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RESPONSE OF CERAIN MORPHOLOGICAL AND PHYSIOLOGICAL ASPECTS AS WELL AS YIELD AND ITS COMPONENTS OF POTATO PLANTS TO BIO-AND MINERAL FERTILIZERS.

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ABSTRACT

This study aimed to investigate the effects of both bio-and mineral fertilizers on certain morphological, physiological and anatomical aspects as well as yield and its components of potato plant. The most important results achieved are summarized as follows:

All growth parameters expressed by plant height, number of branches and leaves per plant, leaf area of potato plants, photosynthetic pigments, carbohydrate fraction the shoot system as well as yield and its components were deceased with decreasing the level of NPK less than the recommended dose (control)

All bacterial strains increased most of the plant growth parameters. Inoculation with NFB strain individually or in combination with other strain was most effective in this respect. Moreover, all bacterial strains used showed an additive effects to the effect of 100% NPK on potatoes growth.

Anatomically, inoculation of bacterial strains used, over all NPK doses increased leaflet thickness in the midrib region, mesophyll tissue thickness, midrib V.B. dimension, xylem, phloem tissue thickness and metaxylem vessel dimension. Moreover, stem diameter, cortex thickness, large vascular bundle dimensions, external and internal pholem and xylem tissues thickness as well as pith tissue dimension were also increased.

The results indicate that, all the anatomical parameters studied of the leaf and stem were decreased compared with the control (100% from the recommended dose). The decrease was a concentration dependent.

INTRODUCTION

Potato (Solanum tuberosum L.; Solanaceae) is one of the most important vegetable crops. Potato tubers are an excellent source of nutrients, protein, carbohydrates, mineral and ascorbic acid (Pondy and Chadha, 1996).The amount needed is greater than that produced. Therefore, considerable attention has been directed to improve potatoes growth, productivity and tuber quality.

Chemical fertilizers, particularly nitrogen salts are commonly used for these proposes (Hussein and Radwan, 2002). Several investigators showed that, mineral sources of N-fertilizers accumulate more toxicity of NO-3 and NO-2 ions within the plant tissues and tubers represented a serious problem for human health (Swann, 1975). The toxic ions of nitrate and nitrite forming from nitrification are well known as an environmental pollutant (Alexander, 1977).

Great efforts have been directed to overcome the problems of chemical fertilizers which are generally represented in increasing costs as well as environmental pollution and its negative effects on human health. These effects have been given decrease the recommended chemical fertilizer doses by application of bio-fertilizers (Abd El-Naem *et al.*, 1999). Application of bio-fertilizer is an important economically to reduce the cost of fertilizers and ecologically to pollution of the environmental (Verma, 1990). Using bio-fertilizer for potato plants as a substitute for the N-chemical fertilizer may be recommended to reduce nitrate contents and improve the yield quality (Abd El-Ati, 1998 and El-Banna and Tolba, 2000).

The present investigation aimed to study to what extent bio-fertilizers can replace some of the recommended NPK mineral fertilizers and its productivity.

Certain morphological and physiological aspects and the anatomical structure of the stem and leaves as well as tuber quality were also studied.

MATERIAL AND METHODS

Two field experiments were carried out at the Agricultural Experimental Station, Faculty of Agriculture, Mansoura University, Egypt during the two growing seasons of 2001/2002and 2002/2003.

Potatoes tubers; Spunta cv. (imported from Holland) were obtained from Agric. Res. Center (ARC), Ministry of Agric., Egypt. Tubers were divided to pieces, averaging approximately 50 g weight.

Soil samples and analysis:

The mechanical and chemical analyses of the soil used were carried out in the two growing seasons as described by Jackson (1973) and Page *et al.*, (1982) and presented in Table (1).

Table (1): The physiochemical properties of the experimental soil used during the two growing seasons of 2001/2002 and 2002/2003.

Season	1. Mechanical Analysis				Organic Matter	Calcium carbonate	PH (1:2.5 soil: water suspension)	Soil texture
	Soil Fraction %							
	Coarse sand	Fine sand	Silt	Clay				
2001/2002	2.43	21.43	27.66	48.29	0.99	2.09	7.80	Clayey
2002/2003	2.58	22.50	25.92	49.00	1.10	2.12	7.65	

	2. Chemical Analysis								
	EC dsm-1 soil paste extract at 25 C0	CATIONS (meq/L)				ANIONS (meq/L)			
		Ca^{++}	Mg^{++}	Na^{+}	K^{+}	HCO_3^{-}	$CO_3^{=}$	$SO_4^{=}$	Cl^{-}
2001/2002	1.31	5.33	4.22	10.40	0.39	2.44	-	7.68	10.63
2002/2003	1.45	5.21	4.11	10.99	0.37	2.07	-	7.80	11.00

	3. Nutrients Analysis mg/100 g soil		
	N	P	K
2001/2002	25.00	8.30	268..91
2002/2003	33.00	8.50	335.10

Potato tuber pieces were inoculated with bacteria suspension, individually or incombinations directly before planting to form the following treatments:

1- Without bio-fertilizers.
2- Inoculation with Azospirillum brasilense (NFB).
3- Inoculation with Pseudomonas fluorescens (PDB).
4- Inoculation with Bacillus circulans (SB).
5- Inoculation with (NFB + PDB).
6- Inoculation with (NFB + SB).
7- Inoculation with (PDB + SB).
8- Inoculation with (NFB + PDB + SB).

The treated potato pieces planted in the ridges at 12-15 Cm depth (25 cm apart) on 12nd October, 2001 and 15th October, 2002 growing seasons respectively.

Mineral fertilizer treatments:

As recommended by the Agric. Res. Center, Egypt, nitrogen fertilizer in the form of ammonium nitrate (33.3% N) was used at the dose of 180 kg N/fed. at three equal doses. The first was used after emergence (18-21 days from planting), whereas the second and third doses were applied before the 2nd and the 3rd irrigations respectively (31 and 46 days from planting). Calcium superphosphate (15.5% P2O5), as a source of phosphorus, at the dose of 75 kg P2O5 /fed., was added to the soil before planting and during soil preparation. Potassium sulphate (48 % K2O) was used as a source of potassium at the dose of 96 kg K2O/fed. at two times, the first half was added with the first addition of N-fertilizer, and the second with the third doses of N-fertilizer.

The mineral fertilizer treatments were used at the three following different rates:

1- 100% NPK from the recommended dose (control).
2- 75% NPK.
3- 50% NPK.

These treatments were used with or without the bio-fertilizer treatments. Each treatment was replicated 5 times. The treatments were arranged in a factorial complete randomized block design system.

90 days from planting the following morphological characters were recorded during the two growing seasons ; plant height (cm), number of branches and leaves per plant as well as leaf area (cm2) per plant (Koller, 1972).

As for the anatomical studies samples were taken from the plants that grown only in the second season. Specimens (5 mm in length) were taken at the middle part from the terminal leaflet of the 3 rd compound leaf and the middle part of the 3 rd internode from the plant tip.

Samples were killed and fixed in Formalin- Alcohol-Acetic acid glacial mixture (FAA 17:2:1 v/v) for 72 hours, washed and dehydrated in alcohol series, cleared by xylene and embedded in paraffin wax (52- 54 ^{o}C m.p.). Cross sections 12-15 µ thick were prepared by a rotary Microtome, stained in Saffranin – light green combination, cleared in oil cloves and mounted in canada balsam (Gerlach, 1977).

Photosynthetic pigments concentrations (mg/g) and their contents (mg/plant) fresh weight (Wettestein, 1957) as well as carbohydrate fractions in the shoot systems were determined (Amberger, 1954) .

At harvesting (105 days from planting) tubers yield (g) per plant, tubers numbers per plant, tubers dry weight (g) per plant and total tubers yield (ton/fed) were recorded.

Data were subjected to statistical analysis of variance according to (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

1-Morphological characters:

Generally, as it shown in Table (2), all growth parameters studied decreased with decreasing NPK mineral fertilizers treatments dose less than the recommended one (control) .

The decrease was a concentration dependent. The lowest NPK dose (50% from recommended dose) recorded lowest values on all plant growth parameters compared with the control(100% recommended dose).

Data in the same table show that plant height, number of branches and leaves as well as leaf area of potato plants were decreased with decreasing the level of NPK less than the recommended dose (control), this inhibition rate was more pronounced under 50% NPK from the recommended dose.

Regarding the effects of bio-fertilizers used, the data indicated, in general that, all bacterial strains increased most of the plant growth parameters. Inoculation with NFB strain individually or in combination with other strains was most effective in this respect. The interaction treatments showed that, all bacterial strains used showed an additive effects to the effects of 100% NPK on potatoes growth. Moreover, it was found that, all bacterial strains largely counteracted depressing effect the mineral nutrients stress on potatoes growth. Better counteraction effect was achieved at 75% NPK dose. While, less counteraction was achieved at 50% NPK dose.

The reduction in growth due to decreasing NPK dose may be related to inhibition of both meristimatic activity and elongation of cells under nutrients stress (Arish and Bardisi, 1999).

The increasing effect of bio-fertilizers on plant growth may be attributed to its effects on the syntheses and production several of plant hormones mainly; IAA, GA and cytokinins, which play an important role in the formation of new cells and plant tissues resulted in stimulation in plant growth (Salisbury and Ross, 1992 and Kawthar *et al.*, 2002).

The stimulative effect of mineral fertilizers on plant growth may be attributed to its effects on increasing both endogenous plant hormones and nutrients uptake (Helaly *et al.*, 1985; Hammad and El-Gamal, 2005). Moreover, nitrogen is an essential element for building up protoplasm, amino acids and proteins which induce cell division and initiate meristimatic activity (Arish and Bardisi, 1999). They added that, potassium element is very important in overall metabolism of plant enzymes activity. In addition, phosphorus play an important role in cell division and development of meristimatic tissues (Ashour, 1998).

Table (2): Effects of mineral and/or bio-fertilizers on plant height (cm), number of branches and leaves as well as leaf area (cm2) per plant of potato plants grown during the two growing seasons of 2001/2002 (S1) and 2002/2003 (S2).

Treatments		Plant height (cm)			Number of branches/plant			Number of leaves /plant			Leaf area cm2 /plant		
M-Mineral NPK	B-Bio-fertilizer	S1	S2	Mean	S1	S2	Mean	S1	S2	Mean	S1	S2	Mean
Control 100%	Without	30.30	34.50	31.40	3.11	3.30	3.20	27.9	28.6	28.25	2582	2708	2645
	NFB	36.30	38.60	36.45	3.93	4.11	4.00	31.4	31.0	30.82	2741	2866	2803
	PDB	35.10	36.00	35.55	3.60	3.90	3.75	30.6	32.5	31.95	2709	2832	2770
	SB	31.80	34.70	32.25	3.22	3.50	3.35	28.1	29.9	29.00	2602	2769	2685
	NFP+PDB	38.00	40.00	38.00	4.14	4.37	4.23	32.4	33.3	32.85	2849	2908	2878
	NFB+SB	37.00	39.50	37.25	4.06	4.30	4.30	32.3	32.4	32.35	2811	2900	2855
	PDB+SB	36.80	39.20	37.00	3.97	4.27	4.12	31.9	32.2	32.05	2768	2860	2814
	NFB+PDB+SB	38.60	41.00	38.80	4.20	4.60	4.40	32.6	33.6	33.10	2910	2981	2945
Mean		35.49	39.34	37.41	3.81	4.04	3.92	30.8	31.8	31.55	2746	2853	2799
75%	Without	27.50	30.90	29.20	2.50	2.89	2.70	24.0	24.5	24.25	2447	2467	2457
	NFB	33.30	36.20	34.75	3.63	3.90	3.75	28.9	29.1	29.00	2688	2693	2690
	PDB	32.90	34.80	33.85	3.37	3.71	3.53	28.2	28.6	28.40	2664	2623	2643
	SB	28.80	31.70	30.25	3.10	3.50	3.30	26.3	26.8	26.53	2582	2591	2586
	NFP+PDB	35.40	37.50	36.45	3.72	3.91	3.80	29.0	30.2	29.60	2722	2779	2750
	NFB+SB	34.10	37.23	35.67	3.80	4.07	3.93	28.9	30.0	29.45	2702	2740	2721
	PDB+SB	34.13	34.70	34.42	3.52	4.03	3.75	28.5	29.9	29.20	2700	2725	2712
	NFB+PDB+SB	35.40	40.20	37.75	3.83	4.02	3.90	30.1	31.6	30.80	2828	2790	2809
Mean		32.68	35.40	34.04	3.42	3.74	3.58	28.1	28.8	28.65	2666	2676	2671
50%	Without	24.80	25.00	24.90	2.13	2.22	2.15	18.3	20.7	19.50	2058	2177	2117
	NFB	27.60	29.10	28.35	2.62	3.01	2.80	22.8	23.7	23.25	2347	2453	2400
	PDB	27.40	29.00	28.20	2.70	2.80	2.75	22.2	23.1	22.65	2331	2444	2387
	SB	26.00	26.80	26.40	2.11	2.39	2.25	21.6	21.7	21.65	2376	2369	2372
	NFP+PDB	27.77	29.10	28.43	2.90	3.17	3.13	23.6	25.2	24.38	2391	2580	2485
	NFB+SB	27.30	29.70	28.50	2.73	3.01	2.87	23.5	25.0	24.25	2370	2559	2464
	PDB+SB	27.90	29.30	28.60	2.70	3.00	2.85	23.4	24.8	24.10	2354	2531	2442
	NFB+PDB+SB	29.70	32.70	34.20	3.17	3.13	3.15	24.2	25.4	24.82	2483	2603	2543
Mean		27.31	28.84	28.07	2.83	3.08	2.95	22.4	23.7	25.20	2338	2464	2401
Mean	Without	27.53	30.13	28.83	2.57	2.80	2.68	23.4	24.6	24.0	2362	2450	2406
	NFB	32.40	34.63	33.51	3.40	3.60	3.50	27.5	27.7	27.9	2592	2670	2631
	PDB	31.80	33.93	32.86	3.19	3.53	3.36	27.3	28.3	27.5	2568	2633	2600
	SB	28.86	31.06	29.96	2.80	3.13	2.96	25.3	26.1	25.7	2520	2576	2548
	NFP+PDB	33.72	38.60	36.18	3.57	3.81	3.71	28.2	29.7	28.9	2654	2755	2704
	NFB+SB	32.80	35.47	34.14	3.61	3.79	3.88	28.1	29.1	28.6	2627	2733	2680
	PDB+SB	32.94	34.47	33.67	3.39	3.77	3.58	28.1	29.0	28.5	2607	2705	2656
	NFB+PDB+SB	34.53	37.96	36.25	3.72	3.91	3.81	29.9	31.4	30.6	2740	3791	2765
LSD at 5% for: SxM			1.74			0.08			NS			2.9	
SxB			NS			0.04			0.36			1.8	
BxM			NS			0.11			0.45			3.6	
SxMxB			NS			0.14			0.63			5.0	

2- Anatomical structure:

2.1- Leaflet internal structure:

Data presented in Table (3) and illustrated in Figs (1 and 2) indicate that, inoculation of bacterial strains used, over all NPK doses increased leaflet thickness in the midrib region, mesophyll tissue thickness, palisade tissue thickness, midrib V.B. dimensions (length and width), xylem tissue , phloem tissue thickness and metaxylem vessel dimension.

Data in the same table show that, NPK stress decreased all the anatomical parameters studied of the leaf compared with the control (100% recommended dose) . The decrease was a concentration dependent.

2.2- Stem structure:

Data presented in table (4) and illustrated in Figs (3 and 4) indicate that, all bacterial inoculation treatments increased stem diameter, cortex thickness, large vascular bundle dimensions, external and internal phloem and xylem tissues thickness as well as pith tissue dimension. Metaxylem vessel dimension was also increased compared with non-inoculated plants. Inoculation with (NFB) individually or in combination with other bacterial strains used (Fig. 3 D) were generally the best treatments in this respect compared with those grown without inoculation (Fig. 3 A).

Data show also that, the anatomical parameters studied were decreased with decreasing NPK fertilizer dose. Plants treated with 100% recommended dose of NPK resulted higher values than that treated with 75% and the decrease was a concentration dependent, overall the presence of bio-fertilizers. The increase in stem diameter due to the inoculation with mixed three strains of used bacteria may be attributed to their ability to release plant growth substances , mainly; IAA and cytokinins (Omay *et al.,* 1993). Auxins and cytokinins increased cell division and cell enlargement (Arteca, 1996). The increase in stem diameter under full recommended dose of mineral fertilization may be attributed to the effects of nutrients on increasing meristematic activity as well as cell division and its elongation through auxin production (Salem, 2000). El-Rewainy *et al.,* (2004) reported that, nitrogen not only increased the growth substances but also increase their translocation in the plant. In addition phosphorus is a component of RNA and DNA (Marschner, 1995) therefore it play an important for cell division activity.

3- Physiological characters :

3.1- Photosynthetic pigments:

Data in Table (5) indicate that, each of the bio-fertilizers used had a stimulative effect on all photosynthetic pigments fraction concentrations as well as their content during the two growing seasons when compared with uninoculated one. The inoculation with NFB was more effective than the other strains used in this respect.

Data also show that, NPK stress decreased all the photosynthetic pigments concentrations and their content compared with the control (100% recommended dose).

The addition of mineral fertilizer showed a synergistic effect to that of the bacterial strains used on increasing all photosynthetic pigments concentrations and their content.

Compared with the control (100% recommended NPK) , data also show that, the plants which received mixed strains of used bacteria and grown under 75% NPK (from the recommended dose) showed higher values of chlorophyll a, b and their total than the plants treated with mixed bacterial strains and grown under 50% NPK (from the recommended dose).

Table (3): Effects of mineral and/or bio-fertilizers on some anatomical characters (µn) of the terminal leaflet of the 3^{rd} compound leaf from the potato plants tip during the second season of 2002/2003.

Treatments		Anatomical characters									
		Leaflet thickness in the midrib region µn	Mesophyll tissue thickness	Palisade tissue thickness µn	Spongy tissue thickness µn	Midrib V.B. dimension		Xylem tissue thickness of midrib bundle µn	Phloem tissue thickness of midrib bundle		Metaxylem vessel dimension µn
Mineral NPK (M)	Bio-fertilizer (B)					Length	Width		External	Internal	
100%	Control	1750	538	280	258	645	470	310	170	153	56
	NFB	1862	572	295	277	680	410	330	177	167	60
	PDB	1810	562	292	270	665	395	318	175	158	58
	SB	1785	554	290	264	648	375	315	172	154	55
	NFP+PDB	1935	580	310	290	700	475	340	180	166	62
	NFB+SB	1910	575	320	285	690	472	334	178	163	60
	PDB+SB	1880	564	324	270	680	450	338	172	154	64
	NFB+PDB+SB	2030	645	335	310	734	512	355	190	176	70
Mean		1870	508	305	278	680	444	330	156	161	60
75%	Control	1610	465	235	230	535	320	230	148	144	50
	NFB	1844	500	250	246	560	387	245	157	157	58
	PDB	1820	496	248	242	557	370	240	153	154	55
	SB	1815	490	245	242	510	335	190	155	152	48
	NFP+PDB	1865	562	284	255	605	354	265	164	162	60
	NFB+SB	1860	556	278	278	590	343	253	162	158	58
	PDB+SB	1852	531	275	256	580	348	247	160	150	60
	NFB+PDB+SB	2491	775	395	380	807	465	376	268	265	88
Mean		1894	546	276	266	593	365	255	170	167	59
50%	Control	1040	305	160	145	263	250	142	64	57	35
	NFB	1130	445	225	220	318	290	160	78	55	44
	PDB	1090	435	220	215	290	275	154	78	48	40
	SB	1075	395	205	190	270	270	147	70	42	36
	NFP+PDB	1145	430	230	225	310	278	163	77	63	48
	NFB+SB	1140	424	227	222	320	310	154	80	60	45
	PDB+SB	1135	421	224	220	332	302	177	82	58	46
	NFB+PDB+SB	1193	474	244	230	345	335	185	85	68	52
Mean		1118	416	216	208	306	288	160	76	56	43
Control		1466	436	225	211	481	346	227	127	118	47
NFB		1612	505	256	247	519	362	245	137	126	54
PDB		1573	497	253	242	504	346	237	135	120	51
SB		1558	479	246	232	476	326	217	132	116	46
NFP+PDB		1648	524	274	256	445	369	256	140	130	56
NFB+SB		1636	518	275	261	533	375	247	140	127	54
PDB+SB		1622	505	274	248	530	368	254	138	120	56
NFB+PDB+SB		1904	631	324	306	628	437	305	181	169	70
LSD at 5% for: M		1.3	1.2	1.4	1.3	1.9	0.7	0.3	0.1	0.2	1.0
B		2.2	2.0	2.2	2.1	3.2	1.1	0.4	0.2	0.4	1.6
MxB		3.7	3.5	3.9	3.6	5.5	1.9	0.8	0.3	0.7	2.8

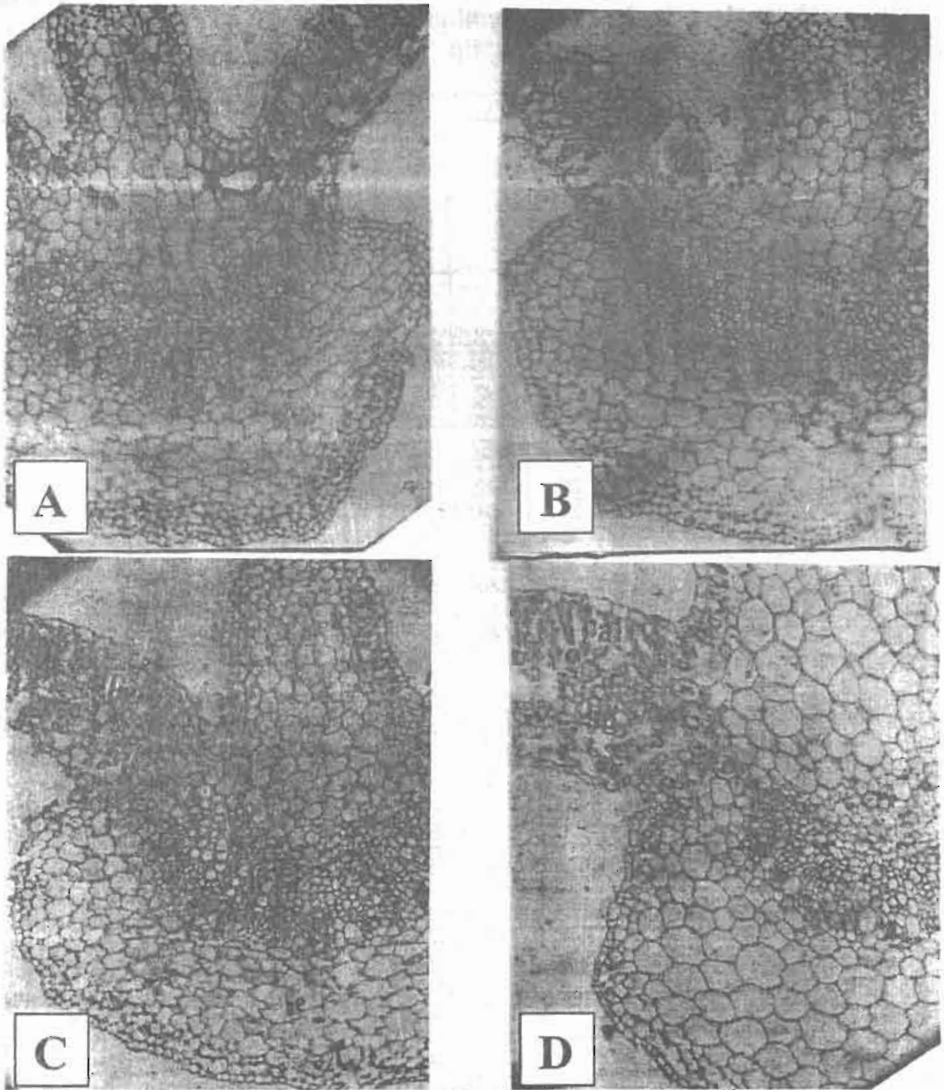

Fig (1): Cross sections of the terminal leaflet blade of the 3rd compound leaf from the potato plant tip as affected by some biofertilizers (Obj. x10. Oc. X 15)
Pal= palisade tissue SP= spongy tissue X= xylem Ph= phloem
Mi=midvein vascular bundle

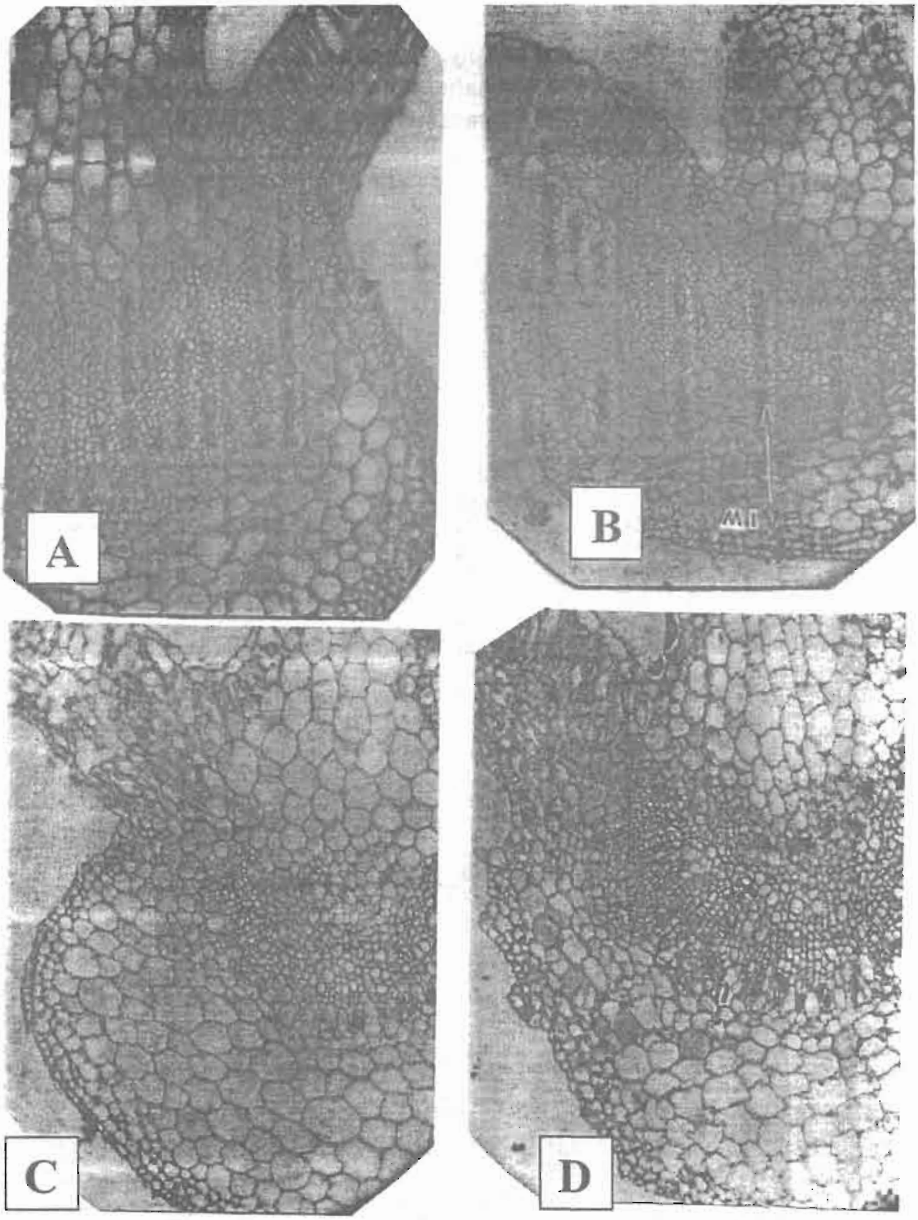

Fig (2): Cross sections of the terminal leaflet blade of the 3rd compound leaf from the potato plant tip as affected by different doses of mineral fertilizers and their interactions with biofertilizers (Obj. x10. Oc. X 15)

A:100%NPK B:75% NPK C:75% NPK+NFB D:75%NPK +(NFB+PDB+SB)

Pal= palisade tissue SP= spongy tissue X= xylem Ph= phloem

Mi=midvein vascular bundle.

Table (4): Effects of mineral and/or bio-fertilizers on some anatomical characters (µn) of the main stem at the 3rd internode of potato plants during the second season of 2002/2003.

Treatments		Anatomical characters								
				Large vascular dimension µn		Phloem tissue thickness µn				
Mineral NPK (M)	Bio-fertilizer (B)	Stem diameter µn	Cortex thickness µn	Length	Width	External	Internal	Xylem tissue thickness µn	Metaxylem vessel dimension µn	Pith dimension µn
100%	Control	2165	530	435	470	105	84	240	72	1200
	NFB	2490	550	490	495	130	88	264	80	1450
	PDB	2305	545	460	485	124	82	248	78	1300
	SB	2278	540	448	580	118	82	240	74	1290
	NFP+PDB	2680	580	560	530	178	96	280	88	1540
	NFB+SB	2626	582	544	515	168	92	278	82	1500
	PDB+SB	2602	578	534	500	164	90	270	80	1490
	NFB+PDB +SB	2640	528	570	500	170	96	310	100	1530
Mean		2473	554	505	453	144	88	239	81	1412
75%	Control	1850	450	400	310	100	78	210	70	1000
	NFB	2230	480	470	380	120	86	254	76	1280
	PDB	2112	464	448	364	115	84	238	74	1200
	SB	2036	456	430	348	110	80	230	72	1150
	NFP+PDB	2378	498	490	450	124	90	266	86	1390
	NFB+SB	2278	488	480	420	122	90	256	82	1310
	PDB+SB	2282	482	500	410	150	92	250	84	1300
	NFB+PDB +SB	2580	650	600	580	180	98	315	110	1500
Mean		2218	496	477	357	127	87	223	81	1266
50%	Control	1362	300	262	200	80	32	140	32	800
	NFB	1595	380	325	240	90	44	180	48	890
	PDB	1484	344	300	232	88	36	164	40	840
	SB	1425	330	275	224	84	36	148	34	820
	NFP+PDB	1638	394	334	248	92	48	195	64	910
	NFB+SB	1618	388	330	236	90	44	188	60	900
	PDB+SB	1614	384	325	230	88	42	186	52	905
	NFB+PDB +SB	1705	410	340	255	98	60	200	68	955
Mean		1555	366	311	233	88	42	175	49	877
Control		1792	426	365	326	95	64	196	58	1000
NFB		2105	470	428	371	113	72	232	68	1206
PDB		1967	451	402	360	109	67	216	64	1113
SB		1913	442	387	384	104	66	206	60	1086
NFP+PDB		2232	490	461	409	131	78	247	79	1280
NFB+SB		2174	486	451	390	126	75	240	74	1236
PDB+SB		2166	481	453	380	134	74	235	72	1231
NFB+PDB+SB		2308	529	503	445	149	84	275	92	1328
LSD at 5% for: M		1.1	1.8	1.8	1.9	1.2	0.9	1.9	1.0	1.5
B		1.7	3.1	3.0	3.2	2.0	1.4	3.1	1.6	2.4
MxB		3.0	5.1	5.2	5.5	3.5	2.5	5.1	2.7	4.2

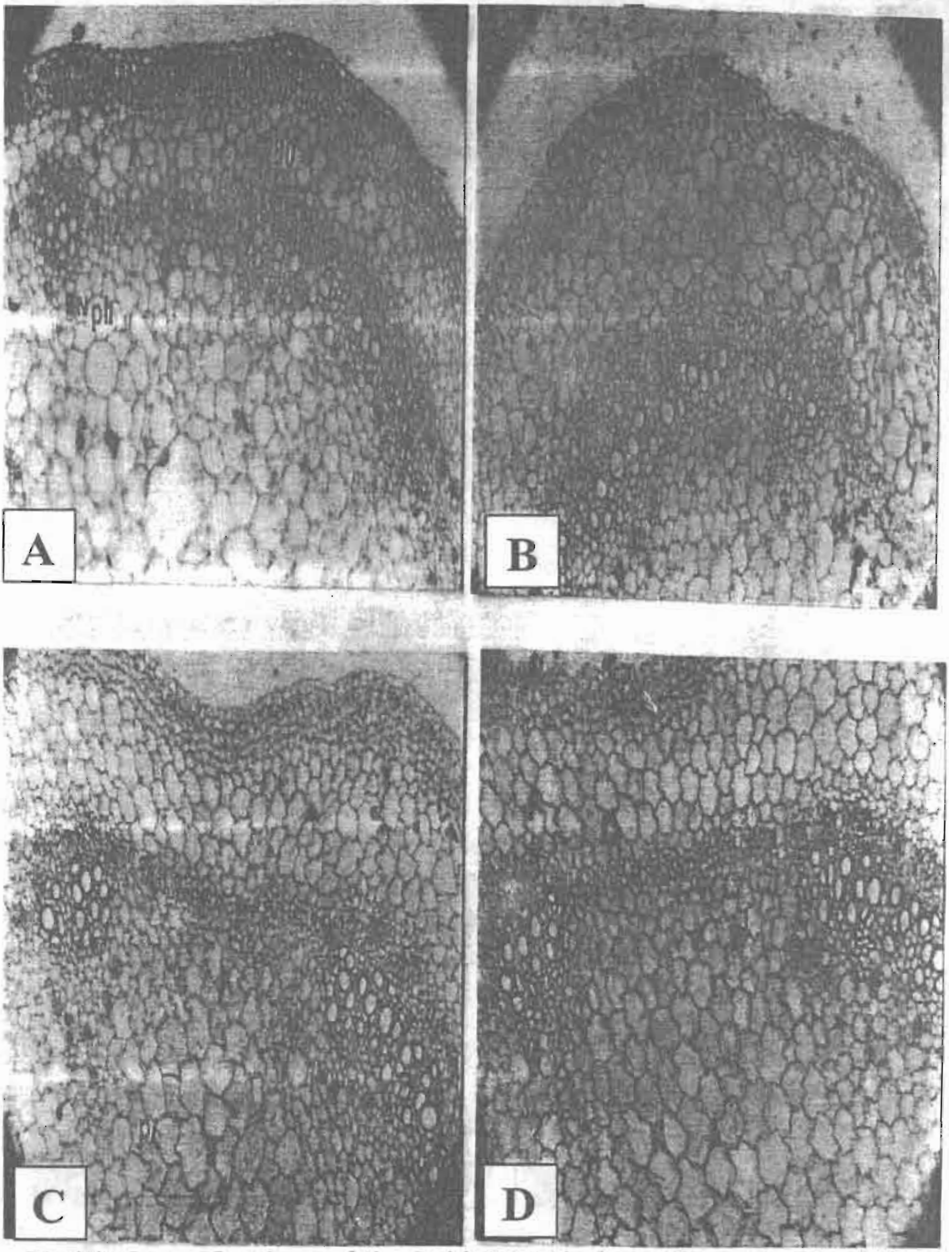

Fig (3): Cross Sections of the 3rd internode from the potato plant tip as affected by some biofertilizers (Obj. x 10. Oc. X15). Co= cortex EN. Ph= Enternal phloem

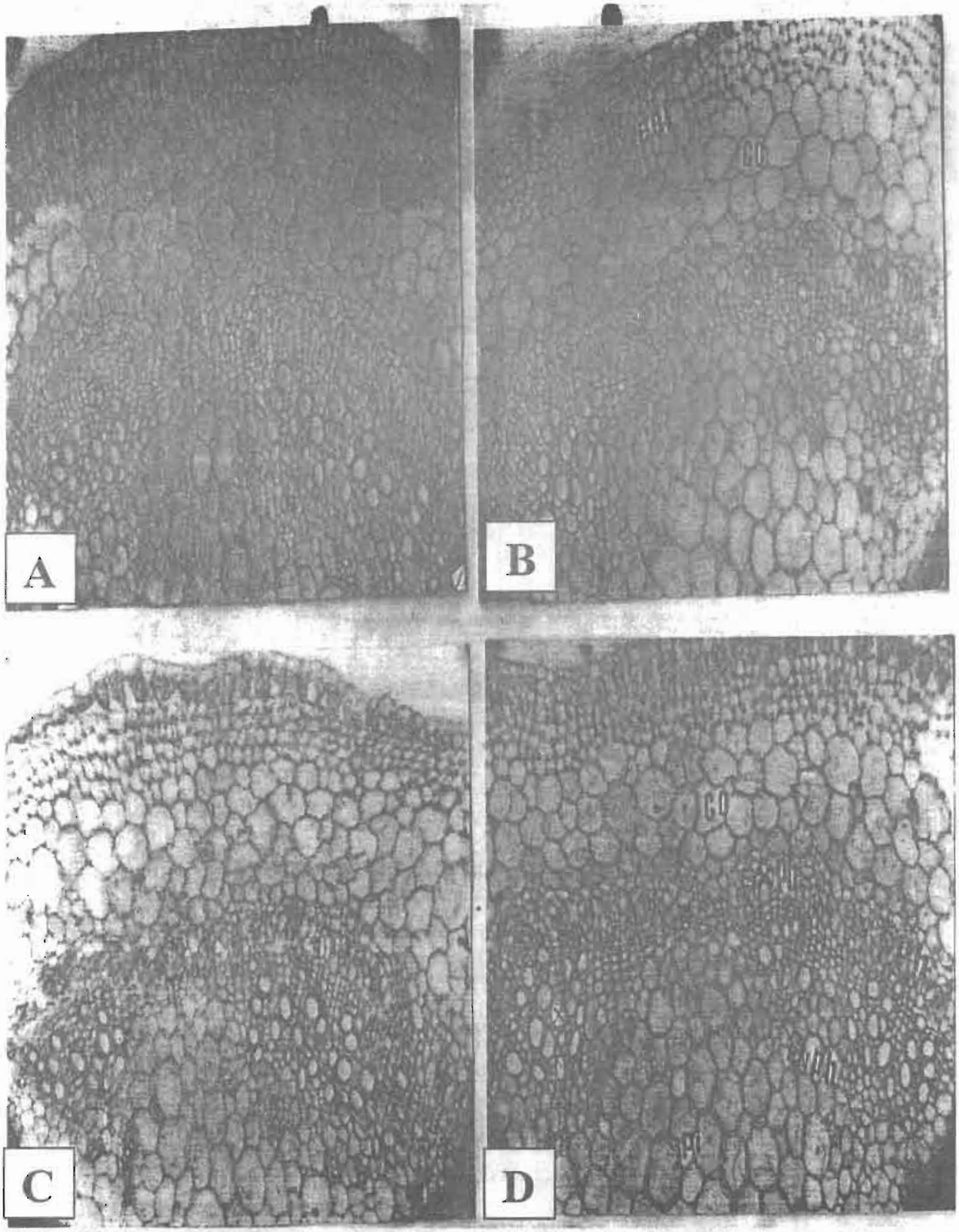

Fig (4): Cross sections of the 3rd internode from the potato plant tip as affected by different doses of mineral fertilizers and their interactions withbiofertilizers (Obj.x10.Oc.X 15) A:unteratedB:100% recommended NPK C: 75% NPK +(NFB+PDB+SB)
Col= colenchyma Co= cortex Exph= External phloem
Ph= Pholem Enph= Enternal phloem Pi= pith

The enhancing effects of bio-fertilizers on chlorophylls concentration and their content may be attributed to their effects on increasing the production of growth substances especially cytokinins (Omay *et al.*, 1993). Cytokinins are known to stimulate chlorophyll synthesis and delay chlorophyll destruction and senescence (Daiziel and Lawrence, 1984). The decrease in chlorophylls under NPK stress may be due to the inhibiting effects of nutrients deficiency of the activity of Fe-containing enzymes; cytochrom oxidase (Maximova and Matychen, 1965). The disruption in chloroplast structure (Helaly, 1984) which in turn, may decrease the rate of chlorophylls biosynthesis and their accumulation.

3.2- Carbohydrate fractions:

Data in Table (6) were parallel with those obtained above with respect to photosynthetic pigments. Mineral fertilizers at full recommended dose (control) attained the highest reducing sugars, non-reducing sugars, total sugars and total carbohydrates concentrations in the shoots of potato plants. The carbohydrate fractions were decreased with decreasing NPK fertilizers doses less than the control. However, polysaccharides were increased as a result of NPK dose decrease and the lowest values were recorded in the control.

Application of bio-fertilizers, over all the NPK minerals doses, improved the accumulation of reducing sugars, non-reducing sugars, total sugars and total carbohydrates whereas, decreased that of polysaccharides in comparison to the plants grown without bio-fertilizers inoculation. The most effective treatment was found with NFB+PDB+SB followed by NFB+PDB and NFB+SB respectively. Moreover, the data indicated that, NFB strain was the most effective treatment followed by PDB and SB respectively.

Regarding the interaction treatments, data in the same table clearly show that, inoculation with all used bacteria strains and their interactions with NPK doses increased significantly the concentrations of reducing, non-reducing and total sugars as well as total carbohydrates whereas, decreased insoluble carbohydrates in the shoot system of potato plants. These results are true in the two growing seasons.

The additive effects of bio-fertilizers was more pronounced at the control (100% NPK). As NPK dose decreased, it seems that all bio-fertilizers used, with the superiority of NFB strain, counteracted the depression effect of NPK up to 75% dose. At 75% NK dose combined with bio-fertilizers attained nearly similar results with those recorded in the control plant with slight differences between them. Again, the most effective strains was found with NFB followed with DB and SB respectively. However, using these strains, all together, recorded highest counteraction effect. On the other , bio-fertilizers used failed to counteracted the harmful effects of NPK at 50% dose from the recommended dose. Bio-fertilizers in the presence of NPK at 50% dose from the recommended dose attained the minimum values in this respect.

Table [redacted] of mineral and/or bio- fertilizers on chlorophyll a , b and total chlorophylls (a+b) concentrations (mg/g F.Wt.) and their content (mg/plant) in the 3rd upper compound leaf of potato plants grown in the two growing seasons of 2001/2002 (S1) and 2002/2003(S2).

Treatments		Chlorophyll a Concentration (mg/g F.Wt.)			Chlorophyll b Concentration (mg/g F.Wt.)			Chlorophylls (a+b) Concentration (mg/g F.Wt.)			Chlorophylls (a+b) content (mg/plant)		
M- Mineral NPK	B- Bio-fertilizer	S1	S2	Mean	S1	S2	Mean	S1	S2	Mean	S1	S2	Mean
Control 100%	Without	0.930	0.995	0.961	0.413	0.435	0.424	1.343	1.430	1.386	98.0	117.7	107.9
	NFB	1.002	1.017	1.008	0.465	0.495	0.480	1.467	1.512	1.489	111.7	125.9	118.8
	PDB	0.986	1.014	1.000	0.424	0.472	0.448	1.410	1.486	1.448	107.7	124.7	116.2
	SB	0.942	1.006	0.974	0.416	0.443	0.430	1.358	1.449	1.403	101.8	119.1	110.5
	NFP+PDB	1.005	1.030	1.017	0.495	0.500	0.497	1.500	1.430	1.515	117.0	114.4	115.7
	NFB+SB	1.005	1.025	1.015	0.470	0.500	0.485	1.475	1.525	1.500	113.9	128.1	121.1
	PDB+SB	0.994	1.020	1.007	0.472	0.486	0.479	1.466	1.506	1.486	114.3	128.0	121.2
	NFB+PDB+SB	1.007	1.033	1.020	0.500	0.505	0.502	1.507	1.538	1.522	118.8	132.4	125.6
Mean		0.985	1.020	1.002	0.456	0.474	0.465	1.441	1.497	1.457	110.4	123.8	117.1
75%	Without	0.902	0.991	0.946	0.360	0.399	0.379	1.262	1.390	1.326	91.1	111.2	101.1
	NFB	0.986	1.010	0.998	0.447	0.440	0.443	1.433	1.450	1.441	108.0	120.6	114.3
	PDB	0.982	0.998	0.990	0.408	0.421	0.414	1.390	1.419	1.404	105.2	118.8	112.0
	SB	0.931	1.003	0.967	0.364	0.409	0.386	1.295	1.412	1.353	95.8	112.2	104.0
	NFP+PDB	0.997	1.019	1.008	0.478	0.472	0.475	1.475	1.491	1.483	115.0	127.1	121.1
	NFB+SB	0.997	1.016	1.006	0.456	0.459	0.457	1.453	1.475	1.464	110.8	124.4	117.6
	PDB+SB	0.981	1.017	0.999	0.421	0.441	0.431	1.402	1.427	1.414	107.5	120.5	114.0
	NFB+PDB+SB	1.002	1.018	1.010	0.492	0.485	0.488	1.494	1.503	1.498	116.5	128.5	122.5
Mean		0.976	1.011	0.993	0.420	0.446	0.433	1.397	1.452	1.426	106.3	120.4	113.3
50%	Without	0.892	0.966	0.929	0.303	0.323	0.313	1.195	1.279	1.237	73.4	97.9	85.7
	NFB	0.915	0.988	0.951	0.349	0.351	0.350	1.264	1.339	1.301	92.5	105.8	99.1
	PDB	0.904	0.985	0.945	0.318	0.347	0.333	1.222	1.332	1.277	90.3	106.4	98.4
	SB	0.900	0.980	0.940	0.315	0.325	0.320	1.215	1.305	1.260	88.2	101.7	94.9
	NFP+PDB	0.939	0.993	0.966	0.367	0.382	0.374	1.306	1.375	1.340	96.4	111.5	103.9
	NFB+SB	0.934	0.993	0.963	0.370	0.365	0.367	1.304	1.358	1.331	95.6	107.9	101.8
	PDB+SB	0.905	0.990	0.947	0.351	0.359	0.355	1.256	1.349	1.302	92.4	106.9	99.7
	NFB+PDB+SB	0.943	1.000	0.971	0.367	0.391	0.379	1.310	1.391	1.350	97.3	115.0	106.2
Mean		0.924	0.996	0.960	0.342	0.367	0.349	1.134	1.342	1.309	90.8	106.7	98.7
Mean	Without	0.908	0.991	0.949	0.359	0.386	0.372	1.267	1.366	1.321	87.5	108.9	98.2
	NFB	0.971	1.005	0.985	0.420	0.439	0.429	1.391	1.444	1.414	104.1	117.4	110.7
	PDB	0.960	0.999	0.983	0.383	0.430	0.406	1.344	1.429	1.389	101.1	116.6	108.8
	SB	0.924	0.996	0.961	0.364	0.392	0.378	1.289	1.389	1.339	95.3	111.0	103.1
	NFP+PDB	0.980	1.014	0.996	0.447	0.451	0.449	1.427	1.465	1.446	109.5	117.7	113.6
	NFB+SB	0.978	1.011	0.993	0.422	0.441	0.431	1.401	1.443	1.424	106.8	120.2	113.5
	PDB+SB	0.960	1.009	0.985	0.408	0.399	0.403	1.368	1.416	1.386	104.8	118.5	111.6
	NFB+PDB+SB	0.984	1.021	0.999	0.453	0.460	0.456	1.437	1.477	1.455	110.9	125.3	118.1
LSD at 5% for: SxB			0.003			0.003			NS			0.2	
SxM			0.001			0.002			0.019			0.4	
BxM			0.004			0.004			NS			0.5	
SxBxM			0.005			0.006			NS			0.7	

Table (6): Effects of mineral and/or bio- fertilizers on reducing sugars, non-reducing sugars, total sugars, polysaccharides and total carbohydrates concentration (mg/g D.Wt) in the shoot system of potato plants grown during the two growing seasons of 2001/2002 (S1) and 2002/2003 (S2).

Treatments		Reducing sugars			Non-reducing sugars			Total sugars			Polysaccharides			Total carbohydrates		
M- Mineral NPK	B- Bio-fertilizer	S1	S2	Mean	S1	S2	Mean	S1	S2	Mean	S1	S2	Mean	S1	S2	Mean
Control 100%	Without	20.98	19.17	20.07	2.91	2.59	2.75	22.08	23.57	22.82	100.06	102.11	101.09	122.88	125.68	124.28
	NFB	23.17	21.48	22.32	2.65	3.72	3.18	24.13	26.89	25.51	98.88	99.27	99.08	123.01	126.16	124.58
	PDB	21.75	21.66	21.20	1.87	2.54	2.20	23.53	24.49	23.51	99.43	101.23	100.33	122.96	125.72	124.34
	SB	20.62	21.52	19.82	1.90	2.27	2.08	22.42	24.89	23.65	99.98	100.08	100.03	122.99	124.97	124.34
	NFP+PDB	30.62	28.96	30.29	3.66	4.19	3.92	33.62	31.81	32.62	98.60	98.27	98.43	132.22	130.08	131.15
	NFB+SB	21.21	24.62	25.41	3.35	3.42	3.38	27.97	29.63	28.80	98.33	98.55	98.44	126.30	128.18	127.24
	PDB+SB	23.04	25.54	25.41	3.25	3.65	3.45	25.79	29.69	30.30	98.28	98.58	98.43	124.00	128.57	126.28
	NFB+PDB+SB	35.44	32.93	34.18	4.47	4.96	4.71	41.40	40.40	40.90	95.68	96.07	96.43	137.08	136.47	136.77
Mean		23.86	25.16	24.51	3.01	2.12	3.21	27.24	28.61	27.92		99.27	99.21	126.43	128.22	127.58
75%	Without	18.44	16.16	17.30	2.07	3.72	4.71	18.23	22.16	20.19	99.54	101.41	102.46	120.71	124.60	122.65
	NFB	22.29	20.65	21.47	2.47	2.72	2.59	23.12	25.01	24.06	99.01	100.63	101.28	123.80	125.86	124.83
	PDB	21.96	19.69	19.82	1.15	2.36	1.75	20.84	24.32	22.58	99.37	100.60	101.26	121.71	124.98	123.34
	SB	19.19	19.69	19.04	1.27	2.01	1.64	20.16	22.20	21.18	99.50	101.22	101.71	121.71	125.08	123.39
	NFP+PDB	30.83	27.51	29.17	3.45	3.69	3.57	30.96	34.52	32.74	98.55	99.88	99.13	130.00	133.74	131.87
	NFB+SB	25.98	23.63	24.80	1.72	2.34	2.03	25.35	28.32	26.83	98.76	99.66	100.10	125.44	128.43	126.93
	PDB+SB	22.95	21.54	22.24	1.09	2.33	1.71	22.83	25.28	23.95	98.81	99.29	100.25	122.81	125.61	124.21
	NFB+PDB+SB	35.49	31.85	33.67	4.10	4.51	4.30	35.95	40.00	37.97	95.10	96.54	95.65	135.93	135.33	135.63
Mean		22.36	24.52	23.44	2.16	2.96	2.56	24.53	27.48	26.00	98.58	99.93	99.50	125.63	128.32	127.58
50%	Without	15.33	14.17	14.75	1.46	1.46	1.46	15.63	18.82	16.22	102.48	102.44	100.47	115.17	118.23	138.63
	NFB	17.88	16.95	17.58	1.33	2.48	1.90	18.21	20.39	19.30	101.68	100.85	99.82	117.22	121.02	119.12
	PDB	17.43	16.83	17.13	1.12	2.24	1.68	17.95	19.69	19.81	100.87	101.66	100.08	117.32	120.47	118.89
	SB	16.41	16.58	15.99	1.62	1.49	1.55	18.20	18.90	18.55	101.55	101.88	100.36	117.70	119.12	118.89
	NFP+PDB	23.42	20.06	21.74	2.27	2.21	2.24	18.33	25.73	24.03	99.04	99.22	99.22	120.88	125.81	123.24
	NFB+SB	19.27	18.49	18.88	1.84	2.76	2.30	20.33	22.03	21.18	100.09	100.11	99.21	119.09	121.69	120.39
	PDB+SB	19.09	18.21	18.65	1.54	1.85	1.69	19.75	20.04	19.89	100.18	100.33	99.04	118.56	119.33	118.94
	NFB+PDB+SB	29.48	27.43	28.45	3.06	3.55	3.30	29.49	33.03	31.26	95.98	95.33	95.82	124.59	129.57	127.08
Mean		18.46	19.83	19.15	2.16	2.96	2.02	20.24	21.95	21.09	100.23	100.23	100.60	119.06	122.13	120.59
Mean	Without	16.50	18.25	17.37	2.15	2.59	2.36	18.65	20.85	19.75	100.70	101.98	101.34	119.58	122.83	121.21
	NFB	19.69	21.22	17.36	2.15	2.97	2.56	21.82	24.09	22.96	99.85	100.25	100.05	119.58	124.34	121.21
	PDB	18.73	20.05	19.39	1.38	2.38	1.88	20.11	22.49	21.30	99.85	100.25	100.56	120.66	123.72	122.19
	SB	17.99	18.57	18.28	1.59	1.92	1.88	19.59	20.50	20.04	100.34	101.08	100.70	120.80	123.05	121.92
	NFP+PDB	25.84	28.29	27.07	3.13	3.36	3.24	28.97	31.68	30.33	98.73	99.12	98.93	127.70	129.81	128.75
	NFB+SB	22.25	23.82	23.03	2.30	2.84	3.24	24.55	26.66	25.60	99.08	99.44	99.25	123.61	126.10	124.85
	PDB+SB	20.76	21.69	21.23	1.96	2.84	2.28	24.55	24.00	23.36	99.09	99.40	99.24	121.79	124.50	123.14
	NFB+PDB+SB	30.74	33.47	32.10	3.88	4.34	4.11	35.61	37.81	36.71	95.58	95.98	95.78	134.86	136.12	135.49
LSD at 5% for: SxM			0.05			0.01			0.02			0.01			0.08	
SxB			0.08			0.01			0.01			0.02			0.14	
MxB			0.11			0.01			0.02			0.02			0.17	
SxMxB			0.14			0.01			0.03			0.03			0.23	

The increase of total sugars and total carbohydrates concentration due to the bio-fertilizers as shown in the present study was supported by Agamy (2004) and Mohamed, Faten (2007). They showed that, bio-fertilizers significantly increased leaf chlorophylls and carotenoides concentration than those of unfertilized plants. The enhancing effect of bio-fertilizers on growth and photosynthetic pigments as well as the availability of mineral uptake and large increase in the rate of photosynthesis by the plant which are sufficient to plant growth may explain the increase of total carbohydrates concentration.

The stimulating effects of both bio- and mineral fertilizers on sugar concentration may be related to their effects on enhancing photosynthetic pigments in the leaves and different plant hormones as shown in the resent investigation.

4- yield and its components:

Data in Table (7) indicate that tuber yield (g) per plant, tubers number per plant, tubers dry weight per plant and total yield (ton/fed) during the two growing seasons were decreased with decreasing dose of NK fertilizers, overall the bio-fertilizers used.

Table (7) : Effects of mineral and/or bio-fertilizers on tubers yield (g) per plant, tubers numbers per plant, tubers dry weight (g) per plant and total tubers yield (ton/fed) of potato plant grown during the two growing seasons of 2001/2002 (S1) and 2002/2003 (S2).

Treatments		Tubers yield (g) / plant			Tubers numbers /plant			Tubers dry weight (g) /plant			Total tubers yield (ton/fed.)		
M-Mineral NPK	B-Bio-fertilizer	S1	S2	Mean	S1	S2	Mean	S1	S2	Mean	S1	S2	Mean
Control 100%	Without	425.710	538.224	481.965	3.59	5.03	4.31	63.890	87.668	75.780	9.730	10.790	10.260
	NFB	470.738	588.562	529.700	4.77	5.53	5.15	74.093	92.171	83.129	11.128	12.138	11.635
	PDB	468.841	585.218	526.980	4.65	5.66	5.15	73.743	91.870	82.705	11.062	12.182	11.620
	SB	457.062	508.887	482.975	4.64	5.14	4.89	69.690	88.540	79.115	10.397	11.280	10.840
	NFP+PDB	487.041	597.602	542.320	5.34	6.33	5.83	78.386	95.362	86.875	11.311	12.387	11.850
	NFB+SB	483.310	589.203	536.255	5.31	5.97	5.64	77.350	94.353	85.851	11.180	12.262	11.720
	PDB+SB	475.328	595.362	535.345	5.08	5.86	5.47	75:329	92.566	83.950	11.161	12.178	11.670
	NFB+PDB+SB	492.152	598.911	545.530	5.56	6.48	6.02	80.848	97.421	89.135	11.342	12.483	11.910
Mean		470.022	575.245	3522.64	4.87	5.75	5.31	74.541	92.094	83.317	10.914	11.962	11.438
75%	Without	481.980	428.655	375.326	3.95	5.07	4.51	60.433	85.922	73.175	8.053	9.164	8.605
	NFB	558.481	499.405	440.332	4.42	5.52	4.97	72.610	86.901	79.755	9.698	10.908	10.305
	PDB	562.723	497.640	432.962	4.30	5.48	4.89	72.485	86.913	79.695	9.641	10.878	10.265
	SB	502.652	454.500	406.350	4.13	5.47	4.80	70.044	82.730	76.385	8.960	9.920	9.440
	NFP+PDB	573.947	515.138	456.326	5.60	5.93	5.76	77.173	88.910	86.040	10.472	11.519	10.995
	NFB+SB	562.980	507.890	452.802	5.46	5.91	5.69	74.660	87.699	81.180	10.226	11.197	10.715
	PDB+SB	565.232	505.030	444.831	5.34	5.60	5.47	73.951	86.977	80.465	10.123	11.132	10.825
	NFB+PDB+SB	582.668	530.000	477.329	5.70	5.96	5.83	79.239	93.659	86.450	10.639	11.630	11.135
Mean		435.782	548.782	492.282	4.86	5.62	5.24	73.198	86.839	80.018	9.726	10.795	10.261
50%	Without	328.144	456.678	392.410	2.57	3.67	3.12	48.671	71.560	60.115	6.440	7.431	6.935
	NFB	408.478	516.452	462.465	3.14	4.24	3.69	55.657	77.070	66.465	8.112	8.830	8.471
	PDB	405.141	518.680	461.910	3.25	3.78	3.51	55.224	77.503	66.362	8.092	8.812	8.452
	SB	359.491	481.649	420.570	2.92	3.78	3.35	49.260	73.122	61.190	7.038	8.000	7.520
	NFP+PDB	417.520	537.901	477.710	4.22	4.33	4.27	60.081	80.896	70.490	8.539	9.607	9.075
	NFB+SB	408.832	533.062	470.945	4.29	4.31	4.30	58.893	78.202	68.545	8.271	9.231	8.750
	PDB+SB	410.451	527.022	468.735	3.96	4.00	3.98	57.480	77.030	67.255	8.219	9.078	8.650
	NFB+PDB+SB	430.001	546.686	488.343	4.39	4.45	4.42	61.378	83.593	72.485	8.549	9.928	9.338
Mean		384.756	514.766	449.761	3.59	4.07	3.83	55.855	77.372	66.613	7.933	8.865	8.399
Mean	Without	376.393	492.293	434.343	3.37	4.59	3.98	60.330	79.050	69.690	8.073	9.127	8.600
	NFB	438.737	555.777	496.432	4.11	5.11	4.60	67.476	85.383	76.430	9.640	10.627	10.133
	PDB	436.760	554.127	496.268	4.07	4.97	4.52	67.190	85.357	76.274	9.603	10.627	10.115
	SB	407.633	497.730	452.682	3.91	4.81	4.35	62.996	81.463	72.230	8.800	9.733	9.267
	NFP+PDB	453.630	569.618	511.723	5.05	5.53	5.29	71.880	88.390	80.135	10.107	11.173	10.640
	NFB+SB	448.313	561.747	505.030	5.02	5.41	5.21	70.300	86.750	78.525	9.833	10.797	10.395
	PDB+SB	443.537	562.537	503.037	4.79	5.15	4.97	68.920	85.526	77.223	9.893	10.897	10.315
	NFB+PDB+SB	466.493	576.090	521.291	5.22	5.63	5.42	73.823	91.556	82.690	10.243	11.347	10.795
LSD at 5% for: SxM		2.551			0.140			NS			NS		
SxB		0.047			0.089			1.156			NS		
MxB		3.124			0.144			NS			NS		
SxMxB		4.418			0.244			NS			NS		

It is also show that bio-fertilization exerted positive effects in this respect particularly with the combined treatment of NFB+PDB+SB.

Concerning the effects of interaction treatments between bio- and mineral fertilizers on tubers numbers and tubers dry weight (g) per plant, the data presented in the same tables show that, tubers numbers and tubers dry weight (g) per plant were significantly increased with all used bacterial strains inoculation interacted with mineral fertilizer doses. Plant inoculation with mixed strains of used bacteria were the most effective in this respect. Similarly, the inoculation of plants with any of the three bacterial strains and grown under 75% NPK gave high values regarding yield compared with the uninoculated ones grown under 100% NPK

The increase in tuber yield per plant and potatoes tubers yield per fadden under mineral and/or bio-fertilizers may be due to their effects on increasing plant vigor growth represented plant height, number of branches and leaves per plant as well as leaf area per plant (Table 2) and photosynthetic pigments (Table 5).

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بعض الإستجابات المورفولوجيه والفسيولوجيه والتشريحيه والمحصول ومكوناته لنبات البطاطس للتسميد الحيوى والمعدنى.

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أجرى هذا البحث بهدف دراسة ثلاث مستويات مختلفة من التسميد المعدنى أحداهما التركيز الموصى به كمعاملة مقارنه، 75% و50% من جرعة التسميد الموصى به، ثلاث سلالات بكتيريه كمصدر للتسميد الحيوى هى سلالة ازوسبريلليم المثبته للنيتروجين، سلالة سيدوموناس فلوريسينس المذيبه للفوسفات وسلالة الباسلس سيركيولنس الميسرة لاطلاق البوتاسيوم المرتبط بمعادن التربه على بعض الصفات المورفولوجيه والفسيولوجيه والتشريحيه والمحصول ومكوناته لنبات البطاطس. وتتلخص اهم التاثيرات الرئيسيه فى الاتى:

أدى نقص التسميد المعدنى عن الجرعه الموصى بها الى نقص طول النبات وعدد الافرع وعدد الاوراق ومساحة الورقه للنبات وكذلك صبغات البناء الضوئى والكربوهيدرات فى الاوراق وكذلك المحصول ومكوناته متمثلا فى عدد الدرنات ووزن الدرنات لكل نبات والوزن الجاف للدرنات والمصول الكلى يالطن للفدان. كما أدى التلقيح الحيوي بمخلوط السلالات البكتيريه المستخدمه الى حدوث تأثير إضافى موجب على صفات النمو والمحصول.

تشريحيا، أدى إضافة كل من السماد الحيوي أو السماد المعدنى وتفاعلاتهما الى زيادة سمك الوريقه، والنسيج المتوسط وأبعاد الحزمه الوعائيه الرئيسيه كما أدى الى زيادة قطر الساق وسمك نسيج القشرة ونسيجى الخشب ، اللحاء (الخارجى والداخلى) وقطر نسيج النخاع.

وخلصت النتائج الى أن إستعمال المخصبات الحيوية زاد من مقاومة نمو نبات البطاطس لنقص تركيز المخصبات المعدنية حتى 50% من الجرعة الموصى بها دون التأثير على إنتاجية محصول البطاطس بالإضافة الى خفض تكاليف الإنتاج والحد من التلوث البيئى مع تقليل التأثيرات الضارة لإستعمال الأسمدة الكيميائية على صحة الإنسان.