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RESPONSE OF TOMATO TO BIOLOGICAL AND MINERAL FERTILIZERS UNDER CALCAREOUS SOIL CONDITIONS

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By

H. A. F.Mahmoud and M. A.T. Amara *

*Plant Production Department. * Soil Fertility and Microbiology Department , Desert Research Center.*

ABSTRACT

Two field experiments were carried out during two successive seasons, 1996 - 1997 and 1997-1998 in Maryout Experimental Station (D.R.C), Alexanderia Governorate , Egypt , to evaluate the role of biofertilization technique and / or NPK fertilizers on different tomato characters as well as microbial activity . The treatments comprised different species of *Bacillus* and *Pseudomonas* isolates supported by different doses of NPK which were added as ammonium sulphate + calcium super phosphate + potassium sulphate in rates 100% (400 + 300 + 200) Kg./ fed. , 75% , 50% , 25% and 0 % from the recommended doses . The obtained results indicated that several plant parameters were stimulated significantly as a result of biofertilization and NPK applications referring to control . Biofertilization with B_4 (*Bacillus subtilis*) and B_2 (*Bacillus megatherium*) were the best treatments combined with 50% of NPK dose .This treatment led to an increase in growth parameters , fruit yield , TSS and vitamin C as well as nutrient content . The application of NPK either individually or in combination with biofertilizer improved CO_2 evolution. By increasing of NPK rates up to 100% dose, growth characters, fruit yield, fruit quality and mineral content were significantly increased when compared with the control treatment.

Key words: *biofertilizers, calcareous soil , NPK fertilizers, tomato.*

1. INTRODUCTION

Tomato (*Lycopersicon esculentum Mill*) is considered one of the most important vegetables . It is grown in a relatively large area in Egypt and considered one of the main economical export vegetable crops , in addition to its usage in local markets and processing . Nowadays biofertilization technique is used beside mineral fertilizers for the plant nutritional requirements in agriculture . Attempts are carried out to minimize the use of mineral fertilizers for its high cost as well as its environmental pollution problems .Several soil bacteria particularly those belonging to the genera *Bacillus* and *Pseudomonas* which are phosphate dissolvers were used as a biofertilizer for providing the growing plants with an available form of phosphorus by producing organic acids which reduce the pH and bring about the dissolution of bound forms of phosphate , (Rovira, 1963 and Amara 1994). Also, *B. polymyxa* , *B. macerans* , *B. circulans* and some *Pseudomonas* strains were used as N - fixers having the ability to fix atmospheric nitrogen and consequently stimulated plant growth,(Bally *et al.*, 1983) . In addition Abdel Ghafar *et al.*,(1996) showed that *B. subtilis* , *B. cereus* and *Ps. fluorescens* frequently inhibit pathogens by producing antibiotic and fluorescent siderophores .

Growth characters, yield and dry matter percentage of tomato were increased by increasing NPK rates. [Brun *et al.*, (1986); Kooner and Randhawa (1990) and Shibhila and Balakrishnan (1990)].Also, increasing NPK rates had a beneficial effect on fruit content of T.S.S. and ascorbic acid (Patil and Bojappa ,1984;Kooner and Randhawa , 1990 and Al Afifi *et al.*, (1993). Application of NPK increased their uptake by tomato plants (Al Afifi *et al.*, 1993 and Guo and Lu, 1991) .

Regarding the interaction effect of microbial inoculation combined with mineral NPK fertilizers on plant growth, Kumaraswamy and Madalageri (1990) showed that the highest yield of tomato was obtained by adding NPK at the rate of 60 N, 30 P_2O_5 and 50 K_2O /h combined with *Azotobacter chroococcum*. Also, Harridy and Amara (1998) recorded a positive response of rosella plants to *Rhizobium* and *Azotobacter* inoculation as compared with the higher dose of nitrogen (80 Kg N/ fed.) without inoculation .

The main objective of the present work was to determine the optimum rate of NPK fertilizers with the most effective genera of inoculates which stimulate the CO_2 evolution , growth , yield , fruit quality and NPK uptake of tomato plants under calcareous soil conditions.

2. MATERIALS AND METHODS

A field experiment was carried out over a period of two successive seasons *i.e.*, 1996-1997 and 1997-1998 in Maryout Experimental Station of the Desert Research Center , Egypt . Some physical and chemical properties of the soil are presented in Table (1). Analysis was carried out according to Piper (1950) and Jackson (1958) .

A split plot design with 3 replicates was used . Eight bacterial isolates were randomly distributed as main plots , five *Bacillus* species and three isolates as *Pseudomonas flourescens* are shown in the following :

1- *Bacillus polymyxa* (B_1)
2- *Bacillus megatherium* (B_2)
3- *Bacillus macerans* (B_3)
4- *Bacillus subtilis* (B_4)
5- *Bacillus cereus* (B_5)
6- Ps_1 as a mutant
7- Ps_2 , isolated from wheat rhizosphere
8- Ps_3 , isolated from salt marches
9- Control treatment ,without biofertilization

Each bacterial treatment and control were divided into five subplots considered as NPK treatments as follows:

1. $(NPK)_1$ 100% as recommended dose { 400 Kg amm. sulphate (20.5% N) + 300Kg calcium super phosphate (15.5 % P_2O_5) + 200 Kg potassium sulphate (48% K_2O) /fed. }.
2. $(NPK)_2$, 75% from $(NPK)_1$.
3. $(NPK)_3$, 50% from $(NPK)_1$.
4. $(NPK)_4$, 25% from $(NPK)_1$.
5. Control .

N and K fertilizers were added at two equal doses after 3 and 6 weeks from transplanting while P was added once before transplant-

ing as basal application .

Seeds of tomato cv. Castle Rock were sown on July 15 th , and the seedlings were transplanted after forty days from sowing , 20 cm apart on ridges one meter wide and 3.5 m long . The experimental unit contained three ridges 10.5 m^2 (1/400 fed.). Organic fertilizer at 25 m^3 /fed. was added to all treatments one month before transplanting . Seedlings of tomato were dipped in heavy cell suspension of different types of bacteria for 3 hr before setting in the permanent field.

Five *Bacillus* spp. and three *Pseudomonas flourescens* strains were isolated from different soils and plants cultivated in desert soils. Isolation and identification of the isolates were carried out according to Bergey's Manual of Systematic Bacteriology (1984) .

Isolates of *Bacillus* and *Pseudomonas* were grown separately in Bunt and Rovira, (Abd El- Hafez, A.M.,1966)and KBM (King *et al.*, 1954) media at 30 °C for 2 days, respectively.

Data were recorded on the following characters :

A- Vegetative growth: Plant height (cm), plant weight (gm) and dry matter (%) were measured after 70 days from transplanting .It was estimated by dividing hundred times of dry weight of plant material over its fresh weight.

B- Yield and quality : Harvesting started from 25 Jan. and continued till 20 th April and from 20 Jan. till 14th April for the 1st and 2 nd season, respectively . The following data were recorded : total yield as ton/fed., average fruit weight (gm), total soluble solids (%) using Zeiss laboratory refractometer and vitamin C (mg/100 g fresh weight) according to A.O.A.C., (1975).

C-Minerals content: Nitrogen , phosphorus and potassium contents as a percentage of dry weight were estimated in the digest of leaves collected at 10 weeks from transplanting . Total nitrogen was determined by the method of Huphries (1965). Phosphorus was spectrophotometrically estimated using the method of El-Hineidy and Agiza(1957) . Potassium was determined using flame photometer , Brown and Lilliland (1964) .

Data were statistically analyzed by the method of Snedecor (1966)

D-Microbiological determination : Rhizospheric soil of tomato plants were taken at two stages of growth, the first after 70 days from transplanting and the second at harvesting time and analyzed for total fungal counts on Martin 's medium (Allen, 1959) and CO_2

evolution rates according to Parmer and Schmidt (1964).

Table (1):Physical and chemical analysis of the experimental soil.

Physical properties	Determination
Texture class : Ca CO_3 %	32.5
Sandy Clay Loam Sand %	55.55
Clay %	24.05
Silt %	20.49
Chemical properties	
EC m.mhos/cm	2.7
pH	8.4
Soluble cations : (mg/100g)	
Na^+	17.41
K^+	1.45
Ca^{++}	5.82
Mg^{++}	3.69
Soluble anions : (mg/100g)	
HCO_3^-	1.303
CO_3^{--}	-
Cl^-	12.955
SO_4^{--}	15.113

3. RESULTS AND DISCUSSION

Effect of mineral fertilizers and / or biofertilizer on:

3.1. Total fungal counts

The effect of *Bacillus* spp. and *Ps. flourescens* isolates alone or in combination with different levels of NPK on fungal counts in the rhizospheric soil of tomato plants is presented in Table (2). The recorded data indicate that control treatment without biofertilization gave higher fungal counts than biofertilized ones, and fertilization with *Bacillus* spp. was superior than that with *Pseudomonas* isolates , being in the average of 31 , 14 , 10 and 45 ,25 and 13 $x10^2$ /gm rhizospheric soil for control , *Bacillus* spp and *Ps.* treatments during the first and second stages of growth, respectively . This may be due to the production of siderphores compounds which inhibit fungal spore germination *via* causing unavailability of iron (Jagnow 1991) or due to the lysis of chitinaceous cell walls of patho-

Table (2): Effect of biofertilization combined with different doses of inorganic fertilizers on total fungal counts ($x10^2$ /g rhizospheric soil). Average of 2 seasons .

Chem. fert.	Stage I						Stage II					
Bio. fert.	A	B	C	D	E	X	A	B	C	D	E	X
Cont.	60.0	32.0	20.0	10.0	-	30.5	84.0	40.0	33.0	21.0	-	44.5
B_1	35.0	10.0	6.0	4.0	2.0	11.4	60.0	27.0	22.0	17.0	1.6	25.5
B_2	28.0	15.0	12.0	5.0	3.0	12.6	70.0	25.0	20.0	16.0	4.0	27.0
B_3	37.0	16.0	12.0	9.0	5.0	15.8	70.0	32.0	30.0	25.0	2.8	32.0
B_4	22.0	23.0	17.0	5.0	1.2	13.6	50.0	22.0	11.0	7.0	1.0	18.2
B_5	55.0	14.0	18.0	3.0	2.5	18.5	50.0	20.0	14.0	11.0	2.2	19.4
Mean	35.4	15.6	13.0	5.2	2.7	14.4	60.0	25.0	19.4	15.2	2.3	24.4
Ps_1	40.0	10.0	3.0	2.0	0.5	11.1	50.0	15.0	12.0	2.0	0.6	15.9
Ps_2	31.0	11.0	13.0	8.0	1.0	12.8	33.0	15.0	13.0	9.0	1.2	14.2
Ps_3	16.0	11.0	8.0	1.0	0.3	7.3	20.0	10.0	7.0	4.0	0.8	8.4
Mean	29.0	10.7	8.0	3.7	0.6	10.4	34.3	13.3	10.7	5.0	0.9	12.8

A,B,C,D&E refer to 100%, 75%, 50%, 25% and 0% NPK rates, respectively from the recommended dose .

genic fungi by specific enzymes produced by bacteria (Nelson *et al.* , 1986) . Furthermore , NPK application induced favorable effect on fungal counts which increased by increasing the rate of NPK applied, being in the average of 32.2 , 13.1, 10.5 , 4.5 , 1.6 and 47.1 , 19.2 , 15.0 , 10.1,1.6 x10^2 /g soil for 100% , 75% , 50% , 25% and 0% /NPK during the two growth periods, respectively .

3.2. Rate of CO_2 evolution

Rate of CO_2 evolution was determined as an indication of microbial activities in the tested soil samples. Results in Table (3) showed that the levels of CO_2 evolution were affected by inoculation and chemical fertilization . As expected, addition of biofertilizers in combination with different doses of NPK stimulated CO_2 evolution . The maximal CO_2 evolutions were recorded under treatments inoculated with *Ps. fluo.* ,which ranged from 59.4 to 10 mg CO_2 /100 g soil/hr . While the corresponding figures for *Bacillus* spp were 28.6 to 7.3 under different NPK levels . With respect to NPK fertilization , the rates of CO_2 evolution were increased consequently with the increase of NPK levels within the studied doses . The average values were 21.4 , 16.2 , 13.3 , 10.2 , 10.0 and 34.2 , 25.7, 20.5 , 17.1 and 15.4 for 100% , 75% , 50% , 25 % and 0% NPK during the two growth periods, respectively .

3.3. Vegetative growth

3.3.1. Plant height (cm)

Data presented in Table (4) show the effect of different bacterial inoculation and/or different doses of NPK on the height of tomato plants . Generally speaking , plant inoculation with either *Bacillus* or *Pseudomonas* in combination with NPK fertilizer significantly increased plant height as compared with non-inoculated ones . However, the magnitude of this increase varied according to the dose of NPK applied regardless of the form of bacterial type .

Treatments receiving 25% of NPK gave the lowest figures of plant height while 100% NPK treatment showed the highest ones . These results agree with those obtained by El-Beheidi *et al* .,(1990 a and b) and Shahien *et al*., (1994) . Regardless of the type of bacteria ,inoculation had a positive effect on plant height , this might be due to excretion of some growth regulating substances. Gibberellin-like

+Table (3): Rates of CO_2 evolution (mg/100g dry rhizospheric soil/hr) from tomato plants inoculated with biofertilizers in combination with NPK rates (average of 2 seasons).

Chem. fert.	Stage I						Stage II					
Bio. fert.	A	B	C	D	E	X	A	B	C	D	E	X
Cont.	13.52	9.81	8.31	6.43	6.10	8.80	24.41	15.52	13.33	13.10	12.82	15.80
B_1	15.40	10.46	8.80	7.40	7.30	9.90	26.40	17.60	15.40	14.16	15.60	17.80
B_2	15.60	12.76	10.56	7.92	8.10	11.00	24.75	21.20	17.60	15.20	12.70	18.30
B_3	17.60	17.60	10.46	8.60	9.30	12.70	26.40	22.00	19.80	17.60	14.90	20.10
B_4	17.60	10.56	10.70	8.60	9.40	11.40	28.60	22.00	17.60	19.80	15.00	20.60
B_5	16.92	11.46	11.20	8.60	8.10	11.30	18.50	17.60	14.08	14.52	9.70	14.90
Mean	16.60	12.60	10.30	8.20	8.40	11.30	24.90	20.10	16.90	16.30	13.60	18.30
Ps_1	22.00	19.40	18.33	13.00	11.00	16.70	53.51	46.20	34.70	22.00	19.40	35.16
Ps_2	34.60	22.00	17.60	13.00	13.30	20.10	59.40	34.70	26.40	22.00	21.30	32.80
Ps_3	22.00	18.04	13.20	11.00	10.90	15.00	17.60	13.20	11.40	10.00	10.89	12.62
Mean	26.20	19.80	16.40	12.30	11.70	17.30	43.50	31.40	24.20	18.00	17.20	26.90

A,B,C,D&E refer to 100%, 75%, 50%, 25% and 0% NPK rates, respectively from the recommended dose.

Table (4): Effect of inorganic and biofertilizers on plant height (cm) of tomato under calcareous soil conditions .

Chem. fert.	1996-1997						1997-1998					
Bio. fert.	A	B	C	D	E	X̄	A	B	C	D	E	X̄
Cont.	34.0	28.0	24.0	20.0	19.0	25.0	36.6	33.0	30.0	25.0	20.3	29.0
B_1	41.0	37.0	34.0	26.3	25.7	32.8	43.3	39.7	37.0	32.3	28.7	36.2
B_2	37.3	34.0	29.0	27.7	23.7	30.3	38.7	38.1	35.0	33.1	26.3	34.2
B_3	40.3	34.7	31.3	26.0	24.7	31.4	40.3	40.3	39.0	34.7	27.3	36.3
B_4	39.3	36.3	27.3	24.3	23.7	25.3	41.0	34.0	37.3	27.7	22.7	32.5
B_5	38.7	34.3	37.7	32.0	21.7	32.9	39.3	39.0	38.7	36.7	26.0	35.9
Ps_1	35.3	28.7	28.3	25.0	29.7	29.4	38.3	36.7	35.7	29.0	21.7	32.3
Ps_2	36.0	35.7	32.0	29.0	24.3	29.4	38.3	35.3	30.0	27.7	21.7	30.6
Ps_3	33.7	31.7	30.3	27.3	22.0	29.0	41.0	39.7	37.7	33.3	25.7	35.5
Mean	37.3	33.4	30.4	26.4	23.8		45.6	37.3	35.6	31.1	24.5	
L. S. D. at 0.05 for : Bio. fert.				3.437						2.90		
Chem. fert.				2.385						2.131		
Bio. X Chem.				N.S						N.S.		

A,B,C,D&E refer to 100%, 75%, 50%, 25% and 0% NPK rates, respectively from the recommended dose .

substances in culture of *Bacillus megatherium* (Hussain and Vancura, 1970) *Bacillus subtilis* (Katzenelson and Cole,1965) and *Pseudomonas* species (Eklund , 1970) were detected .

3.3.2. Plant weight (gm)

Data recorded in Table (5) showed the effect of bacterial inoculation and / or different doses of NPK fertilizers on plant weight . Treatments receiving different doses of NPK and inoculated with either *Bacillus* or *Ps.* sp.produced higher weights than those of non-inoculated ones . The highest figures were recorded with B_1 and Ps_3 sp. receiving 50% ,75% and 100 % NPK . The stimulatory effect on plant weight was affected by dose of NPK application , the highest dose gave the highest weight . These results agree with those of Shibhila and Balakrishnan (1990).

3.3.3. Dry matter (%)

The percentage of dry matter of tomato plant ($\frac{\text{dry weight of shoot/ plant}}{\text{Fresh weight}}$ x 100) as affected by biological and chemical fertilizers are illustrated in Table (6) . Dry matter was increased in ascending order with increasing NPK rates up to 100% . In both seasons, the combination between bacteria and NPK (50 % or 100%) showed the highest increase . These results agree with those mentioned by Devlin (1979). This may be due to the increase of photosynthesis process as a result of NPK application and bacterial inoculation which supply small amounts of gibberellin which increase leaf area and produce a greater photosynthetic surface. Also, increment by NPK application may be due to the beneficial effect of N ,P and K within the plant .

3.3.4. Fruit weight (gm)

Results in Table (7) showed the effect of bio-fertilizers and / or mineral fertilizers of (NPK) on tomato fruit weight . The results revealed that bacterial inoculation combined with NPK at rates of 50 % , 75% and 100% from the recommended dose showed the highest effect regardless the type of bacterial inoculation . However, plants inoculated with B_4 (*Bacillus subtilis*) combined with different rates gave the best fruit weight being in the average of 82.5 and 84.3 gm

Table (5): Effect of inorganic and biofertilizers on plant weight (gm) of tomato under calcareous soil conditions .

Chem. fert.	1996-1997						1997-1998					
Bio. fert.	A	B	C	D	E	X̄	A	B	C	D	E	X̄
Cont.	300.0	260.0	210.0	140.0	097.0	201.4	260.0	252.0	210.0	135.0	104.0	192.2
B_1	523.7	456.0	391.0	244.7	170.0	352.9	382.7	366.7	367.0	216.6	141.3	294.9
B_2	475.7	402.7	368.7	241.0	169.3	331.5	380.7	347.0	347.3	182.0	142.0	280.2
B_3	493.0	300.0	339.7	158.0	142.0	304.5	384.7	362.7	347.0	189.3	142.6	285.3
B_4	440.3	365.0	270.7	143.0	107.0	257.2	297.0	301.0	256.0	168.6	126.6	229.8
B_5	336.3	220.3	274.0	190.7	111.3	226.5	311.7	336.0	282.6	183.3	124.3	247.6
Ps_1	269.0	252.0	249.3	144.0	107.3	204.3	258.3	252.7	240.0	146.6	110.0	201.5
Ps_2	472.3	411.0	364.0	153.3	125.3	503.2	386.0	315.3	285.0	142.6	122.6	250.3
Ps_3	521.3	377.3	339.3	235.3	143.7	323.4	416.0	327.7	298.0	225.3	126.0	278.7
Mean	422.3	319.4	311.9	183.3	130.3		342.1	317.9	292.6	176.4	126.6	

L.S.D at 0.05 for : Bio. fert. 53.589 33.2888

Chem. fert. 29.026 21.036

Bio. X Chem. 123.55 N.S.

A,B,C,D&E refer to 100%, 75%, 50%, 25% and 0% NPK rates, respectively from the recommended dose .

Table (6): Effect of inorganic and biofertilizers on dry matter (%) of tomato under calcareous soil conditions .

Chem. fert.	1996 - 1997						1997 - 1998					
Bio. fert.	A	B	C	D	E	X	A	B	C	D	E	X
Cont.	15.1	15.0	14.0	12.9	13.2	13.8	15.4	15.0	14.2	12.8	12.2	13.9
B_1	15.8	15.6	15.5	13.8	13.7	14.9	16.7	15.8	16.8	14.2	12.8	13.5
B_2	15.9	15.7	15.5	14.2	13.8	15.0	16.4	15.8	16.1	13.8	13.6	15.1
B_3	15.3	15.0	15.0	14.0	13.7	14.6	15.1	15.2	15.3	13.5	13.0	14.4
B_4	15.5	15.6	15.5	14.1	13.5	14.8	15.8	15.5	15.8	14.5	13.4	15.0
B_5	15.5	15.5	15.4	13.8	13.5	14.7	15.8	15.5	16.0	14.2	14.0	15.1
Ps_1	15.1	15.1	15.0	14.0	13.3	14.5	15.3	15.3	15.5	14.1	13.6	14.8
Ps_2	15.8	15.5	15.4	14.0	13.6	14.9	15.4	15.1	14.7	14.2	13.7	14.6
Ps_3	15.8	15.5	15.3	14.1	13.0	14.7	16.1	15.7	15.5	14.5	13.5	15.1
Mean	15.5	15.4	15.2	13.9	13.4		15.8	15.4	15.5	14.0	13.3	
L.S.D at 0.05 for : Bio. fert.					0.396						0.421	
Chem. fert.					0.212						0.293	
Bio. X Chem.					N.S.						0.882	

A,B,C,D&E refer to 100%, 75%, 50%, 25% and 0% NPK rates, respectively from the recommended dose .

Table (7): Effect of inorganic and biofertilizers on fruit weight (gm) of tomato under calcareous soil conditions .

Chem. fert.	1996 - 1997						1997 - 1998					
Bio. fert.	A	B	C	D	E	X̄	A	B	C	D	E	X̄
Cont.	73.67	78.66	64.67	54.33	47.30	63.73	78.33	74.33	67.33	59.33	52.00	66.26
B_1	88.33	87.33	88.33	73.33	69.00	81.26	93.33	90.66	85.00	74.67	68.00	82.33
B_2	75.33	80.00	81.33	77.67	68.00	76.46	91.66	82.00	88.66	81.66	78.33	84.46
B_3	79.70	73.33	77.33	64.33	63.33	71.60	89.66	89.33	86.66	69.00	66.66	80.26
B_4	87.66	98.33	90.00	71.00	65.67	82.53	89.33	96.00	92.33	75.66	68.00	84.26
B_5	75.33	81.00	86.33	70.66	70.66	76.80	85.66	82.66	86.00	75.33	64.66	78.86
Ps_1	70.66	70.66	70.66	66.66	58.00	67.83	85.00	81.33	81.00	69.33	61.33	75.60
Ps_2	80.66	82.60	83.00	59.00	49.66	70.98	93.66	82.66	77.33	68.33	58.33	76.06
Ps_3	78.33	91.00	79.33	71.33	68.33	77.66	78.00	78.33	81.00	73.33	65.33	75.20
Mean	78.85	82.55	80.11	67.59	62.22		87.18	84.14	82.81	71.25	64.74	

L.S.D at 0.05 for : Bio. fert. 8.999 5.380
Chem. fert. 5.512 4.898
Bio. X Chem. N.S. N.S.

A,B,C,D&E refer to 100%, 75%, 50%, 25% and 0% NPK rates, respectively from the recommended dose .

effect regardless the type of bacterial inoculation . However, plants inoculated with B_4 (*Bacillus subtilis*) combined with different rates gave the best fruit weight being in the average of 82.5 and 84.3 gm for the first and second seasons, respectively . These results agree with those obtained by Agwah and Mahmoud (1994) . This may be due to increasing photosynthesis and increasing plant growth (Ozbun *et al* ., 1965) .

3.4. Yield and quality

3.4.1.Total yield

Data in Table (8) indicate that inoculation either with *Bacillus* spp. or *Pseudomonas* isolates significantly increased total yield of tomato over the non-inoculated ones regardless of the doses of NPK applied . However, the magnitude of increase was affected by the type of inocula. B_4 (*Bacillus subtilis*) followed by B_2 (*Bacillus megatherium*) gave higher effect than treatments inoculated with *B* spp , while Ps_3(hallophilic isolate) was superior than treatments receiving Ps_2 . Total yield was increased with increasing NPK rates when compared with the control . These results are in line with those obtained by Shibhila and Balakrishnan (1990). The stimulatory effect of biofertilization was increased by NPK application (50%, 75% and 100% from the recommended dose). Finally, the highest total yield of tomato was recorded under B_4 and NPK at the rate 75% (15.8 ton/fed.) . The favorable effects of biofertilizer and /or NPK may be referred to reduced fruit dropping during ripening (Wilocox , 1964) and /or supplying of growth hormones produced by biofertilizer application. Amara (1994) and Kavimandan and Gaur (1971) found that *Bacillus megatherium* and *Pseudomonas fluorescens* are two of the bacteria decomposing organic phosphates which improved crop yield . Besides, Kumaraswamy and Madalageri (1990) revealed that the application of NPK at 50 % from the recommended dose with *Azotobacter* inoculation increased yield of tomato plants .

3.4.2 Total soluble solids (T.S.S %)

The results shown in Table (9), indicated that *Pseudomonas* (Ps_1) was the best of all tested bacterial types when combined with mineral fertilizers (100% NPK)for the two seasons . Generally speaking , mineral fertilizers gave positive effect on T.S.S of tomato with or with out biofertilizer, being in the average of 6.1 . 5.7 . 5.2 .

Table (8): Effect of inorganic and biofertilizers on total yield (ton/fed.) of tomato under calcareous soil conditions .

Chem. fert.	1996 - 1997						1997 - 1998					
Bio. fert.	A	B	C	D	E	X̄	A	B	C	D	E	X̄
Cont.	13.15	13.07	11.28	9.65	8.27	11.08	13.95	13.00	12.50	10.15	8.84	11.69
B_1	14.30	14.30	14.15	11.93	11.06	13.14	14.41	13.94	13.67	11.14	10.85	12.80
B_2	13.40	13.30	13.38	13.10	11.73	12.98	14.66	13.94	13.40	12.90	11.82	13.34
B_3	12.09	12.76	12.91	11.41	10.47	11.92	13.17	13.21	14.82	11.63	10.70	12.71
B_4	15.16	15.76	14.40	11.56	11.05	13.58	14.26	14.39	14.40	13.85	11.29	13.64
B_5	14.45	13.63	13.78	11.49	11.01	12.87	13.63	13.52	13.50	11.69	9.96	12.46
Ps_1	12.03	11.65	11.70	10.76	9.67	11.16	13.62	13.74	12.79	11.73	9.90	12.36
Ps_2	13.90	13.05	13.04	9.78	8.33	11.62	14.21	12.75	12.21	10.96	9.42	11.86
Ps_3	13.57	13.70	13.62	11.09	11.56	12.71	12.46	13.43	12.42	11.58	10.07	11.79
Mean	13.56	13.46	13.14	11.19	10.35		13.82	13.44	13.30	11.74	10.32	

L.S.D at 0.05 for : Bio. fert. 0.479 0.979

Chem. fert. 0.320 0.678

Bio. X Chem. 0.965 N.S.

A,B,C,D&E refer to 100%, 75%, 50%, 25% and 0% NPK rates, respectively from the recommended dose .

Table (9) : Effect of inorganic and biofertilizers on T.S.S . and Vit . C of tomato plants under calcareous soil conditions .

Chem. fert.	T.S.S. (%)												V.C											
	1996 - 1997						1997 - 1998						1996 - 1997						1997 - 1998					
Bio. fert.	A	B	C	D	E	X̄	A	B	C	D	E	X̄	A	B	C	D	E	X̄	A	B	C	D	E	X̄
Cont.	6.0	5.6	5.0	4.8	4.3	5.1	5.3	5.1	5.0	4.7	4.3	4.8	22.3	22.9	22.3	21.9	22.0	22.2	23.3	23.1	21.7	21.2	23.3	22.5
B_1	7.0	7.0	5.0	4.8	5.5	5.8	6.5	6.1	5.6	5.0	5.5	5.7	22.7	22.6	22.8	21.2	22.2	22.3	22.6	22.3	22.6	21.7	21.2	22.0
B_2	6.6	5.1	5.5	5.5	6.0	5.7	5.5	5.5	4.8	5.3	5.6	5.3	25.5	25.0	25.5	22.6	22.5	24.1	24.3	24.4	25.1	23.2	22.8	23.9
B_3	6.6	7.0	5.0	5.1	4.6	5.6	6.6	5.8	4.3	4.6	4.8	5.2	24.8	23.9	24.8	24.0	24.4	24.3	26.0	24.6	24.4	23.2	23.0	19.3
B_4	5.3	5.5	5.8	4.6	4.0	5.0	5.5	5.1	6.0	6.1	4.3	5.4	26.2	23.4	23.9	23.2	23.9	24.1	25.0	24.2	23.5	23.6	23.9	24.0
B_5	5.1	5.6	5.0	5.6	4.6	5.1	5.0	5.5	5.0	7.0	4.3	5.3	22.3	23.2	25.1	22.6	22.5	23.1	22.6	22.2	25.0	22.2	22.1	22.7
Ps_1	7.5	6.1	5.3	6.0	6.0	6.1	8.3	5.5	5.3	5.1	6.3	6.1	24.3	22.6	23.6	23.7	23.0	23.4	24.2	22.4	23.6	23.2	22.0	23.0
Ps_2	5.5	4.8	5.3	5.3	5.8	5.3	5.8	4.8	5.3	5.1	4.5	5.1	26.5	23.5	23.2	23.5	23.4	24.0	24.5	22.7	22.4	23.3	22.2	23.0
Ps_3	5.5	5.1	5.3	4.3	4.6	4.9	5.3	5.5	5.3	4.8	5.1	5.2	25.2	23.9	24.2	23.7	24.6	24.3	24.1	23.8	23.9	23.5	24.6	23.9.
Mean	6.1	5.7	5.2	5.1	4.5		5.9	5.4	5.1	5.3	4.9	-	24.4	23.4	23.9	22.9	23.1		24.0	23.4	23.5	22.6	22.7	

L.S.D at 0.05 for :	Bio. fert.	N.S.	N.S.	1.027	0.690
	Chem. fert.	0.511	0.370	0.562	0.522
	Bio. X Chem.	N.S.	1.114	1.692	1.571

A,B,C,D and E refer to 100%, 75%, 50%, 25% and 0% NPK rates, respectively from the recommended dose .

5.1 , 4.5 and 5.9 , 5.4 , 5.1 , 5.3 and 4.9 % for 100% , 75% , 50 %, 25% NPK in the first and second seasons , respectively . This may be due to the influence of NPK application on photosynthesis and respiration (Ozbun *et al* ., 1965 and Devlin, 1979) . Also, Patil and Bojappa (1984) indicated that increasing application of NPK increased fruit sugars .

3.4.3. Vitamin C content (mg/100gm)

Results shown in Table (9) indicate significant effect of the interaction between NPK application and biofertilizers treatments . The highest effect was recorded with - plants inoculated with B_2 and B_4 with 100% , 75% , 50 % NPK for *Bacillus* spp and Ps_3 under the same rates .These results agree with those obtained by Kumaraswamy and Madalageri,1990 and Melton and Dufault, 1991 .

3.5. Mineral content

Data presented in Tables (10 and 11) revealed that total nitrogen , phosphorus and potassium contents were increased in tomato shoots with increasing NPK application specially when plants were inoculated with bacteria . Inoculation with *Bacillus* (B_1 and B_3) which are nitrogen fixing organisms increased the nitrogen percentage. Inoculation with either *Bacillus* (B_2 and B_4) or Ps_3 which are phosphate dissolving bacteria increased the phosphorus percentage. Concerning the K percentage in plant , it was observed that inoculation with *Bacillus* (B_4 and B_5) increased K percentage if compared with the other bacterial types . Also, inoculation with *Pseudomonas* (Ps_2-Ps_3) showed the same trend . NPK content in tomato plants was significantly increased with increasing application of NPK . This may be due to that increasing NPK rates which enhanced NPK uptake and increased their content in plants . In accordance with these findings , nitrogen , phosphorus and potassium application increased their uptake in tomato plants (Guo and Lu, 1991 and Al-Afifi *et al*.,1993) . The best results obtained with B_1, B_2 , B_3 , B_4 and B_5 inoculation in addition to NPK application at rates of 50%,75% and 100% . These results agree with those obtained by Amara and Dahdoh , (1997) .

Summing up, the effect of inculation with *Bacillus* spp and *Pseudomonas* isolates alone or in combination with NPK rates

Table (10) :Effect of inorganic and biofertilizers on nitrogen and phosphorus contents (%) of tomato plants under calcareous soil conditions .

Chem. fert.	N %												P %											
	1996 - 1997						1997 - 1998						1996 - 1997						1997 - 1998					
Bio. fert.	A	B	C	D	E	X	A	B	C	D	E	X	A	B	C	D	E	X	A	B	C	D	E	X
Cont.	4.57	4.43	4.20	3.80	3.43	4.09	4.50	4.37	4.07	3.77	3.40	4.02	0.61	0.60	0.49	0.38	0.32	0.48	0.72	0.64	0.62	0.44	0.37	0.56
B_1	5.07	4.97	4.90	4.33	3.97	4.65	5.00	4.93	4.80	4.10	4.03	4.57	0.69	0.63	0.55	0.44	0.31	0.52	0.74	0.70	0.63	0.44	0.36	0.57
B_2	4.77	4.77	4.73	4.03	3.73	4.41	4.73	4.67	4.60	3.93	3.33	4.25	0.85	0.87	0.78	0.61	0.59	0.74	1.30	0.84	0.76	0.61	0.55	0.81
B_3	5.07	5.03	4.53	3.97	3.87	4.49	5.00	4.73	4.66	4.20	4.07	4.53	0.66	0.63	0.58	0.39	0.37	0.53	0.67	0.66	0.63	0.47	0.39	0.56
B_4	4.73	4.60	4.53	3.80	3.66	4.26	4.70	4.53	4.53	4.07	3.77	4.32	0.82	0.85	0.84	0.65	0.61	0.75	0.87	0.84	0.78	0.58	0.50	0.71
B_5	4.63	4.53	4.43	3.93	3.77	4.26	4.63	4.66	4.53	3.83	3.70	4.27	0.78	0.68	0.68	0.61	0.49	0.65	0.76	0.68	0.66	0.48	0.42	0.60
Ps_1	4.53	4.40	4.43	3.93	3.63	4.18	4.53	4.43	4.43	4.03	3.70	4.20	0.72	0.68	0.63	0.56	0.43	0.58	0.80	0.70	0.57	0.46	0.43	0.59
Ps_2	4.70	4.60	4.47	3.93	3.70	4.28	4.66	4.67	4.53	4.10	3.77	4.35	0.68	0.69	0.66	0.51	0.40	0.59	0.76	0.69	0.70	0.49	0.36	0.60
Ps_3	4.63	4.40	4.27	3.87	3.77	4.19	4.70	4.63	4.67	4.10	3.73	4.37	0.85	0.82	0.79	0.54	0.60	0.72	0.94	0.72	0.71	0.57	0.41	0.67
Mean	4.74	4.64	4.50	3.95	3.73	4.31	4.72	4.65	4.54	4.01	3.72	4.33	0.74	0.71	0.67	0.52	0.46	0.62	0.84	0.72	0.67	0.50	0.42	0.63

L.S.D at 0.05 for : Bio. fert.	0.115	0.230	0.082	0.108
Chem. fert.	0.120	0.149	0.054	0.069
Bio. X Chem.	N.S.	N.S.	N.S.	N.S.

A,B,C,D and E refer to 100%, 75%, 50%, 25% and 0% NPK rates, respectively from the recommended dose .

Table (11): Effect of inorganic and biofertilizers on K (%) of tomato plants under calcareous soil conditions .

Chem. fert.	1996-1997						1997-1998					
Bio. fert.	A	B	C	D	E	X̄	A	B	C	D	E	X̄
Control.	5.20	5.13	4.90	4.50	4.40	4.83	4.60	4.70	4.41	4.00	3.21	4.18
B_1	5.50	5.20	5.30	4.53	4.17	4.94	5.50	5.31	4.42	3.90	3.32	4.49
B_2	5.37	5.20	4.77	4.43	4.23	4.80	5.41	5.11	4.60	4.11	3.21	4.49
B_3	5.37	5.20	4.87	4.37	4.23	4.81	5.60	5.60	4.70	4.10	3.30	4.66
B_4	5.43	5.37	5.33	4.87	4.40	5.08	5.71	5.13	4.81	3.92	3.50	4.61
B_5	5.43	5.27	5.13	4.70	4.33	4.97	5.32	5.21	5.11	4.51	3.41	4.71
Ps_1	5.13	4.57	4.43	4.27	4.20	4.52	5.30	5.12	4.72	4.33	3.22	4.54
Ps_2	5.37	5.27	5.43	4.73	4.33	5.03	5.22	5.00	4.80	3.33	3.52	4.37
Ps_3	5.30	5.20	5.13	4.77	4.47	4.97	5.21	5.03	5.30	4.40	3.50	4.69
Mean	5.23	5.16	5.03	4.57	4.31		5.32	5.13	4.76	4.07	3.35	

L.S.D at 0.05 for : Bio. fert. 0.135 N.S.

Chem. fert. 0.131 0.186

Bio. X Chem. N.S. 0.561

A,B,C,D&E refer to 100%, 75%, 50%, 25% and 0% NPK rates, respectively from the recommended dose .

enhance different plant characters *i.e.* plant hight, plant weight, fruit weight, total yield and its quality . *Bacillus subtilis* (B_4) followed by *Bacillus megatherium*(B_2) combined with 50% NPK from the recommended dose recorded the highest effect on most parameters of plant yield and quality . The average of the two seasons was14.4 , 13.4 ton/fed. , 91.2 ,85.0 gm , 6.0 , 5.2 % and 23.7 and 25.3 mg/100gm for total yield , fruit weight , T.S.S and Vit.C, respectively . On the other hand, Ps_3 (hallophelic isolate) was the best among *Pseudomonas* isolates in combination with 50% NPK . The average corresponding figures were 13.0 ton/fed. , 80.2gm ,5% and24.1 mg/100gm, respectively.

From the present results , we can conclude that biofertilization with different species of *Bacillus* or *Ps. fluorescns* reduced the cost of tomato production by minimizing the use of chemical fertilizers doses , reaching 50% of full dose of N , P and K .

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استجابة الطماطم للتسميد الحيوى و المعدنى تحت ظروف الاراض الجيرية

حسنة احمد فؤاد محمود - *ميرفت احمد طاهر أماره

قسم الإنتاج النباتي - *قسم خصوبة و ميكروبيولوجيا الأراضي
مركز بحوث الصحراء

ملخص

تم إجراء هذه التجربة الحقلية خـــلال موســمي 1996 - 1997، 1997-1998 بمحطة بحوث مريوط (مركز بحوث الصحراء) محافظة الإســكندرية ، لدراسة تأثير التسميد الحيوي او المعدني (ن ، فو ، بو) أو تأثيرهما معا علــى صفات الطماطم المختلفة و النشاط الميكروبي . و كانت المعاملات من أنــواع مختلفة من *Bacillus* and *Pseudomonas* ومستويات من(N, P, K) التي تم اضافتها في صورة كبريتات أمونيوم + سوبر فوسفات + كبريتــات بوتاســيوم ، 100% (200+300+400) كجم / فدان ، 75 % ، 50% ، 25% ، صفر % من المعدل الموصى به .

و قد زادت صفات النمو معنويا كنتيجة لاســتخدام التســميد الحيــوي و المعدني بالمقارنة بالكنترول . و كانت أفضل المعاملات البكتيرية هي استخــدام (*Bacillus megatherium*) B_2 , (*Bacillus subtilis*) B_4 مع 50%(ن ، فو، بو) من الموصى به (100%) حيث أدي إلى زيادة صفات النمو ، و محصــول الثمار ، نسبة المواد الصلبة الذائبة ، فيتامين ج بالإضافة إلى محتوى العنــاصر (N, P, K).

كما أدى إضافة النيتروجين ، الفوسفور و البوتاسيوم فقط أو مع التسميد الحيوي إلى زيادة I_2 المنطلق .

أدت زيادة معدلات التسميد المعدني ألي زيادة معنويــة فــي صفــات النمو، محصول الثمار ، جودة الثمار و محتوى العناصر عند المقارنــة بمعاملــة الكنترول .

وبذلك أمكن تقليل تكاليف التسميد الكيماوي وتقليل التلوث الناتج منه بتقليــل الكميات المضافة عن المعدلات الموصى بها إلى النصف لأنه أعطى نتائج معنوية مثل المعدلات المرتفعة الموصى بها .

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