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EFFECT OF BIOFERTILIZERS ON YIELD, QUALITY AND STORABILITY OF TOMATOES

Abd-El Rahman, S.Z.; T.M. El-Shiekh and A.M. Hewedy
Vegetable Res. Dept., Hort. Res. Inst., Agrc. Res. Center

ABSTRACT

A field experiment was carried out at Kaha Vegetable Experimental farm during two summer seasons of 1997 and 1998 to evaluate the effect of single and combined applications of some biofertilizers in term of yield, fruit characters and storeability of tomato "Castle Rock cv.". Rizobacterein, Nitrobein and Cerialein were used as nitrogen fixing bacteria, in addition to Posphorein as Phosphate dissolving bacteria.

Results indicate that inoculation of tomato plants with biofertilizer treatments with single or combined application in the presence of 75% from NPK chemical fertilizer recommendation markedly increased the number of fruits per plant, average fruit weight and early, total and marketable yields as compared with the uninoculated plants in the presence of 100% NPK. The highest values was obtained by using Phosphorein + Cerialein followed by Phosphorein + Rizobacterein. Application a mixed biofertilizer, i.e. Phosphorein + a source of nitrogen fixing bacteria had more stimulative effect than using Phosphorein alone on these characters. Cerialein was the best single application treatment.

Results indicate also that inoculation of tomato plants with mixture of Phosphorein + Cerialein and / or Phosphorein + Rizobacterein with 75% NPK gave fruit with good quality and storeability concerning fruit firmness, T.S.S, dry matter content, ascorbic acid, acidity, Lycopene, weight loss and decay percentage, pre and post storage period. Therefore, these biofertilizers can be recommended for tomato to improve productively, fruit quality and storeability, beside this, it reduced the need for mineral fertilizer by about 25%, decreased the production cost and environmental pollution.

INTRODUCTION

Tomato is a vegetable of prime importance in Egypt for local and foreign markets, in addition to developing of canning industry. Increasing tomato production is a wide aim that can be expected by using many ways, one of them is fertilization.

Using some modern nutrients (biofertilizers) with the objective of increasing the number of such microorganisms and accelerating certain microbial processes to augment the extent of the availability of nutrients in a form that can be easily assimilated by plants. These microorganisms which are used as a biofertilizers induce stimulative effect in plant growth and production by fixing the atmospheric nitrogen in free active state e.g. Rizobacterein and Nitrobein and also phosphate dissolving bacteria e.g. Phosphorein mobilizing phosphate and micronutrients, while Cerialein, Nitrobein and Rizobacterein secreting growth promoting factor, e.g. Cytokinine like substances and auxin, Saber (1996) and Awad (1998). So, the use of biofertilizers may be benefit in reducing high rates of mineral

fertilizer, which may help in increasing vegetable exportation to the European countries.

Tomato fruit yield and its component responded significantly to biofertilizer application, Shahaby (1981), Kumaraswany and Madalageri (1990) recorded the highest tomato fruit yield by inoculated tomato seedling with Azotobacter. Shahaby *et al* (1993), Terry *et al* (1995) and Awad (1998) obtained higher tomato fruit yield with the best quality by using various biofertilizers, e.g. Azospirillum, Azotobacter, Psudomonas and / or Clostridium.

Bechelt (1989); Radwan (1983); Shahaby *et al.* (1993); Yuki *et al* (1994); Terry *et al.* (1995) and Awad (1998) indicated that application of various biofertilizers in dual or triple applications enhanced fruit quality of tomato as compared with single application. Awad (1998) found that adding multi strain biofertilizers to tomato plant in the presence of one third of NPK dose increased plant growth and its yield. Barakat and Gabr (1998) reported that using a composite of Azotobacter, Azospirillum and Klebsiella + 100Kg.N/fed. produced higher total yield and increased number of fruits per plant over using nitrogen alone, (without bacterial inoculation). Ouda (2000) found that inoculation tomato seedling with a mixture of Phosphorein + Microbien + 25% of recommended NPK gave a relatively higher early and mid season yield than that obtained from using 100% of recommended NPK.

Tantawy (2000) observed that maximum increment of both average fruit weight, marketable and total yield were obtained via using Microbien + Phosphorein treatment. On the other hand, control treatment (without inoculation) produced significantly the lowest early, marketable and total yield.

The aim of this present work was to study the effect of single and combined applications of some biofertilizers in terms of yield, fruit characters and storeability of tomatoes.

MATERIALS AND METHODS

A field experiment was carried out at Kaha Vegetable Research Farm, Horticulture Research Institute, Kalubia Governorate during two summer seasons of 1997 and 1998.

The soil of the experiment was clay loam, the physical and chemical properties of the soil are shown in Table (1). Tomato seeds of cultivar castle rock were sown in the nursery on January 5th and 7th in 1997 and 1998 under plastic low tunnel protection and transplanting was conducted on march 2nd and 4th in 1997 and 1998, respectively, this on ridges of one meter wide and 4.5 meter long. Uniform tomato seedlings were transplanted after inoculated with many strains of bacteria at spacing of 30 cm in the row.

Table (1): The physical and chemical properties of the experimental soil during 1997 and 1998 seasons

Variable	1997 season		1998 season	
	0-30 cm depth	30-60 cm depth	0-30 cm depth	30-60 cm depth
1) Physical properties				
Sand %	18.6	18.4	18.1	20.2
Slit %	21.8	21.8	26.8	28.4
Clay %	60.4	64.4	61.4	66.5
2) Chemical properties				
PH	7.9	7.8	8.0	7.9
Available N ppm	97.9	107.8	87.5	97.9
Available P ppm	5.9	5.3	6.2	6.0
Available K ppm	215.8	216.3	216.2	200.0
Total Ca Co_3 %	2.4	2.8	2.7	2.9

This experiment contained nine inoculations with many strains of bacteria as follows:

1- Inoculation with Bacillus megaterium, phosphate dissolving bacteria under the commercial name of “Phosphorein”.
2- Inoculation with Azotobacter, nitrogen fixing bacteria under the commercial name of “Rizobacterein”.
3- Inoculation with Azospirillum, nitrogen fixing bacteria under the commercial name of “Nitrobein”.
4- Inoculation with Pseudomonas, nitrogen fixing bacteria under the commercial name of “Cerialein”.
5- Inoculation with a Mixture of Bacillus megaterium and Azotobacter sp.
6- Inoculation with a Mixture of Bacillus megaterium and Azospirillum sp.
7- Inoculation with a Mixture of Bacillus megaterium and Pseudomonas sp.
8- Inoculation with a Mixture of Bacillus megaterium, Azotobacter sp, Azospirillum sp and Pseudomonas sp.
9- Control (uninoculated treatment).

The efficient strains of bacteria in peat growth media containing 28-32 x 10^8 cells/100g peat which were obtained from Microbiology Dept., National Research Center. The bacterial growth media was used at a rate of 500 g/fed. Which dissolved in 3 litter water with 100g. Adabic gum and the tomato seedling roots were dipped 5 min. in this suspension before transplanting. The biofertilized treatments received only 75% of the recommended rates of mineral fertilizers of NPK, while the control treatment fertilized with the complete fertilizer recommendation of tomato NPK at a rate of 120-45-96 unit/fed.

The previous treatments were arranged in four replicates using a complete randomized blocks design. The area of the experiment plot was

13.5m^2 including three ridges (4.5m. long & 1m. a part). Drip irrigation system and normal cultural practices were carried out whenever it was needed according to recommendations of the Ministry of Agriculture.

Data recorded were as follows:

1- Yield and its components:

a- Number of fruit per plant.

b- Early yield (the first four pickings "ton/fed.").

c- Total yield (ton/fed.).

d- Marketable yield (ton/fed.).

e- Fruit characters: Ten fruits were chosen randomly from each treatment in each replicate to determine these characters. Average fruit weight(gm), fruit length(cm), fruit diameter(cm), flesh thickness(cm), number of locules per fruit, firmness(N), total soluble solids(T.S.S) and dry matter in percent and ascorbic acid, acidity and lycopene as mg/100gm fresh weight at harvest.

2- Postharvest properties:

Tomato fruits at turning stage were picked at the mid harvesting season and transported to the laboratory at Giza, cleaned with dry towels, graded and sorted after discarding misshaped and injured fruits, where sound and healthy fruits were chosen for storage experiment.

A split plot design was adopted having the inoculation substances (nine treatments) as main plots and shelf life period (five periods) as sub plots. Twelve fruits were put in a carton box (30 x 20 x 10cm) as one replicate. Fifteen replicates for each treatment and which served as a control, were stored in cold room (10°c and 85% R.H). in all stored fruits, samples were taken as random from 3 replicates for each treatment and examined every 3 day intervals.

The following data were recorded:

a- Weight loss, and decay (in percent).

b- Firmness(N) was measured by Magness and Ballauf pressure tester with a plunger of 3/16 inch expressed as Lb/in^2 and adjusted in Newton (as recommended by ASHS Postharvest Working Group).

c- T.S.S., acidity, ascorbic acid and lycopene contents were determined according to (A.O.A.C, 1980).

Statistical analysis of data was done according to Snedecor and Cochran (1980).

RESULTS AND DISCUSSION

Data in Table (2) show that the use of biofertilizers in the form of nitrogen fixing bacteria and phosphate dissolving bacteria played a significant influence on the number of fruits per plant, average fruit weight and early, total and marketable yield. Although, biofertilizers treatments markedly increased these characters as compared with the untreated control plants.

Moreover, the highest values was obtained by using Phosphorien + Cerialein and followed by Phosphorien + Rizobacterien when compared with the other treatments.

Table (2): effect of root inoculation with biofertilizers on fruit yield and its components of tomato during 1997 and 1998 seasons

Treatments	No. of fruit per plant	Average fruit weight "gm"	Early yield ton / fed	Total yield ton / fed	Marketabl yield ton / fed
	1997 season				
Phosphorein	28.0	111.6	9.90	33.20	28.24
Rizobacterein	26.0	108.3	9.73	32.40	26.51
Nitrobein	26.0	110.0	9.36	32.05	25.94
Cerialein	30.0	113.3	10.00	34.20	31.03
Phosphorein + Riz.	32.6	116.6	10.23	34.95	32.82
Phosphorein + Nitrobein	31.0	113.3	10.00	34.65	31.71
Phosphorein + Cerialein	34.6	121.6	10.43	36.65	33.94
Phospho.+Riz+Nit+Ceri.	32.0	113.3	10.16	35.20	30.15
Control	20.6	100.6	8.56	27.35	20.17
L.S.D at 5%	3.7	7.0	0.26	0.92	3.05
	1998 season				
Phosphorein	34.0	116.6	10.68	35.00	28.34
Rizobacterein	32.6	116.3	10.70	34.70	26.62
Nitrobein	33.0	113.3	10.70	34.60	27.36
Cerialein	36.0	126.6	11.20	37.50	31.24
Phosphorein + Riz.	38.0	130.0	11.73	37.90	34.26
Phosphorein + Nitrobein	35.6	126.6	11.80	37.85	32.80
Phosphorein + Cerialein	39.3	135.0	12.10	40.10	37.17
Phospho.+Riz+Nit+Ceri.	37.0	128.3	10.86	36.90	32.15
Control	26.0	110.0	9.90	30.10	21.54
L.S.D at 5%	2.5	5.5	0.30	0.88	3.31

From the same data, it was clear that a mixed biofertilizer, i.e. Phosphorien + a source of nitrogen fixing bacteria had more stimulative effect than using Phosphorien alone on early, total and marketable yield as well as number of fruits per plant and average fruit weight. Meanwhile, the later treatment, i.e. Phosphorien was significantly better than the control treatment, where no biofertilizers was used. The values of fruit yield components in tomato plants under the condition of single biofertilized application varied from treatment to another, but Cerialein was the best single application treatment.

Many previous studies recorded a stimulative effect on total yield of tomato plant treated with biofertilizers due to increasing, fruit set percentage, number of fruit per cluster, number of cluster per plant and average fruit weight (Barakat and Gabr(1998); Ouda(2000) and Tantawy (2000)).

Inoculation of tomato plants with mixture of phosphorien + Cerialein led to improvement in the early and total yield. However, such improvements were larger than these found due to using Phosphorien + Rizobacterien + Nitrobien + Cerialein.

These results may be attributed to the competition among the used bacteria on the energy derived from the degradation of plant residues. Moreover, Subba Ra (1982) reported that the population of nitrogen fixing bacteria, such as Rizobacterian and Nitrien; in the soil influenced by the associative antagonists action of soil microflora and organic matter content of soil. On the other hand, the increments recorded here in the tomato yield are also previously recorded on tomato due to using a mixture of Phosphorien + Microbien (Ouda, 2000 and Tantawy, 2000).

Regarding fruit characteristics, it is evident from the data in Table (3) that average fruit length, diameter, flesh thickness and number of locules per fruit of tomato fruits were significantly increased with inoculating tomato plants with biofertilization materials, either single or combined application. While the lowest values were given by control treatment (no biofertilizers).

Inoculation with a mixture of Phosphorien + Cerialein and Phosphorien + Rizobacterien were the superior. These results hold true in the two growing seasons. The enhancing of these biofertilizing materials may be attributed to the ability of N-fixing bacteria to supply the plants with nitrogen and to release plants promoting substances which could stimulate absorption of nutrients and efficiency of nutrient metabolism. Also, such results of many investigators may explain the role of phosphate dissolving bacteria in availability of soil immobilized phosphorus. These results are in agreement with those obtained by Saber (1996) and Awad(1998) for fixing nitrogen bacteria and Gomaa (1989); Monib *et al.* (1990); and Awad (1998) on tomato plants treated with biofertilizers.

Table (3): Effect of root inoculation with biofertilizers on physical characteristics of tomato fruit during 1997 and 1998 seasons.

Treatments	Fruit length (cm)	Fruit diameter (cm)	Flesh thikness (cm)	Number of locules per fruit
	1997 season			
Phosphorein	4.47	3.52	0.56	3.95
Rizobacterein	4.32	3.38	0.54	4.42
Nitrobein	4.18	3.42	0.54	4.58
Cerialein	4.36	3.30	0.55	4.66
Phosphorein + Riz.	5.05	4.27	0.63	4.06
Phosphorein + Nitrobein	4.92	4.14	0.60	3.24
Phosphorein + Cerialein	5.11	4.34	0.68	3.11
Phospho.+Riz+Nit+Ceri.	4.63	3.92	0.58	4.00
Control	4.04	3.21	0.51	4.77
L.S.D at 5%	0.30	0.27	0.04	0.21
	1998 season			

Phosphorein	4.55	3.71	0.57	4.12
Rizobacterein	4.36	3.50	0.50	4.58
Nitrobein	4.25	3.66	0.52	4.67
Cerialein	4.46	3.44	0.58	4.73
Phosphorein + Riz.	5.09	4.51	0.64	3.20
Phosphorein + Nitrobein	5.00	4.35	0.60	3.32
Phosphorein + Cerialein	5.25	4.70	0.66	3.16
Phospho.+Riz+Nit+Ceri.	4.70	4.00	0.60	4.37
Control	3.94	3.33	0.50	4.81
L.S.D at 5%	0.27	0.32	0.05	0.30

Concerning the physical and chemical constituents of tomato fruits at harvest, results in Table (4) show clearly that firmness, T.S.S, dry matter, ascorbic acid and lycopene values were significantly increased in tomato fruits obtained from inoculated plants with mixtures of Phosphorein + Cerialein and / or Phosphorein + Rizobacterein. Treating tomato plants with one of Rizobacterein, Nitrobein or mineral fertilizers with no biofertilizers gave fruits with the lowest values of these characters. These results hold true in the two seasons. These results are in harmony with the results obtained by Shahaby *et al.* (1993); Terry *et al.* (1995) and Awad (1998) on tomato fruit quality by inoculated tomato plants with many biofertilizer nutrients in the presence of 75% of chemical fertilizer (NPK).

Table(4): Effect of root inoculation with biofertilizers on physical and chemical properties of tomato fruit at harvest during 1997 and 1998 seasons

Treatments	Firmness (N)	T.S.S %	Dry matter %	Ascorbic acid mg/100g. (F.w*)	Acidity mg/100g. (F.w*)	Lycopene mg/100g. (F.w*)
	1997 season					
Phosphorein	50.71	4.62	4.88	17.20	0.42	0.52
Rizobacterein	42.70	4.03	4.74	18.24	0.43	0.50
Nitrobein	48.04	4.51	4.80	18.32	0.41	0.52
Cerialein	55.16	5.04	4.71	20.72	0.38	0.52
Phosphorein + Riz.	61.83	5.22	5.75	23.50	0.36	0.58
Phosphorein + Nitrobein	60.49	5.04	5.22	22.20	0.35	0.58
Phosphorein + Cerialein	63.16	5.41	5.93	24.73	0.34	0.58
Phospho.+Riz+Nit+Ceri.	56.05	4.82	4.86	22.81	0.36	0.54
Control	45.37	3.72	4.33	16.43	0.48	0.48
L.S.D at 5%	3.71	0.32	0.20	1.06	0.04	0.04
	1998 season					
Phosphorein	48.93	5.12	5.33	18.07	0.44	0.45
Rizobacterein	44.48	5.03	5.06	18.67	0.45	0.44
Nitrobein	48.19	5.03	5.22	16.00	0.43	0.45
Cerialein	49.21	5.23	5.17	19.07	0.41	0.46
Phosphorein + Riz.	54.12	5.63	6.23	23.50	0.38	0.52
Phosphorein + Nitrobein	51.15	5.48	6.00	21.14	0.39	0.51
Phosphorein + Cerialein	55.60	5.71	6.11	21.72	0.39	0.52
Phospho.+Riz+Nit+Ceri.	51.15	5.42	5.30	20.03	0.40	0.48
Control	39.29	4.52	4.42	15.67	0.50	0.42

L.S.D at 5%	3.55	0.28	0.41	1.22	0.33	0.04

*** fresh weight**

The titratable acidity of tomato fruits significantly differ between the used treatments as shown in Table (4). Biofertilization with all microorganisms reduced titratable acidity of tomato fruit compared with non-biofertilized. Acidity of tomato fruits obtained from use of dual or multi application with phosphate dissolving bacteria + nitrogen fixing bacteria was lower than that obtained from single application. Moreover, further decrease in acidity was recorded when Phosphorein was combined with Cerialein.

These results are true in the two seasons. Similar conclusion was obtained by Shahaby *et al.* (1993); Terry *et al.* (1995) and Awad (1998).

Regarding weight loss, data in Table (5) indicated that application of all biofertilizers inhibited the weight loss percentage in tomato fruit, whereas the highest value of loss in fresh weight were obtained in untreated fruits (no biofertilizers). The mixtures of Phosphorein + Cerialein or Phospherein + Rizobacterein being the most effective treatment in respect to weight loss.

These results may be due to biofertilizers increased dry matter, potassium and phosphorus in tomato fruits (Ouda, 2000 and Tantawy, 2000) which depressed the respiration rate (Shafshak, 1961), and also potassium increasing the osmotic potential in the cells of fruits (Gardener, 1985) whish dimensioned the water loss in tomato fruits during storage and consequently retarded the fresh weight loss.

The results in the same table indicate a progressive increase in the percentage of loss in tomato fruit weight during storage. These might be due to the loss in moisture through transpiration and loss in dry matter content through respiration process (El-Sheikh *et al.*, 1997).

The effect of the interaction between storage period and inoculating treatment on weight loss was significant in both seasons.

Table (5): Effect of root inoculation with biofertilizers on weight loss percentage of tomato fruits during storage in 1997 and 1998 seasons.

Treatments	Storage period in days (1997)					Storage period in days (1998)				
	3	6	9	12	Mean	3	6	9	12	Mean
Phosphorein	1.72	3.57	4.79	7.40	4.37	1.62	3.31	4.93	6.92	4.20
Rizobacterein	1.83	3.62	5.01	7.71	4.54	1.95	3.85	5.21	7.27	4.57
Nitrobein	1.80	3.35	5.40	7.37	4.48	1.68	3.37	5.12	6.27	4.11
Cerialein	1.71	2.89	4.60	6.50	3.93	1.51	3.07	4.51	5.95	3.76
Phosphorein + Riz.	1.48	2.63	3.97	5.38	3.36	1.24	2.17	4.00	5.10	3.13
Phosphorein + Nitrobein	1.69	2.62	4.22	5.30	3.46	1.41	2.44	4.33	5.41	3.40
Phosphorein + Cerialein	1.40	2.19	3.63	5.23	3.11	1.23	2.04	4.01	4.91	3.05
Phospho.+Riz+Nit+Ceri.	1.44	2.65	4.23	5.66	3.50	1.43	2.52	4.39	5.52	3.47
Control	1.80	3.81	6.27	7.92	4.95	2.14	4.22	5.59	7.75	4.93
Mean	1.65	3.04	4.68	6.50		1.58	3.00	4.68	6.12	
L.S.D at 5%: Treatment			**0.20**					**0.16**		
Storage periods			**0.16**					**0.12**		
Treatment X S. period			**0.39**					**0.30**		

Regarding decay, data in Table (6) show that the highest values of decay percentage were obtained in tomato fruits of plants treated with chemical fertilizer and /or Rizobacterein and Nitrobein adding with 75% of NPK. These results hold true in the two seasons. On the other hand, the lowest decay percentage was recorded in fruits of inoculating tomato plants as pre harvest treatment with mixture of Phosphorein + Cerialein followed by Phosphorein + Rizobacterein. These favorable effect might be attributed to the inhibitory effect of biofertilizers on the development of certain type of microorganisms during storage of tomato fruits..

It is clear from the same data that the decay percentage of fruit increased considerably and consistently with the prolongation of storage period. This results may be due to the continous chemical and biochemical changes happened in the fruits such as moisture condensation and transformation of complex compounds to simple forms of more liability of fungal infection such as the solid Protopectin to the soluble pectin form.
These results are in harmony with the results obtained by El-Sheikh, (1988).

However, the decay occurred after 9 days of storage in tomato fruits obtained from single biofertilizer application and control (no biofertilizer), and after 12 days in fruit obtained from dual or multi biofertilizers application (Table 6).

Table (6): Effect of root inoculation with biofertilizers on decay percentage of tomato fruits during storage in 1997 and 1998 seasons.

Treatments	Storage period in days (1997)					Storage period in days (1998)				
	3	6	9	12	Mean	3	6	9	12	Mean
Phosphorein	0.00	0.00	3.80	28.93	8.18	0.00	0.00	8.57	32.70	10.32
Rizobacterein	0.00	0.00	11.37	36.00	11.84	0.00	0.00	9.10	34.37	10.87
Nitrobein	0.00	0.00	8.77	34.13	10.23	0.00	0.00	11.07	32.90	10.99
Cerialein	0.00	0.00	2.70	24.73	6.86	0.00	0.00	6.43	28.97	8.85
Phosphorein + Riz.	0.00	0.00	0.00	18.13	4.53	0.00	0.00	0.00	19.90	4.98
Phosphorein + Nitrobein	0.00	0.00	0.00	20.73	5.18	0.00	0.00	0.00	22.23	5.56
Phosphorein + Cerialein	0.00	0.00	0.00	16.73	4.18	0.00	0.00	0.00	13.33	3.33
Phospho.+Riz+Nit+Ceri.	0.00	0.00	0.00	21.10	5.28	0.00	0.00	0.00	25.83	6.46
Control	0.00	0.00	7.30	40.57	11.97	0.00	0.00	15.23	36.23	12.62
Mean	0.00	0.00	3.77	26.56		0.00	0.00	5.60	27.27	

Concerning fruit firmness, data in Table (7) indicate clearly that tomato fruits obtained from plants inoculated with dual or dual or multi biofertilizer application under the condition of 75% NPK gave the highest value in fruit firmness during storage. The favorable treatment was inoculated tomato plants with Phosphorein + Cerialein followed by Phosphorein + Rizobacterein which gave the firmest tomatoes. The values of fruit firmness of tomato plants under the condition of single biofertilizer application varied from treatment to another, but Cerialein was the best single treatment. The control treatment which received 100% of NPk recommendation gave the lowest value of fruit firmness during storage. These results hold true in both seasons and it might be attributed to that biofertilizers increased available

p,k, fe, zn, mn and cu in the soil (Saber and Kabesh, 1990 and Saber and Gomaa, 1993), in addition these material increased firmness of fruits during storage (El-Sheikh, 1988).

From the obtained data it appear that firmness of tomato fruits was significantly affected by the storage period. Therefore, there was a significant reduction in fruit firmness by the prolongation of storage period in both seasons of investigation. These results are in harmony with the results obtained by El-Sheikh,(1988) on tomato.

The decrease in fruit firmness may be due to gradual breakdown of protopectin to lower molecular weight fraction, which are more soluble in water and this was directly correlated with the rate of softening of the fruits (Wills *et al.*, 1981).

The interaction between all used treatments and storage period was significant for tomato fruit firmness in both seasons. Generally, these was a gradual reduction in fruit firmness with the prolongation of storage period for all treatments.

Inoculating tomato plants with Phosphorein + Cerialein or Phosphorein + Rizobactrein gave fruits with highest total soluble solids contents, while the fruits obtained from plants inoculated with Rizobacerein and / or which received mineral fertilization, gave fruits with the lowest T.S.S values. These results were true in the two seasons (Table 8).

Total soluble solids (T.S.S) increased with prolongation storage period until 6 days, then it began to decrease gradually (Table 8). The changes in T.S.S. during storage controlled with three factors, i.e. the loss of dry matter through respiration and metabolic activity; the conversation of insoluble compounds to simple soluble substances and the loss of moisture from the fruit through evaporation and transpiration. Thus, the T.S.S. concentration during storage might be attributed to the changes of these compounds. El-Sheikh (1988) obtained similar results. The increment in T.S.S. at the first period of storage might owe to the rate of moisture loss through transpiration and the conversion of complex compounds to sugars. The reduction at the end of storage period might owe to the utilization of sugars in respiration.

The interaction between biofertilization treatment and storage period was significant

Results in Table (9) indicate that ascorbic acid content was statistically influenced by the effect of biofertilizer materials, whereas, the highest value of Vit.C was recorded in fruit obtained from plants inoculated with the mixture of Phosphorein and Cerialein, the lowest value of this content was noticed in fruit obtained from plants treated with mineral fertilizer (control). These results hold true in both seasons.

From the same data, Vit. C increased gradually with prolongation storage period until 6 days then it began to decrease till the end of storage period. The concentration of this parameter in the tissues of tomato fruits suffered much changes during storage, whereas, it reached its lowest values at the end of storage period. These results might owe much to the utilization of this compounds in respiration. These results are in accordance with those obtained by El-sheikh (1988) on tomatoes.

The effect of interaction between various used treatments and storage period on Vit. C of tomato fruits was significant in both seasons.

With respect to acidity, the highest values of titratable acidity was recorded in tomato fruits obtained from plants treated with mineral fertilizers. On the other hand, the lowest acidity contents were recorded in fruits from plants inoculated with the mixture of Phosphorein and Cerialein followed by the mixture of Phosphorein and Rizobacterein. These results hold true in the two growing seasons (Table 10).

	+	7,8

Table (9): Effect of root inoculation with biofertilizers on Ascorbic acid content (mg/100g.fresh weight) of tomato fruits during storage in 1997 and 1998 seasons.

Treatments	Storage period in days (1997)						Storage period in days (1998)					
	0	3	6	9	12	Mean	0	3	6	9	12	Mean
Phosphorein	17.20	18.97	20.57	18.60	15.87	18.24	18.07	20.20	22.00	16.43	13.40	18.02
Rizobacterein	18.24	20.40	22.07	18.90	14.07	18.85	18.67	18.13	20.47	16.27	12.17	17.14
Nitrobein	18.32	20.53	22.63	19.07	14.83	19.07	16.00	20.30	22.00	16.37	13.57	17.65
Cerialein	20.72	22.40	24.03	19.83	16.77	20.75	19.07	21.13	23.13	19.10	14.33	19.35
Phosphorein + Riz.	23.50	26.00	28.37	25.07	19.90	24.57	23.50	26.00	28.37	25.07	19.90	24.57
Phosphorein+ Nitrobein	22.20	24.70	27.13	22.83	18.97	23.17	21.14	21.37	25.77	24.53	17.83	22.12
Phosphorein + Cerialein	24.73	27.00	29.33	25.97	20.93	25.59	21.72	24.13	27.80	23.20	20.80	23.53
Phospho.+Riz+Nit+Ceri	22.81	25.00	27.20	23.23	19.17	23.48	20.03	21.17	25.60	20.70	16.07	20.71
Control	16.43	16.40	19.37	16.43	12.77	16.27	15.67	18.13	20.13	15.17	11.67	16.15
Mean	20.46	22.38	24.52	21.10	17.10		19.32	21.17	23.92	19.65	15.53	

L.S.D at 5%:			
	Treatment	0.86	0.88
	Storage period	0.62	0.60
	Treatment X S. period	1.06	1.12

The titratable acidity in the tissues of tomato fruits decreased gradually during storage as shown in Table (10). The tomato fruit acidity suffered marked changes during their storage period. The titratable acidity is a function of organic acids in the fruits.

The decline in titratable acidity of tomato fruitjuice during storage might be attributed to the oxidation of organic acids to carbon dioxide during storage. Similar conclusion was obtained by El-sheikh (1988) on tomatoes.

Concerning the interaction between various treatment applications and storage period, results showed significant effect in both seasons

Table (10): Effect of root inoculation with biofertilizers on total acidity (mg/100g.fresh weight) of tomato fruits during storage in 1997 and 1998 seasons.

Treatments	Storage period in days (1997)						Storage period in days (1998)					
	0	3	6	9	12	Mean	0	3	6	9	12	Mean
Phosphorein	0.42	0.40	0.36	0.33	0.30	0.36	0.44	0.39	0.37	0.34	0.31	0.37
Rizobacterein	0.43	0.40	0.38	0.34	0.30	0.37	0.45	0.42	0.40	0.37	0.33	0.39
Nitrobein	0.41	0.39	0.36	0.34	0.29	0.36	0.43	0.40	0.38	0.35	0.32	0.38
Cerialein	0.38	0.36	0.34	0.29	0.26	0.33	0.41	0.38	0.36	0.34	0.31	0.36
Phosphorein + Riz.	0.36	0.34	0.31	0.29	0.24	0.31	0.38	0.36	0.34	0.32	0.29	0.34
Phosphorein+ Nitrobein	0.35	0.33	0.32	0.28	0.24	0.30	0.39	0.35	0.35	0.33	0.29	0.35
Phosphorein + Cerialein	0.34	0.32	0.29	0.27	0.23	0.29	0.38	0.46	0.33	0.31	0.27	0.33
Phospho.+Riz+Nit+Ceri	0.36	0.32	0.29	0.27	0.24	0.30	0.40	0.38	0.35	0.34	0.30	0.35
Control	0.48	0.45	0.41	0.38	0.34	0.41	0.50	0.46	0.41	0.38	0.35	0.42
Mean	0.39	0.37	0.34	0.31	0.27		0.42	0.39	0.37	0.34	0.31	

L.S.D at 5%:			
	Treatment	0.01	0.01
	Storage period	0.02	0.02
	Treatment X S. period	0.03	0.04

Concerning lycopene, results showed that the lowest values of lycopene content of tomato fruits were recorded in fruits obtained from plants treated with control treatment (mineral fertilizers) followed by inoculated

tomato plants with Phosphorein, Rizobacterein and / or Nitrobein. On the contrary, the highest values of lycopene were obtained in fruits their plants inoculated with the mixture of Phosphorein and Cerialein followed by fruits obtained from plants treated (inoculated) with the mixture of Phosphorein and Rizobacterein. These results hold true in both seasons.

The increase in lycopene concentration with prolongation storage period may be due to the destruction of chlorophyll and transformation of chloroplants to chromoplasts(Hulme, 1970).

The interaction between biofertilization treatment and storage period was significant.

Table (11): Effect of root inoculation with biofertilizers on lycopene content (mg/100g.fresh weight) of tomato fruits during storage in 1997 and 1998 seasons.

Treatments	Storage period in days (1997)						Storage period in days (1998)					
	0	3	6	9	12	Mean	0	3	6	9	12	Mean
Phosphorein	0.52	0.53	0.55	0.58	0.60	0.56	0.45	0.46	0.48	0.50	0.51	0.48
Rizobacterein	0.50	0.53	0.55	0.57	0.59	0.55	0.44	0.45	0.47	0.53	0.53	0.49
Nitrobein	0.52	0.55	0.56	0.58	0.59	0.56	0.45	0.47	0.49	0.50	0.52	0.49
Cerialein	0.52	0.55	0.57	0.60	0.60	0.57	0.46	0.50	0.52	0.54	0.57	0.52
Phosphorein + Riz.	0.58	0.59	0.62	0.64	0.66	0.62	0.52	0.54	0.56	0.60	0.62	0.57
Phosphorein+ Nitrobein	0.58	0.60	0.63	0.64	0.67	0.62	0.51	0.51	0.54	0.57	0.61	0.55
Phosphorein + Cerialein	0.58	0.60	0.63	0.65	0.67	0.63	0.52	0.54	0.57	0.59	0.63	0.57
Phospho.+Riz+Nit+Ceri	0.54	0.57	0.59	0.62	0.63	0.59	0.48	0.51	0.53	0.57	0.59	0.54
Control	0.48	0.50	0.53	0.55	0.58	0.53	0.42	0.44	0.47	0.49	0.51	0.47
Mean	0.54	0.56	0.58	0.60	0.62		0.47	0.49	0.51	0.54	0.57	
L.S.D at 5%: **Treatment**					**0.02**							**0.02**
Storage period					**0.04**							**0.04**
Treatment X S. period					**0.07**							**0.06**

In general, from the results of this study , it could be concluded that tomato plants inoculations with (Phosphorein + Cerialein) and (Phosphorein + Rizobacterein) with 75% NPK is the recommended treatments for improvement productivity and storeability. Therefore, these biofertilizers application reduced the need for mineral fertilizer by about 25% beside this, decrease the production cost and environment pollution.

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تأثير السماد الحيوى على المحصول و الجودة و القدرة التخزينية للطماطم

سعيد زكريا عبد الرحمن – توفيق محمد على الشيخ – عبد الرؤوف محمود هويدى
أقسام بحوث الخضر - معهد بحوث البساتين – مركز البحوث الزراعية

اجريت التجرنة بمزرعة الخضر بقها و التابعة لمعهد بحوث البساتين خلال العروة الصيفى لموسمى ١٩٩٨،١٩٩٧ و ذلك لدراسة تأثير التسميد الحيوى بالاضافات الفردية أو المتعددة على المحصول و صفات الثمار و القدرة التخزينية لصنف الطماطم "كاسيل روك". و قد أستخدم رايزوبكترين, نيتروبين, سيريلين لتثبيت النيتروجين كما أستخدم السماد الفوسفاتى الحيوى(فوسفورين) كمذيب للفسفور.

اوضحت النتائج أن تلقيح نباتات الطماطم بالسماد الحيوى سواء منفردا أو خليط من كل منهما و فى وجود ٧٥% من الاسمدة الكيماوية النيتروجينية و الفوسفورية و البوتاسية الموصي بها أدت الى زيادة عدد الثمار على النبات و وزن وجود ١٠٠% من توصيات التسميد الكيماوى الأزوتى و الفوسفورى و البوتاسى, و قد اعطت المعاملة فوسفورين + سيريلين و فوسفورين + ريزوبكترين أعلى قيمة, كما اوضحت النتائج أن أستخدام خليط من فوسفورين + اي مصدر من البكتريا المثبتة للنيتروجين كانت افضل من استخدام الفوسفورين منفردا على الصفات السابقة. كما يعتبر سيريلين افضل الأسمدة المستخدمة منفردا.

كما ادى تلقيح نباتات الطماطم بخليط من المعاملة فوسفورين + سيريلين و فوسفورين + ريزوبكترين الى تحسين صفات الجودة و القدرة التخزينية لثمار الطماطم من ناحية الصلابة, المواد الصلبة الذائبة و المادة الجافة و نسبة الفقد فى الوزن و التالف و ذلك بعد الحصاد و التخزين. لذلك فأنه يمكن التوصية بأستخدام التسميد الحيوى (فوسفورين + سيريلين) و (فوسفورين + ريزوبكترين) مع ٧٥% من الأسمدة الكيماوية NPK الموصي بها و الذى ادى الى تحسين المحصول و وجودة الثمار و قدرتها التخزينية بالأضافة الى انقاص المعدل المطلوب من السماد الكيماوى NPK بحوالى ٢٥% و كذلك تخفيض تكاليف الأنتاج و تلوث البيئة.

Table (7): Effect of root inoculation with biofertilizers on firmness (N) percentage of tomato fruits during storage in 1997 and 1998 seasons.

Treatments	Storage period in days (1997)						Storage period in days (1998)					
	0	3	6	9	12	Mean	0	3	6	9	12	Mean
Phosphorein	50.71	49.23	45.37	42.11	38.25	45.13	48.93	46.70	44.18	41.22	38.25	43.68
Rizobacterein	42.70	40.92	39.73	36.77	34.99	39.02	44.48	42.11	38.25	34.99	31.14	38.19
Nitrobein	48.04	46.70	44.77	41.51	39.14	44.03	48.19	45.96	43.29	40.33	37.36	43.03
Cerialein	55.16	53.68	51.30	48.93	44.47	50.71	49.21	48.93	47.00	43.59	41.22	45.99
Phosphorein + Riz.	61.83	60.49	58.12	53.38	48.93	56.55	54.12	52.34	50.41	47.74	45.07	49.94
Phosphorein+ Nitrobein	60.49	58.71	55.75	53.38	47.74	55.22	51.15	49.37	47.74	45.07	42.11	47.09
Phosphorein + Cerialein	63.16	61.38	59.01	58.12	51.60	58.85	55.60	53.82	52.04	49.52	47.74	51.74
Phospho.+Riz+Nit+Ceri	56.05	55.16	53.38	50.41	48.04	55.61	51.15	49.23	47.00	43.59	41.22	46.44
Control	45.37	43.15	40.33	35.88	31.44	39.23	39.29	36.77	33.61	30.25	27.58	33.18
Mean	53.72	51.05	49.75	46.72	42.73		49.12	47.25	44.84	41.81	33.18	
L.S.D at 5%: Treatment			**1.36**				**1.42**					
Storage period			**1.12**				**1.23**					
Treatment X S. period			**2.74**				**2.88**					

Table (8): Effect of root inoculation with biofertilizers on total soluble solid percentage of tomato fruits during storage in 1997 and 1998 seasons.

Treatments	Storage period in days (1997)						Storage period in days (1998)					
	0	3	6	9	12	Mean	0	3	6	9	12	Mean
Phosphorein	4.62	4.83	5.13	4.87	4.83	4.80	5.12	5.31	5.47	5.13	4.82	5.16
Rizobacterein	4.03	4.43	4.67	4.22	4.04	4.25	5.03	5.23	5.40	5.07	4.73	5.09
Nitrobein	4.51	4.72	4.83	4.47	4.10	4.52	5.03	5.27	5.47	5.13	4.72	5.11
Cerialein	5.04	5.23	5.40	5.07	4.63	5.07	5.23	5.41	5.53	5.23	4.87	5.18
Phosphorein + Riz.	5.22	5.61	5.87	5.41	5.13	5.44	5.63	5.82	5.97	5.67	5.27	5.66
Phosphorein+ Nitrobein	5.04	5.53	5.67	5.42	5.07	5.33	5.48	5.61	5.82	5.47	5.22	5.51
Phosphorein + Cerialein	5.41	5.67	5.87	5.62	5.33	5.57	5.71	5.91	6.04	5.72	5.33	5,72
Phospho.+Riz+Nit+Ceri	4.82	5.27	5.47	5.13	4.87	5.11	5.43	5.67	5.57	5.22	4.87	5.35
Control	3.72	4.13	4.67	4.42	4.04	4.24	4.52	4.72	4.91	4.63	4.27	4.59
Mean	4.71	5.05	5.29	4.97	4.67		5.24	5.44	5.58	5.26	4.90	
L.S.D at 5%: Treatment			**0.22**				**0.18**					
Storage periods			**0.16**				**0.12**					
Treatment X S. period			**0.32**				**0.30**					