر) مقارنة بنباتات الكنترول. أعطت التركيزات الثلاثة الاولى من المحلول زيادة معنوية فى ارتفاع النباتات ، عدد السيقان للنبات ، عدد الاوراق للنبات، المساحة الكلية لأوراق النبات، عدد الدرنات للنبات وكذلك وزنها وذلك خلال موسمى النمو. وأعطت المعاملة بالتركيز ٥ مللى / لتر القيم الاعلى فى معظم الصفات المورفولوجية مقارنة بالكنترول بينما كل من التركيزين ١٥، ٢٠ مللى / لتر أعطيا إنخفاضا معنويا لتلك الصفات.

الدراسة التشريحية أجريت على النباتات المعاملة بالتركيزات ٥ ، ١٥ مللى / لتر اللذان أعطيا أكبر إختلافات مقارنة بالكنترول. أعطت المعاملة ٥ مللى / لتر السمك الاكبر فى الجذر ، السلامية الثانية، وقياسات السلامية القاعدية، المحقن وأيضا سمك نصل الوريقة.