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NATURAL PHOSPHATE AFFECTING MAIZE AS A PROTECTIVE CROP FOR TOMATO UNDER ENVIRONMENTAL STRESS CONDITIONS AT TOSHKY

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Abstract

Toshky is a new area in the southern part of Egypt. Recently, the national project is interested in cultivating these lands to get clean agriculture free from pollution. The concept of agricultural practices in this area should be completely different as compared to the old lands in the Nile Delta and the Valley. Intercropping would help to get annual income within the growing season. The intercropping system is one of the important factors to increase the income and may protect another crop from damage. The aim is to study sources as well as doses of phosphate in combination of intercropping by using maize as a protective crop for tomato traits and production under conditions of environmental stress. Two field trials were carried out at the Agricultural Research Station, Southern Valley, Toshky. The experiment was carried out for two years during 2000/2001 and 2001/2002 seasons in a randomized complete block design. The treatments are different mainly in phosphate sources (natural rock phosphate and super phosphate) and doses. Transplanting dates for tomato (castle rock) hybrid were on 25th and 30th of December in both seasons 2000/2001 and 2001/2002, respectively, while sowing dates of maize were on 15th and 20th of February in the two seasons, respectively. Tomato was transplanted in lines 100 cm width with 50 cm between each two drippers. Maize (TWC 310) was planted in hills spaced 25 cm on the other side of the drippers.

Soil varies from loamy to sandy loam; salinity, content of organic matter and soil fertility are very low and soil reaction tends to alkalinity. Calcium carbonate is about 13% and the soil behaved as calcareous. Based on the soil taxonomy the soil could be classified as Typic Xerofluvants loam, mixed hyper thermic to Typic Torripsamments, sandy loam, mixed hyper thermic. It may be worth to mention that intercropping tomato with maize saved irrigation water by 40% compared with solo treatments. Tomato fruits are significantly affected by intercropping tomato with maize and phosphate sources and doses. The damage of tomato fruits was decreased and marketable yield increased. These could be attributed to the height of maize plants that acts as shadow on tomato plants and protect fruits from sun rays and reduce the effect of direct burning on fruits. Phosphate fertilizers may affect maize without significant effect on maize yield. The most advantage for using intercropping is to maximize usage unit of land and water to produce a maximum production.

INTRODUCTION

The new virgin area in the extreme south of the Nile Valley, of Egypt, Toshky area, is very important, at least, to get clean agriculture free from pollution. In the new reclaimed area, the agricultural practices are completely different as compared to the old land in the Nile Delta and Valley. The climate is very hot in the summer and very cold in winter's night with dry conditions. The evaporation rate is very high in summer season; the total amount of rainfall is scarce. Therefore, suitable technique of water management is important to increase the efficiency of irrigation water for both unit of crop production and soil unit. There is a need for more study to develop appropriate guidelines for farmers and investors for sustainable agriculture and to prevent soil deterioration. The Ministry of Agriculture has constructed a new Agricultural Research Station in the southern valley at Abosimble "Toshky" close to the Nasser Lake in 1998. The Agricultural Research Station will cover different branches of research especially those of soil, water and environment as well as field crops and horticulture (Abdel-Aal, 1999). Agricultural intensification is considered to be one of the important ways of solving or decreasing the large gap between the production and consumption of food products. In such cases intercropping would help farmers getting annual income within the growing season. One advantage of intercropping is to reduce the cost of weed control.

Maize is grown in a climate ranges from temperate to tropic during the period when mean daily temperature is above 15°C (FAO, 1979). The crop tolerates hot and dry climatic conditions so long as sufficient water is available to the plant and temperature is below 45°C. tomato is moderately sensitive to soil salinity (FAO, 1979); tomato can be grown under a wide range of well-drained soils. Tomato fruits are highly affected with high temperature. Also, exposing tomato fruits directly to sun rays leads to great damage and loss in yield crop. Many investigators suggested the cultivating of maize as a shadow growth protective for tomato fruits from damage. Pino *et al* (1994) found that three rows of tomato alternated with one of maize resulted in the highest tomato yields of 14.88 and 21.20 T/ha and corncob (for fodder) yields of 51.8 and 49.61 kg/ha in 1991 and 1992, respectively. This was equivalent to 54% increase in economic value (pesos/ha) compared with the tomato only in 1991 and 24.50% increase in 1992. Srinivasan *et al* (1994) using maize and marginal (*Tageetes erecta* cv. Golden Age) as a trap crop for the management of Helicverpa armigera on tomato. Initial experiments involved observational row trials with simultaneous transplanting/seeding of both tomato and trap crop (Maize) in exploded blocks. One row of the trap crop was raised, on both sides and parallel to 10 and 15 rows of tomato. Results indicate that based on the success in observational row trials, systematic studies involving planting combinations of 10, 12, 14, 16, 18 and 20 rows of tomato were evaluated with one row of *T. erecta* planted on either side or parallel to each of these combinations. The percentages of fruit damaged in 10, 12, 14, 16, 18 and 20 intercropped rows of tomato were 6.0, 7.1, 10.3, 14.1 and 14.5, respectively; control plots had 56.1% damage, when a row of *T. erecta* was raised on either side. Sharma and Tiwari (1996) intercropped tomato cv. Pusa Ruby plants with maize cv. Ganga-2 for the provision of shade. They found that as frequency of maize rows increased, light intensity (reaching the tomato plants), soil temperature and fruit diameter decreased, but percentage fruit set, number and weight of fruits per plant, number of days from sowing to first harvest, juice and seed contents and total and marketable yields increased. They cleared that the only vegetative parameter, which was affected by shade, was plant height, which increased with increasing amount of shade. Fruit yield/plot was highest with 3 rows of tomatoes: 1 row of maize (60.59 kg / 21.6 m^2 plot, compared with 49.02 kg / plot in control). The objective of this study is to investigate the effect of intercropping maize, as to provide shading to tomato, and different sources of phosphate (natural rock phosphate , Rockas, and supper phosphate) as well as applied fertilizer doses on the yield and its components for tomato and maize under the environmental stress conditions of Toshky area at Upper Egypt.

MATERIALS AND METHODS

Two yield trials were carried out at the south valley Agricultural Research Station, Toshky, Agricultural Research Center which is about 1300 km from Cairo and 285 km south from Aswan and near by Lake Nasser. The area lies on latitude 22° 25 North and 31° 5 longitude East. The experiment was carried out for two years during 2000/ 2001 and 2001/2002 seasons in randomized complete block design including eight treatments with four replicates. The treatments are different in phosphate source and dose; the treatments are shown in Table 1.

Recommended fertilizers of 300 kg ammonium sulfate, 200 kg potassium sulfate, 200 kg agricultural sulfur as well as 10 m^3 chicken manure were added together with phosphate treatments to soil before cultivation. The plot size was 90 m^2 (10m length and 9 lines); the distance between each two lines was 1.0 m using drip irrigation system.

Table 1. Experimental treatments

	Treatments	Crop system
T_1	Control (no Phosphate)	Tomato & Maize
T_2	60 Kg P_2O_5 (NP)	Tomato & Maize
T_3	60 Kg P_2O_5 (SP)	Tomato & Maize
T_4	30 Kg P_2O_5 (NP) + 30 Kg P_2O_5 (SP)	Tomato & Maize
T_5	45 Kg P_2O_5 (NP) + 45 Kg P_2O_5 (SP)	Tomato & Maize
T_6	90 Kg P_2O_5 (NP)	Tomato & Maize
T_7	90 Kg P_2O_5 (NP)	Solo Maize
T_8	90 Kg P_2O_5 (NP)	Solo Tomato

NP= Natural Rock phosphate (Rokaz) P_2O_5 29.5% SP= Super phosphate P_2O_5 37.5%

Transplanting dates for tomato (castle rock) hybrid were on 25th and 30th of December in both seasons 2000/2001 and 2001/2002, respectively, while sowing dates of maize was on 15th and 20th of February in the two seasons, respectively. Tomato was transplanted on laterals (50 cm between drippers). Maize (T.W.C. 310) was planted in hills spaced 25 cm on the other side of the drip lines. The evapo-traspiration was calculated from the metrological station data in the site according to Smith (1991). Calculated water requirement was 3648 m^3/fd for maize and 3749 m^3/fd for tomato. The actual water that added by using drip irrigation system was 4488 m^3/fed. Tomato fruits were collected during the two seasons. Maize yield was harvested after 110 days from sowing; ten plants were chosen randomly to determine yield parameters, while the yield/fed. was determined on the whole plot. For tomato, plant height (cm), number of fruits/plant, weight of fruits (kg/plant), percentage of sun damage, fruit yield (Ton/fd), total culls (Ton/fd) and marketable yield (Ton/fd) were determined and calculated. For maize, plant height (cm), ear weight (gm), weight of grain (gm/ear), shelling percentage and yield (Ton/fd) were determined. Two profiles were taken in consecutive layers every 30 cm up to depth of 90 cm. The soil samples were analyzed for mechanical analysis and soil chemical analysis, pH was determined in 1:2.5 soil: water suspension, calcium carbonate was determined using the collin's calcimeter. Cation exchange capacity was determined according to Jackson (1967). Available nitrogen was determined according to Page (1982); available potassium was determined using flame photometer and available phosphorus was determined using Olsen's method (Jackson 1967); zinc, iron, copper and manganese were determined according to Page (1982).

Competitive relationships: Land Equivalent Ratio, (LER), relative crowding coefficient (K) and Aggressivity (Agg.) were calculated according to Willey (1985). Hall (1974) and Mc Gilchrist (1974), respectively

(i) Land Equivalent Ratio (LER)

$$LER=(Y_{tm}/Y_{tt})+(Y_{mt}/Y_{mm})$$

Where Y_{tm}: Yield for intercrop of tomato with maize

Y_{mt}: Yield for intercrop of maize with tomato

Y_{tt}: Yield of pure tomato Y_{mm}: Yield of pure maize

(ii) Relative Crowding Coefficient (K)

$$K=K_1 \times K_2$$

Where $K_1=[Y_{tm} \times Z_2\%]/[(Y_{tt}-Y_{tm}) \times Z_1\%]$

$K_2=[Y_{mt} \times Z_1\%]/[(Y_{mm}-Y_{mt}) \times Z_2\%]$

$Z_1\%$= Area occupied by tomato $Z_2\%$= Area occupied by maize

(iii) Aggressivity (Agg.)

For tomato: ($Ag_t = A_1 - A_2$) and for maize: ($Ag_m = A_2 - A_1$)

$$Ag_t(\text{tomato}) = [Y_{tm} / (Y_{tt} \times Z_1\%] - [Y_{mt} / [Y_{mm} \times Z_2\%]$$

$$Ag_m(\text{maize}) = [Y_{mt} / (Y_{mm} \times Z_2\%] - [Y_{tm} / [Y_{tt} \times Z_1\%]$$

Gross Profit Evaluation

The total income for each treatment was calculated in Egyptian pound/Ton at market prices of L.E. 200/Ton for tomato and L.E. 90/ardab for maize. Data were statistically analyzed according to the procedure out-lined by Roger (1985).

RESULTS AND DISCUSSION

(i). Some Soil physical and chemical Characteristics

Data of the soil characteristics under the experimental field conditions are shown in Table 2. In general, Toshky soil is characterized with many fragments of various rocks; these fragments are different in shape, size and color. Gravels are dominated on the soil surface. Soil texture varies between loamy to sandy loam. In general, saturation percentage (SP) is low. Soil salinity is very low and ranges from 0.9 and 1.3 dS/m either in initial or final state of the experiment. Soil pH varies between 8.9 and 9.1. Cation exchange capacity is low. Calcium carbonate ranges from 12 and 15%; soil behaves as a calcareous soil. The initial organic matter is 0.15% in the surface and decreases with soil depth. After addition of organic manure, organic matter increases generally to double this amount. For initial state of macronutrients, the availability of nitrogen and phosphorus is relatively low and potassium is medium. After additions of fertilizers and organic matter the availability of nitrogen, phosphorus and potassium increased. Regarding micronutrients, generally, there are low amounts of copper, manganese, iron and zinc through the soil profile.

The soil taxonomy could be classified as Typic Xerofluvants loam, mixed hyper thermic to Typic Torripsamments, sandy loam, mixed hyper thermic (according to Soil Survey Staff, 1998).

(ii). Agronomic Traits Aspects

Tomato Crop

Most of the important agronomic traits as well as fruit damage and marketable yield are statistically analyzed and presented in Table 3. For tomato plant height, it seems that there was no significant difference between solo tomato (T_8, 90 kg P_2O_5, NP) and intercropping tomato with maize (T_6, 90kg P_2O_5, NP) in the two seasons. Also results indicate that either natural rock phosphate (Rokaz) or super phosphate fertilizer treatments are not significantly effective on tomato plant height for both seasons except treatment T_4 (30 kg P_2O_5 (NP) + 30 kg P_2O_5 (SP) compared to control treatment (T_1, Control: No Phosphate) in the first season only. Regarding number of tomato fruit per plant, data indicate that solo tomato treatment gave similar fruit number as intercropping treatments and the differences among treatments mean were not significant. Phosphate fertilizers did not show any significant effect on number of tomato fruits per plant. For tomato weight per plant, it seems again that there was no significant effect between solo tomato (T_8) and intercropped (T_6) at the same dose of natural rock phosphate (90 kg P_2O_5, NP) in the two seasons.

Table 2. Some soil characteristics and soil fertility at initial state and after every trial of the experiment.

Profile No.	Soil Depth cm	Soil Texture	Calcium Carbonate %	CEC, meq/100g	pH	Saturation Percentage (SP)			Organic Matter %			Salinity (EC, dS/m)		
						I	Y_1	Y_2	I	Y_1	Y_2	I	Y_1	Y_2
1	0-30	Loamy	15	14	8.9	32	33	30	0.15	0.30	0.30	0.9	1.2	1.2
	30-60	Sandy loam	14	14	9.1	28	30	31	0.05	0.10	0.15	1.1	1.3	1.3
	60-90	Sandy loam	13	13	9.0	30	30	32	0.05	0.05	0.10	1.3	1.3	1.3
2	0-30	Loamy	15	15	8.9	31	32	30	0.15	0.30	0.30	1.0	1.1	1.2
	30-60	Sandy loam	15	15	9.0	28	30	32	0.10	0.10	0.10	0.9	1.2	1.2
	60-90	Sandy loam	15	15	8.9	28	30	30	0.05	0.10	0.10	1.0	1.3	1.4

Profile No	Soil depth, cm	Available N (ppm)			Available P (ppm)			Available K (ppm)		
		I	Y_1	Y_2	I	Y_1	Y_2	I	Y_1	Y_2
1	0-30	25	42	52	7	8	9	220	280	300
	30-60	18	35	38	6	6	6	180	220	220
	60-90	14	20	24	6	6	6	170	170	180
2	0-30	21	38	46	8	10	9	300	330	295
	30-60	17	22	25	7	9	9	206	216	220
	60-90	14	19	21	5	6	6	200	210	210

Profile No	Soil depth, cm	Iron (ppm)			Manganese (ppm)			Zinc (ppm)			Copper (ppm)		
		I	Y_1	Y_2	I	Y_1	Y_2	I	Y_1	Y_2	I	Y_1	Y_2
1	0-30	16	15	13	4	4	4	0.3	0.3	0.2	0.4	0.4	0.4
	30-60	13	14	12	3	3	3	0.3	0.3	0.3	0.2	0.3	0.3
	60-90	13	13	13	4	4	4	0.2	0.2	0.2	0.2	0.2	0.2
2	0-30	12	15	14	3	3	3	0.4	0.4	0.3	0.4	0.4	0.4
	30-60	12	12	12	4	4	4	0.4	0.4	0.4	0.3	0.3	0.3
	60-90	16	15	15	4	4	.4	0.4	0.3	0.3	0.3	0.2	0.2

I: Initial State, Y_1: After the first year (2000/2001), Y_2: After the second year (2001/2002)

Table 3. Tomato traits and yield as affected with intercropping and phosphate source dose in the two seasons (2000/2001 and 2001/2002).

Treatments (P_2O_5)			Plant height (cm)	Number of fruits/plant	Weight of fruits (Kg/plant)	Fruit damage %	Total fruit yield (Ton/fd)	Culls (Ton/fd)	Marketable Yield (Ton/fd)
			2000/2001 season						
T_1	Control	T&M	56.3	39.0	5.3	8.0	37.6	3.00	34.6
T_2	60 Kg (NP)	T&M	57.8	38.5	5.5	6.8	40.0	2.70	37.3
T_3	60 Kg (SP)	T&M	61.3	41.5	5.5	7.5	40.4	3.00	37.4
T_4	30 Kg (NP) + 30 Kg (SP)	T&M	63.0	43.0	5.9	7.5	42.9	3.22	39.7
T_5	45 Kg (NP) + 45 Kg (SP)	T&M	61.3	43.8	6.1	10.3	43.9	4.50	39.4
T_6	90 Kg (NP)	T&M	56.5	43.5	6.3	9.5	45.5	4.30	41.2
T_8	90 Kg (NP)	Solo Tomato	66.3	40.5	6.4	26.3	37.1	9.80	27.4
L.S.D. at 5%			**6.5**	**N.S.**	**0.2**	**1.8**	**2.1**	**0.7**	**2.0**
			2001/2002 season						
T_1	Control	T&M	55.5	35.0	5.5	9.3	37.2	3.4	33.8
T_2	60 Kg (NP)	T&M	51.3	36.3	5.6	8.0	38.7	3.1	35.6
T_3	60 Kg (SP)	T&M	58.8	38.0	5.8	10.0	40.2	4.0	36.2
T_4	30 Kg (NP) + 30 Kg (SP)	T&M	58.0	41.3	5.9	10.5	41.3	4.3	37.0
T_5	45 Kg (NP) + 45 Kg (SP)	T&M	53.8	37.5	6.2	8.0	42.3	3.4	38.9
T_6	90 Kg (NP)	T&M	57.5	40.0	6.2	9.0	44.3	4.0	40.3
T_8	90 Kg (NP)	Solo Tomato	57.5	37.0	6.6	28.0	38.6	10.8	27.8
L.S.D. at 5%			**N.S.**	**N.S.**	**0.24**	**2.8**	**1.69**	**1.20**	**1.78**

Also, statistical analysis did not show any significant differences between both treatments (means of natural rock phosphate and super phosphate on tomato weights per plant). On the other hand, it was noticed that both phosphate fertilizers (natural rock phosphate and super phosphate) significantly affected tomato weights per plant, which increased with increasing phosphate fertilizer doses comparing to control. Regarding total tomato yield, it was significantly affected by intercropping with maize and phosphate fertilizers. For tomato solo grown, the total yield was decreased by 8.4 and 6.0 ton/fd than that intercropped with maize in both seasons 2000/2001 and 2001/2002, respectively. As far as comparing natural rock phosphate with super phosphate is concerned, data did not show any significant difference between the yield of the two treatments means in the two seasons. Both phosphate fertilizers (natural rock phosphate and super phosphate) had almost similar effect on total yield, which increased with increasing phosphate fertilizer rate comparing to control. Concerning tomato fruit damage, data (Table 3) indicate that intercropping and phosphate fertilizers are significantly effective. They decreased fruit damage; the decrease occurs more in intercropping tomato and maize than phosphate fertilizer treatments. The high tomato damage percentages for solo tomato treatment were 26.3 and 28.0% in both seasons 2000/2001 and 2001/2002, respectively, while the fruits damage for intercropping treatments ranged from 6.8 and 10.5%, respectively. Similar results were obtained by Srinivasan, *et al* (1994). For fruit culls, data indicate that phosphate fertilizers and intercropping tomato with maize treatments were significantly effective on fruit culls. These results are in agreement with Sharma and Tiwari (1996). The important parameter for tomato aspect is marketable yield. Results show that both main treatments of phosphate fertilizers and intercropping tomato with maize significantly increase marketable fruits yield in both seasons. The remarkable increase of marketable fruits yield were 41.2 and 40.3 Ton/fd for intercropping tomato compared to 27.38 and 27.78 Ton/fd for solo tomato in seasons 2000/2001 and 2001/2002, respectively. 13.8 and 12.6 Ton/fd represent the increase, respectively. On the other hand, there was no significant effect by using either natural rock phosphate or super phosphate on marketable fruits yields. In general, phosphate treatments increase marketable yield from 34.5 to 41.2 and 33.8 to 40.3 Ton/fd in both seasons, respectively. It may be worth to mention that, intercropping treatments were more effective for marketable yield compared to phosphate fertilizers treatments. Similar results were obtained by Sharma and Tiwari (1996).

Maize Crop

Data in Table 4 indicate most of agronomic traits as affected with intercropping and source of phosphate. The parameters studied were plant height, ear weight, grain weight per ear, shelling percentage and total grain yield. Statistical analysis for plant height is shown in Table 4. Results indicate that planting of maize solo increases significantly plant height as compared with intercropping maize with tomato, in both studied seasons. Also, super phosphate increases plant height significantly as compared with natural rock phosphate treatment. The other treatments show an irrigular trend on maize plant height. Regarding ear weight, data show that no significant difference between solo maize and intercropping maize with tomato on ear weight and also between natural rock phosphate and super phosphate in the two studied seasons. In general, phosphate fertilizers increase ear weight. For grain weight per ear, results indicate that either intercropping or phosphate source of fertilizers did not show any significant effect on grain weight per ear. Statistical analysis for shelling percentage do not indicate effect for either intercropping or phosphate source fertilizers. Concerning total grain yield, results indicate that there is no significant difference between the two treatments of solo maize or intercropping maize with tomato yields. On the other hand, super phosphate fertilizer significantly increases total maize grain yield as compared with natural rock phosphate fertilizer treatment, which did not show any significant effect.

It may be worth to mention that early transplanting (December) of tomato encourages the growth rate without any rivalry of other strange crop that insure a proper environment such as nutritional health and climatic condition until the end of flowering and early fruiting composition which was also favored by phosphate fertilizers. Two months later, intercropping maize on tomato plants gave an opportunity for maize to grow without any competition since the maize roots system is shallow while they are relatively deep for tomato. These variations in the root system between the two crops should enhance the total water and nutrient extraction (Zohry, 1994).

Table 4. Maize traits and yield as affected by intercropping and phosphate source & dose in the two seasons (2000/2001 and 2001/2002).

Treatments (P_2O_5)			Plant height (cm)	Ear weight (gm)	Grain weight (gm/ear)	Shelling (%)	Total grain yield (Ardab/fd)
			2001 season				
T_1	Control	T&M	238.8	338.0	265.0	74.40	25.90
T_2	60 Kg (NP)	T&M	232.5	350.0	265.0	75.84	26.95
T_3	60 Kg (SP)	T&M	248.5	337.0	275.0	78.71	28.06
T_4	30 Kg (NP) + 30 Kg (SP)	T&M	246.8	379.0	275.0	78.48	28.03
T_5	45 Kg (NP) + 45 Kg (SP)	T&M	234.5	356.8	277.5	77.95	29.40
T_6	90 Kg (NP)	T&M	235.5	376.3	272.5	72.52	30.70
T_7	90 Kg (NP)	Solo Maize	249.5	378.0	272.5	72.10	31.58
L.S.D. at 5%			**7.7**	**24.3**	**N.S.**	**N.S.**	**2.1**
			2002 season				
T_1	Control	T&M	237.5	350.0	272.5	77.85	26.25
T_2	60 Kg (NP)	T&M	238.8	335.0	272.0	81.19	26.50
T_3	60 Kg (SP)	T&M	247.5	355.0	282.5	79.58	29.87
T_4	30 Kg (NP) + 30 Kg (SP)	T&M	248.3	351.3	281.5	80.13	30.98
T_5	45 Kg (NP) + 45 Kg (SP)	T&M	243.8	375.0	288.0	76.80	30.98
T_6	90 Kg (NP)	T&M	242.5	371.3	292.5	78.78	31.52
T_7	90 Kg (NP)	Solo Maize	249.3	381.3	297.3	77.97	31.98
L.S.D. at 5%			**5.1**	**18.9**	**13.5**	**N.S.**	**1.39**

More tomato fruits are gained from intercropping with tomato. These advantages could be attributed on the basis of different biological concepts and morphological characteristics between maize, the taller component, and tomato, the shorter companion (Zohry, 1994). Increasing maize plant height than of tomato plant at the tomato fruit stage creates a shadow area for tomato plant, which protects the tomato fruits from direct effect of sun rays. Also, they soften the temperature around the tomato plants. This effect is important for collecting tomato fruits without any damage and increasing marketable crop yield. From physiological point of view, intercropping both crops as a mixture has shown that maize (Quadratic carbon crop, C_4) has the ability to utilize higher light intensities (till 10,000 foot-candle/m^2) more than Calvin cycle plant as tomato (Tri-carbon crop, C_3). This might lead to and explain maximizing benefits of lands per unit area. In addition tri-carbon crop plants emerge large carbon dioxide quantities essential for quadratic carbon maize plants to develop higher gross photosynthesis (Zohry, 1994).

(iii) Saving Irrigation Water

the important advantage for using intercropping system is to maximize usage unit of land and water to produce maximum production. The current work found that the water requirements are 3749 m^3/fd for solo tomato treatment (t_8) and 3648 m^3/fd for solo maize treatment (t_7) using drip irrigation system. In the intercropping treatments tomato with maize, the water requirement is 4488 m^3/fd for any treatment from t_1 to t_6 to produce maximum yield for tomato and maize compared to solo tomato and maize treatments. It may be worth to mention that intercropping tomato with maize saved irrigation water by 40% compared to solo treatments.

(iv). Agronomic Indices Determination

Agronomic Indices Determination (A.I.D.) is obviously a guideline for indication of competitive relationships between plants and representative yield advantages as a result of intercropping. The studies of Agronomic Indices Determination are Land Equivalent Ratio (L.E.R.), Relative Crowding Coefficient (K) and Aggressivity (Agg.).

Land Equivalent Ratio (L.E.R.)

Data shown in Table 5 indicate that all values with different treatments increase than the value of "**1.0**"; it means that all treatments of phosphate fertilizers as well as intercropping tomato with maize, through the first and second seasons are positive on increasing Land Equivalent Ratio.

Table 5. Agronomic indices determination as affected with intercropping tomato with maize and Phosphate fertilizers source and dose during seasons of 2000/ 2001 and 2001/2002.

Treatments (P_2O_5)			Land Equivalent Ratio (LER)	Relative Crowding Coefficient (RCC)	Aggressivity (A)	
			$L_t + L_m$= LER	$K_t \times K_m$ = K	A_t	A_m
			2000/2001 season			
T_1	Control	T&M	1.01+0.82=1.83	80.0 x 4.6=368.0	+0.17	-0.17
T_2	60 Kg (NP)	T&M	1.08+0.85=1.93	14.0 x 5.8=81.2	+0.23	-0.23
T_3	60 Kg (SP)	T&M	1.09+0.91=2.00	12.4 x 9.6=119.0	+0.17	-0.17
T_4	30 Kg (NP) + 30 Kg (SP)	T&M	1.16+0.89=2.05	7.4 x 7.9=60.8	+0.27	-0.27
T_5	45 Kg (NP) + 45 Kg (SP)	T&M	1.18+0.93=2.11	6.5 x 13.5=87.8	+0.25	-0.25
T_6	90 Kg (NP)	T&M	1.23+0.97=2.20	5.4 x 34.9=188.5	+0.25	-0.25
2001/2002 season						
T_1	Control	T&M	0.96+0.82=1.78	26.9 x 4.6=123.9	+0.14	-0.14
T_2	60 Kg (NP)	T&M	1.00+0.82=1.82	3.86 x 4.8=18.5	+0.18	-0.18
T_3	60 Kg (SP)	T&M	1.04+0.92=1.96	25.1 x 14.2= 356.4	+0.12	-0.12
T_4	30 Kg (NP) + 30 Kg (SP)	T&M	1.07+0.97=2.04	15.2 x 30.9= 469.6	+0.11	-0.11
T_5	45 Kg (NP) + 45 Kg (SP)	T&M	1.09+0.97=2.06	11.4 x 31.0=353.4	+0.13	-0.13
T_6	90 Kg (NP)	T&M	1.15+0.99=2.14	7.71 x 68.5=528.2	+0.16	-0.16

L_t: LER (Tomato) K_t: RCC (Tomato) A_t: Agg. (Tomato)
L_m: LER (Maize) K_m: RCC (Maize) A_m: Agg. (Maize)

Data indicate that the control treatment (T_1, No phosphate) has also a value of L.E.R. more than "**1.0**"; the reason for that the other fixed fertilizers (similar to other treatments) were too effective to increase Land Equivalent Ratio. Regarding source of phosphate, there is a relative increase in the values of L.E.R. by using super phosphate (T_3, 60 kg P_2O_5 (SP) comparing to natural rock phosphate, Rokaz (T_2, 60 kg P_2O_5 (NP)). Also the same trend was observed with the increase in the doses of phosphate fertilizers for treatments (T_4, 30 kg P_2O_5 (NP) + 30 kg P_2O_5 (SP)) and (T_5, 45 kg P_2O_5 (NP) + 45 kg P_2O_5 (SP)). The highest value for L.E.R. was 2.2 for treatment 6 (T_6, 90 kg P_2O_5 (NP) in the first season; the same trend was obtained in the second season. In general, results indicate that increase in land usage of tomato intercropped with maize receiving different sources of phosphate as well as phosphate doses were 83, 93, 100, 105, 111 and 120 in the first season and 78, 82, 96, 104, 106 and 114 in the second season for treatments no T_1, T_2, T_3, T_4, T_5, and T_6, respectively. It may be worth to mention that phosphate fertilizers are highly effective in increasing land usage for intercropping.

Relative Crowding Coefficient (K)

Data are shown in Table (5). The values of Relative Crowding Coefficient (K) are more than "**1.0**". It means that all treatments have a positive effect on increasing relative crowding between intercropping maize with tomato. But the values of K are irregular through the different treatments during both seasons. In gerneral, it may be mentioned that the relative crowding coefficient values are higher and may increase with increasing doses of phosphate fetilizers in the second season. The highest value is 528.2 for treatment (T_6, 90 Kg P_2O_5 (NP)).

Aggressivity (Agg.)

Aggressivity is one of the agronomic indices parameters indicating for intercropping treatment that one crop is dominant and the other is not dominated. Data are shown in Table (5). Generally, results show that the values of aggressivity for tomato were positive and for maize were negative. It means that the tomato was the dominant, whereas maize was not the dominated intercrop ocmponent in both seasons.

Gross profit Evaluation

To complete the picture of evaluating both intercropping and phosphate fertilizers including source as well as dose of phosphate, gross profit data are analyzed and represented in Table (6). It is obviously clear that both solo tomato and maize show the lowest gross profit compared to intercropping maize with tomato for both seasons. On the other hand, all phosphate treatments, generally, gave higher values of gross profit in the two seasons. Data indicate that the highest values of the total income (L.E./fd.) achieved by treatment (T_6, 90 Kg P_2O_2 (NP), 11003, 10902.8 L.E. for intercropping tomato and maize in both seasons, respectively.

These results are in a good agreement with Pino, *et al.* (1994).

Table 6. Gross profit as affected with intercropping tomato with maize and phosphate fertilizer source and dose in 2000/2001 and 2001/2002 seasons.

Treatments (P_2O_5)			Gross Profit (L.E.)	
			2000/2001	2001/2002
T_1	Control	T&M	9249.0	9114.5
T_2	60 Kg (NP)	T&M	9881.5	9503.0
T_3	60 Kg (SP)	T&M	10048.0	9920.3
T_4	30 Kg (NP) + 30 Kg (SP)	T&M	10458.7	10724.2
T_5	45 Kg (NP) + 45 Kg (SP)	T&M	10522.0	10572.2
T_6	90 Kg (NP)	T&M	11003.0	10902.8
T_7	90 Kg (NP)	Solo Maize	2842.0	2878.2
T_8	90 Kg (NP)	Solo Tomato	5476.0	5556.0

CONCLUSIONS AND RECOMMENDATION

It may be worth to mention that obtained results clearly explained the importance of phosphate fertilizers and intercropping tomato with maize through three main essential points: (1) maize is a protective crop for tomato plant from direct sunrays and soften high temperature grades in this environmental condition, (ii) saving irrigation water is the main goal to increase the efficiency of water by maximizing crop per unit water and (iii) increasing land equivalent ratio is useful for optimal use of land for both crops. All these were benefits for increasing gross profit per unit land per unit water.

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أثر الفوسفات الطبيعى على الطماطم المحمية بنباتات الأذرة تحت ظروف الإجهاد البيئى لتوشكى

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تعتبر توشكى منطقة هامة فى الجزء الجنوبى لمصر شدت انتباه القائمين على المشروع القومى المصرى لاستغلالها فى الزراعة النظيفة الخالية من الملوثات، ومفهوم أساليب الزراعة تختلف تماماً عن مثيلتها فى الوادى والدلتا، ويعتبر تحميل المحاصيل من العوامل الأساسية لزيادة الدخل السنوى خلال موسم النمو علاوة على حماية المحاصيل القائمة من الهلاك.

يهدف هذا البحث إلى معرفة مصدر وجرعة الفوسفات المناسبة بالإضافة إلى تحميل محصول الذرة كحماية لنباتات الطماطم والإنتاجية تحت ظروف بيئية قاسية. تم تنفيذ تجربة حقلية فى محطة البحوث الزراعية فى جنوب الوادى (توشكى) خلال موسمى (٢٠٠٠/٢٠٠١، ٢٠٠١/٢٠٠٢) باستخدام تصميم القطاعات الكاملة العشوائية، وكانت المعاملات الأساسية لمصادر مختلفة من الفوسفات (حجر الفوسفات الطبيعى، وسوبر فوسفات) ومعدلات إضافة مختلفة، وتم شتل نباتات الطماطم (كاسل روك) فى ٢٥، ٣٠ ديسمبر لكل موسم على التوالى، بينما تم زراعة الذرة (هجين ثلاثى ٣١٠) فى ١٥، ٢٠ فبراير للموسمين، وتم شتل نباتات الطماطم فى خطوط بعرض ١٠٠ سم و٥٠ سم بين كل نقطة رى وأخرى، وتم زراعة الذرة فى جور على مسافات ٢٥ سم على الجانب الآخر من خط الرى.

وقد أظهرت النتائج أن التربة تختلف من طميية إلى رملية طميية ذات محتوى منخفض من المادة العضوية والملوحة والخصوبة وكان الأس الأيدروجينى يميل إلى القلوية ونسبة كربونات الكالسيوم حوالى ١٣٪ وعليه فإن الأرض تسلك سلوك الأرض الجيرية، وقد أوضح التقسيم المورفولوجى أنها تنتمى إلى مجموعة:

(Typic Xerofluvants loam, mixed hyper thermic to Typic Torripsamments, sandy loam, mixed hyper thermic).

ومن الجدير بالذكر أن تحميل الطماطم مع الذرة أدى إلى توفير مياه الرى بحوالى ٤٠٪ بالمقارنة بالمعاملات المنفردة، وقد تأثرت ثمار الطماطم معنوياً بتحميل الطماطم مع الذرة ومصادر وجرعات الفوسفات، حيث قلت ثمار الطماطم الهالكة وزاد المحصول التسويقى وهذا يمكن أن يرجع إلى أن ارتفاع نباتات الذرة عمل على توفير مساحة من الظل لنباتات الطماطم أدت إلى حماية ثمار الطماطم من أشعة الشمس المباشرة وقللت احتراق الثمار، وكان تأثير الفوسفات على محصول الذرة غير معنوى وكانت أكبر ميزة لتحميل المحاصيل هو تعظيم الاستفادة من وحدة الأرض والمياه نتيجة تعظيم الإنتاجية.