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EFFECT OF FUNGICIDES, PLANT DENSITY AND NPK FERTILIZATION LEVEL ON INFECTION WITH EARLY BLIGHT AND LEAF SPOT DISEASES, YIELD AND QUALITY OF TOMATO

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ABSTRACT

Two field experiments were conducted on tomatoes (*Lycopersicon esculentum*, Mill.) cv. Peto 86 to investigate the effect of spraying with fungicides or using various plant densities and NPK fertilization levels on infection with early blight and leaf-spots diseases, yield and quality of tomato fruits as well as nitrate accumulation in plant and fruit. Fungicides doses were Dithane M45, Trimeltox Fort and Cuprosan SD 311 at 200, 250 and 300 g/ 100L; Mancoper at 100, 150 and 200 g/ 100L.

Fungicides decreased infection with both early blight and leaf-spots diseases and increased yield and improved fruit quality. The least infection was given by Trimeltox Fort in the first season and by Cuprosan 311 SD in the second. The least infection was given by the medium dose of all fungicides. Fungicides did not affect total soluble solids, but decreased vitamin C and increased acidity in fruit sap. Nitrate accumulation in plant foliage or fruits were increased, but not to a level harmful to human health. Total nitrogen increased significantly in plant foliage but very slightly in fruits. Thus the use of medium fungicide dose may be beneficial to both producers and consumers.

The culture practice treatment represented by plant intensity and NPK fertilization level showed the lowest infection with one plant/hill receiving the medium fertilizer rate (150 kg N + 64 kg P_2O_5 + 72 kg K_2O/fad). Three plants/hill receiving the highest fertilizer rate (225 kg N+ 96 P_2O_5 + 96 kg K_2O/ fad) gave the highest yield.

Results stress the importance of fungicides along with appropriate culture practices in controlling early blight and leaf-spots diseases on tomatoes and this will benifit producers and consumers.

INTRODUCTION

Tomato (*Lycopersicon esculentum*, Mill.) is one of the most important vegetable crops in Egypt. Much efforts have been made to increase its production to meet domestic and export demands.

Early blight disease caused by *Alternaria solani* causes heavy losses of tomato especially during summer seasons. Studies on leaf spots of tomato in Egypt (El-Helaly, 1971) showed that *Alternaria tenius* and species of *Chaetomium, cocliobolus, Helminthosporium, pleospora* and *Sordaria* could attack the vegetative parts of tomato plants and produce symptoms which resemble those of early blight caused by *Alternaria solani*.

Early blight could greatly influence yield and quality of various tomato cultivars (Basu, 1974).

Diaz Carrasco *et al.* (1977) reported that leaf damage of 11 tomato cvs tested was caused by *A. solani*.

Dithane M22 was reported to be effective against early as well as late blight of tomato (Sidkey *et al.*, 1968 and Senviratne, 1970). Messianen *et al.* (1960) concluded that spraying tomato plants with Cu mixture against *Alternaria solani* gave moderate effects but Zineb and Maneb was more effective and Thirum was insufficiently active. Vorster (1963) controlled tomato early blight and obtained the highest yield using Dithiocarbamate. Abol-Wafa and Kamara (1975) found that good control of *A. Solani* and leaf sport caused by *A. tenuis* on tomato was given by all the tested fungicides Dithane M22, polyram-combi, Bavistin and Vitavax Captan. In field plot trials, Khad and Jol (1980) investigated fungicides against early blight and found that although all used fungicides reduced disease incidence, highest yields were obtained with Dithane M45, blue Cu 50 cuman L. Dithane Z 78 and Captafol. Fadl *et al.* (1985) reported that cuprosan 311 SD, Trimeltox fort, Dithane M45 and Antracol Cuivere gave the best results for controlling early blight disease of tomato.

Numerous investigators studied the effect of adding different levels of nitrogen, phosphorus and potassium on susceptibility of

tomatoes to *A. solani* and leaf-sports, among them, Ramakrishnan *et al.* (1971), El-Fiki (1981) and Agrios (1988). Total fruit yield of tomato was also affected by NPK fertilization level and plant density (Abed and Eid, 1987; Eid *et al.* 1992). this research was conducted in two parts the first part deals with the effect of some fungicides on percentage of infection with early blight and leaf spots diseases, yield and quality of tomato fruits. The second trial deals with effect of some agricultural treatments, i.e. plant density and NPK fertilization level on the percentage of infection and total fruit yield.

MATERIALS AND METHODS

1 - Effect of fungicides on incidence of early blight and leaf-spots of tomato.

Two field experiments were carried out at the Experimental Farm of the Faculty of Agriculture, Moshtohor, Zagazig University during the summer seasons of 1990 and 1991.

Seedlings of tomato *Lycopersicon esculentum,* Mill) cv. Peto-68 were trasnplanted on 19th and 16th of March 1990 and 1991 respectively at 25 cm. apart on one side of ridges 90 cm wide and 3m long. Four fungicides (Dithane M45, Cuprosan 311 SD, Trimeltox Fort and Mancuper) were examined for controlling early blight and leaf spots diseases of tomato underfield condition in three concentrations as indicated in Table (1).

Where the trade name, chemical content, active ingredients and the rate of use for the above mentioned fungicides were clarified. Fungicidal solutions were sprayed with a low pressure sprayer using 200 liter/ faddan. The area of the experimental plot was about 10.8 m^2. It included 4 ridges. 3 m long and 90 cm wide. A complete randomized block design with four replicates was adopted. Application of fungicides were applied five weeks after transplanting and repeated 5 times at 2 weeks intervals. Control plots received only water as spraying solution. Plants were fertilized with NPK(150 kg N, 64 kg P_2O_5 and 72 kg K_2O/Fad.) in the form of ammonium niturate (33.5%N), calcium superphosphate (16% P_2O_5)) and potassium sulphate (48% K_2O), respectively. Fertilizers were devided into three equal portions and then added at 3,7 and 11 weeks after transplanting.

Estimates of infection were carried out after the third spray using the following ratings (Abol-Wafa and Kamara, 1975).

O = no infection.
1 = very weakly infected leaves (up to 1/8 of the leaf surface infected).
2 = weakly infected leaves (up to 1/6 of the leaf surface infected).
3 = moderate infected leaves (up to 1/4 of the leaf surface infected).
4 = severely infected leaves (up to 1/2 of the leaf surface infected).
5 = very severely infected leaves (more than 1/2 of the leaf surface infected).

One hundred mature leaves were taken at random and each was given a rating, and the ratings were converted to a degree of infection as follows (Wenzel, 1949):

$$\text{Degree of infection \%} = \frac{\sum nr \times 100}{5N} \quad \text{Where}$$

n = number of leaves in each category of the ratings.
r = the numerical number given to each category that ranges from (0-5).
N = the total number of examined leaves.

Table (1): Percentage of active ingredients and rate of use of the tested fungicides.

Fungicide	Percentage of active ingredient and chemical components	* Rate of use g/100 L
Dithane M45	44% Mancozeb	200 250 300
Cuprosan 311 S.D	10% Zineb + 10% Maneb + 30% Copper.	200 250 300
Trimeltox Fort	20% Mancozeb + Copper Oxychloride + Sulphate (cu^{++} 21%)	200 250 300
Mancuper MC	52.5% Mancozeb + 17.5% Copper Oxychloride	100 150 200

* rate of fungicide material.

Mature fruits were picked throughout the harvesting period to determine total yield per plot and per feddan. ton.

Chemical constituents: Both of vitamin C content and titratable acidity in fruits were determined as described in A.O.A.C. (1970). the total soluble solids were assayed using hand refractometer. The Total nitrogen and Nitrate-nitrogen were determined in both plant foliage and fruits according to the methods described by Pregl (1945) and Kamal (1951) respectively.

2- Effect of plant density and NPK fertilization on disease infection:

Two field experiments were carrid out at the same growing seasons.

It included 9 treatments which were the combinations of 3 planting densities (1,2 and 3 plants / hill) and 3 fertilizers levels. The 3 NPK fertilization levels were as follows (in kg nutrient / fad.): (75 kg N+ 32 kg P_2O_5 + 48 kgK_2O), (150 kg N + 64 kg P_2O_5+ 72 kg K_2O) and (225 kg N + 96 kg P_2O_5 + 96 kg K_2O). NPK fertilizers were added in the form of ammonium nitrate (33.5% N), calcium superphosate (16% P_2O_5) and potassium sulphate (48% K_2O) respectively. Fertilizers were divided into three portions and then added at 3,7 and 11 weeks after transplanting. A split plot design with four replicates was adopted.Treatments regarding the number of plants / hill served as the main plots while those of NPK fertilization levels served as subplots. The subplot area was 10.8 m^2 ($^1/_{389}$). All plants were sprayed with cuprosan 311 SD (at 250 g/ 100 L) five times at 15-day intervals. The data recorded in this trial was the percentage of infection with early blight and leaf spot diseases and total fruit yield as ton per faddan as previously mentioned in the first experiment. Other agricultural practices wer carried out as commonly followed in the district. Statistical analysis on experimental results were done according to Gomez and Gomez (1983).

RESULTS AND DISCUSSION

Effect of fungicides on infection with the fungal diseases and total fruit yield:

Degree of Infection (Table 2):

All fungicides were effective in reducing the degree of infection with early blight caused by *Alternaria solani* and leaf spots caused by *A. tenuis,*

Table (2): Effect of fungicides on infection with early blight and leaf spots diseases, yield and quality of tomato fruits.

Season		1990						1991					
Fungicides	Conc. g/100L	% of infection	Fruit weight (g)	Total yield ton/fad	Vitamin C (mg / 100 cm3)	Titratabls acidity (mg / 100 cm3)	T.S.S.	% of infection	Fruit weight (g)	Totalyield ton/fad	Vitamin C (mg / 100 cm3)	Titratabls acidity (mg / 100 cm3)	T.S.S.
Dithane M45	200	30.00	70.1	11.66	42.4	590	5.3	37.52	88.13	9.50	38.7	606	6.50
	250	16.67	73.0	12.05	40.5	670	5.3	32.83	74.00	10.10	40.2	646	6.45
	300	15.00	74.2	13.28	39.4	645	5.5	21.22	75.60	11.14	39.5	620	6.55
Trimaltox Fort	200	23.33	69.2	11.37	40.5	535	5.8	34.62	84.63	9.15	40.2	606	6.85
	250	15.00	71.3	12.86	37.9	545	5.7	22.33	85.13	10.32	43.2	596	6.55
	300	16.67	73.4	11.97	37.9	555	5.8	25.68	82.5	9.25	39.8	600	6.45
Cuprosan 311 SD	200	22.50	75.1	12.29	39.3	645	5.8	22.33	83.0	10.19	40.5	656	6.65
	250	20.83	77.0	13.62	39.8	550	5.9	18.98	76.63	11.43	42.8	660	6.80
	300	17.50	78.3	13.78	38.3	605	6.2	23.45	74.25	11.47	41.3	530	6.70
Mancoper	100	29.00	74.0	12.31	42.4	605	5.7	31.27	77.75	10.18	38.3	550	6.50
	150	20.00	76.3	12.38	39.4	610	6.0	16.72	74.88	10.22	40.2	540	6.35
	200	19.16	77.6	12.78	41.6	585	6.1	24.57	70.00	10.54	39.8	600	6.30
Control	-	40.83	68.1	7.16	42.4	595	5.2	50.25	83.00	5.36	43.2	546	6.35
L.S.D. at 0.05		2.67	1.2	0.351	0.35	2.9	N.S.	2.26	4.25	0.154	0.56	2.3	N.S.

N.S = not significant.

and species of *Chaetomium, Cochliobolus, Helminthosporium, Pleaspora, Sordaria* and *Cladosporium* (Marras 1965, El-Faham 1967 and El-Helaly. 1971). However, Trimeltox Fort was particularly more effective in the first season whereas cuprosan 311 SD was the more effective in the second one. Also, there were significant differences between the three concentrations of fungicides.

Both Trimelotox Fort at 250g./ 100L and Dithane M45 at 300 g/ 100 L gave the least infection in the first season whereas Mancoper at 150 g/ 100 L and Cuprosan 311 SD at 250 g/ 100L gave the least infection in the second season. These results are in agreement with those of Madaluni (1962) who found that dithane M 45 at 0.25% gave the best results in controlling *A. solani*. Ramakrishnan and Kandaswamy (1978) found that the most effective and economic control of *A. solani* was given by Dithane M45 (Mancozeb) followed by Benlate (Benomyl) and Difolatan (Captafol). These also agree with De and chattopadhyay (1984).

Fruit Yield:

Among the 4 fungicides, Cuprosan 311 SD was the best in both seasons giving highest fruit weight and yield per faddan compared with the other used fungicides. Also, the highest yield was obtained by the highest cuprosan 311 SD dose, i.e. 300 g/100 L. This was true during both seasons of growth.

Dithane M 45 at its highest dose arranged second in this respect. Increasing the applied dose gave an increase in the fruit yield for all fungicides except Tri-meltox Fort. The superpass of the cuprosan on the other fungicides may be due to its effect on reducing the incidence of the infection with the dangerous fungal diseases and also due to increasing the yield parameters which in turn viced on the total fruit yield.

Vitamin C (ascorbic acid), Titratable acidity and total soluble solids (T.S.S.): Data in Table (2) indicate that T.S.S. was not affected compared with the control treatment. All fungicides caused a decrease in vitamin C concentration. However, there were 3 cases of exception where no change occurred i.e. Dithane M45 at 200 g/100 L and Mancoper at 100 g/ 100 L in season 1990, and Trimeltox Fort at 250 g / 100 L in seasnon 1991.The total acidity showed significant response to most of the used fungicides.

Cuprosan 311 S.D. gave very high contents of titratable acidity. Fric (1976) stated that vitamin C in plants might reduce the oxidised phenolic forms (which are more toxic to the pathogen) to leas toxic compounds. Such compounds may lead to increased percentage of infection in fruits.

Effect of fungicides on nitrate and total nitrogen in tomato plant foliage and fruits: Data in Table (3) show that fungicides increased the contents of NO_3-N and total-N in plant foliage. This increase was particularly evident in case of the higher doses of fungicides.

It is also evident that the contents of NO_3-N in fruits was significantly increased by the used fungicides, whereas, total-N content was not statistically affected. These results are in agreement with those reported by El-Zayat *et al.* (1983) and Abed and Eid (1987). NO_3-N was increased by increasing the fungicides dose. The accumulation of NO_3-N in fruits may be attributed to a state of unequillibrium between N absorption and its assimilation. When the nitrate reductase enzyme is not active in reducing NO_3-N to NH_3, accumulation accurs in both plant foliage and fruits. These results are in agreement with those of Hoff and Wilcox (1970). Thus the use of the medium dose of fungicides may play a role in decreasing the percentage of infection and vitamin C and titratable acidity which may benifit producers and consumers.

Effect of plant density and NPK fertilization level on disease infection and total fruit yield: Data in Table (4) show that the degree of infection was increased by increasing the number of plants per hill. The least degree of infection was obtained by planting one plant per each hill. This may be due to a decrease in relative humidity around the plants, which does not favour infection. Hagazy (1964) and Mansour (1992) reported similar results on faba bean.

As for the effect of NPK fertilization, the least infection reduction was given by the medium level (150 N + 64 P_2O_5 + 72 K_2O kg / fad.) whereas the highest infection was given by the highest level, i.e. (225 kg N+ 96 kg P_2O_5 + 96 kg K_2O / fad). Thus, a balanced state of plant nutrients is of special importance for reducing infection by encouraging good plant growth, increasing its resistance which may lead to evading disease infection.

Ramakrishnan *et al.* (1971) reported that increasing N dose (with or without P or K) reduced infection with *A. solani*. Agrios (1988) mentioned that abundance of N in soil produced young, succulent plants and prolonged its vegetative stage and delayed its maturity. Such plants would be susceptible to pathogen, attacking its tissues. On the other hand, plants

Total (3): Effect of fungicides on nitrate and total nitrogen content in either plant foliage or fruits of tomato (1981 Season).

Fungicides	Conc. g/100L	Plant - foliage		Fruit	
		Nitrate	Total N	Nitrate	Total N
		(mg/100 g* D.W.		(mg/100 g* D.W.	
Dithane M45	200	966	2431	872	2100
	250	979	2550	881	2351
	300	1020	2550	997	2381
Trimaltox fort	200	985	2560	902	2455
	250	1031	2673	932	2461
	300	1045	2841	976	2632
Cuprosan 311 SD	200	835	2555	723	2351
	250	890	2680	801	2430
	300	897	2371	832	2362
Mancoper	100	911	2460	731	2331
	150	943	2470	805	2300
	200	1001	2485	811	2318
Control	-	819	2211	703	2000
L.S.D. at 0.05		**127**	**42.0**	**31**	N.S.

N.S = not significant.

* D.W. = dry weight

Table (4): Effect of plant density and NPK fertilization level on tomato infection with early blight and leaf spots diseases as well as total fru it yield.

Fertilization level Kg/fad / Number of plants/hill	% of Infection							
	* 1990				1991			
	I	II	III	Mean	I	II	III	Mean
1	41.88	36.73	36.01	38.21	43.55	36.85	33.50	37.96
2	36.85	33.50	45.10	38.48	40.20	30.15	46.40	38.92
3	47.74	41.75	44.39	44.63	43.55	46.40	53.60	47.85
Mean	**42.16**	**37.33**	**41.83**		**42.43**	**37.80**	**44.50**	

L.S.D. at 0.05 for:

Number of plants / hill (N):	1.40	1.05
Fertilization level (F):	0.33	0.53
N x F	3.36	3.35

Total Fruit yield (Ton / fad.)

Fertilization level Kg / fad / Number of plants/hill	* 1990				1991			
	I	II	III	Mean	I	II	III	Mean
1	14.1	16.4	17.9	16.1	12.3	14.7	15.6	15.8
2	18.6	19.7	20.3	19.5	16.4	17.3	18.5	17.6
3	21.0	22.4	23.8	22.3	18.8	20.6	21.3	18.5
Mean	**17.9**	**19.5**	**20.7**		**14.2**	**17.4**	**20.3**	

L.S.D. at 0.05 for:

Number of plants / hill (N):	0.13	0.19
Fertilization level (F):	0.07	0.10
NxF	0.21	0.38

* Level I: (75 N + 32 P_2O_5 + 48 K21 Kg. / fad), Level II: (150 N + 64 P_2O_5 + 75 K_2O Kg/fad). Level III: (225 N + 96 P_2O_5 + 96 K_2O Kg/ fad).

grown in media defficient in nitrogen would be very weak, slow in growth and this would also make them susceptible to pathogens. The same researcher added that phosphours increased resistance due to the improvement of the balance of its nutrition and accelerating its maturity and allowing it to escape infection. He also stated that potassium seems to affect establishment and development of pathogen in plant and promote wound healing, it increases resistance to frost injury and thereby reduces infection in frost-killed tissues; it also delays maturity and senescence in some crops beyond the periods in which infections by certain parasites is damaging. In general plants receiving a balanced nutrition, in which all required elements are supplied in appropriate amounts, are more capable of protecting themselves from any further infections and limiting their existing ones. However, even a balanced nutrition may affect development of a disease when the nutrients are too high or too low.

As regards to the effect of plant density and NPK fertilization level on the friut total yield, it is evident from the data in Table (4) that the highest total yield was obtained in case of planting 3 plant per hill within the highest fertilization level (225 kgN + 96 kg P_2O_5 + 96 kg K_2O/ fad.).

These results are in agreement with those reported by Abed and Eid, 1987) and Eid *et al.* (1992) all working on tomato.

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تأثير المبيدات الفطرية و الكثافة الزراعية ومستوى التسميد الآزوتى والفوسفاتى والبوتاسى على الإصابة باللفحة المبكرة وتبقعات الأوراق والمحصول وجودة ثمار الطماطم

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كلية الزراعة بمشتهر- جامعة الزقازيق - فرع بنها

أجريت تجربتان حقليتان على الطماطم صنف بيتو ٨٦ وذلك لمعرفة تأثير الرش بالمبيدات الفطرية أو الكثافة النباتية والتسميد بمستويات مختلفة من الـ NPK على الإصابة بأمراض اللفحة المبكرة وتبقعات الأوراق والمحصول ومحتوى الثمار من فيتامين ج والمواد الصلبه الذائبه والحموضة وتراكم النيترات فى النبات والثمار. واستخدمت الجرعات ٢٠٠ و ٢٥٠ و ٣٠٠ جم/ لتر من المبيدات الفطرية دياثين م ٤٥، تراى ميلتوكس فورت وكوبروزان سوبر د ٣١١ والجرعات ١٠٠، ١٥٠، ٢٠٠ جم/ ١٠٠ لتر من المبيد الفطرى مانكوبر.

أدى الرش بالمبيدات الفطرية إلى نقص نسبة الإصابة باللفحه المبكرة وتبقعات الأوراق كما أدى ذلك إلى زيادة المحصول وتحسين جودة الثمار. وقد أعطى المبيد الفطرى تراى ميلتوكس فورت أقل نسبة إصابه فى الموسم الأول بينما كان المبيد الفطرى كوبروزان سوبر < ٣١١ الأفضل فى الموسم الثانى. كما أن الجرعة المتوسطة من المبيدات كانت لأفضل فى تقليل نسبة الإصابة ولم تؤثر المعامله بالمبيدات على محتوى الثمار من المواد الصلبه الكليه ولكنها أدت إلى نقص فيتامين ج وزيادة الحموضه فى عصير الثمار وقد أدت المبيدات إلى زيادة تراكم النترات معنويا بكل من الأجزاء النباتية والثمار للحد الذى لايضر بصحة الإنسان كما أدت إلى زيادة محتوى الأجزاء النباتية من النيتروجين الكلى ولكن هذه الزيادة فى الثمار لم تصل إلى حد المعنوية. وبذا يكون إستعمال الجرعات المتوسطة من المبيدات الفطرية مفيدا لكل من المنتج والمستهلك وبالنسبة لتأثير الكثافة النباتية والتسميد، فقد وجد أن زراعة نبات واحد فى الجورة مع المستوى المتوسط من التسميد (١٥٠ كجم نيتروجين + ٦٤ كجم فوسفور + ٧٢ كجم بوتاسيوم للفدان) قد أعطى أقل نسبة إصابه بينما زراعة ثلاثة نباتات بالجورة مع مستوى التسميد العالى (٢٢٥ كجم نيتروجين + ٩٦ كجم فوسفور + ٩٦ كجم بوتاسيوم للفدان) قد أعطى أعلى محصول. وتؤكد النتائج على أهمية إستخدام المبيدات الفطرية المذكورة ومعها أتباع المعاملات الزراعية المناسبة لمقاومة أمراض اللفحه وتبقعات الأوراق فى الطماطم بما يعود بالفائده على المنتج والمستهلك.