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Studies on Effects of Endosulfan, Mancozeb and Pirimicarb Pesticides on Agronomic Characteristics of Tomato (*Lycopersicum esculentum*)

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In the present studies, the effects of some pesticides, *e.g.*, endosulfan, mancozeb and pirimicarb on yield and their residues in tomato is reported. According to the results, yield, stem length and number of safe plants and fruits per plant were significantly different at the 1% level. The studies with no pesticide treatments revealed significant decrements. These differences were not significantly different between pesticide treated treatments. According to results, the pirimicarb residue in tomato fruits, seven days after the last sprays, in 1/2 recommended dose and control were lower than the accepted doses announced by Codex. Therefore, for pirimicarb at the current conditions a currency time more than the recommended 7 days should be defined. The residue of endosulfan and mancozeb in all treatments, except the untreated controls, were more than those announced by Codex. Considering the adverse ecological effects of pesticides, it is seen that with half the recommended doses of these pesticides acceptable effects were detected on yield and factors affecting yield such as: number of safe plants and fruits and stem length and statistically equal yields were obtained. In conclusion, it is recommended to harvest fruits longer than the time claimed by companies.

Key Words: Residue, Tomato, Mancozeb, Endosulfan, Pirimicarb, Codex, Reducing pesticide dose.

INTRODUCTION

Various pesticides are commonly used for control of weeds, pests and diseases that affect the cultivation of tomato. Endosulfan is an organochlorine pesticide used primarily to kill insects and mites on crop including tea, coffee, cotton, tomato, fruits, vegetables, rice and grain. It has been identified as a pesticide of concern due to health and environmental problems associated with its use in some countries[1]. A further concern is evidence that endosulfan may cause mutagenic effects in humans if exposure is great enough: endosulfan has been shown to be genotoxic to human cells under experimental conditions[2].

The analysis of organochlorine pesticides has become even more important in recent times because this class of compounds is becoming classified as a subgroup of a class known as endocrine disruption. Endocrine disruptions are thought to

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mimic the actin of the body's natural hormones and there is concern that these compounds are toxic at even lower levels[3]. Despite these dangers, this pesticide is applied widely in tomato fields under the climatic conditions in Mazandaran, Iran.

Mancozeb and pirimicarb belong to dithiocarbamate and carbamate classes respectively, that are used to control aphids and fungi. Unfortunately, heavy use of these and another pesticides without any attention to the rates recommended by the manufacturing companies has been the cause of the increase in the new pests, diseases and removing their natural enemies. Although the low-input pest management program used significantly fewer insecticides than the grower standard, there was no significant difference in yield or net profit between the treatments[4].

On the other hand, economic problems force the farmers to harvest the yield before ending the currency period. The aim of the present study is to determine the residue levels of the above pesticides in tomato, 7 days after last spray, having in mind a re-evaluation of 7 days pre-harvest interval in force in Iran.

EXPERIMENTAL

The trial was set up in 2003 at Dasht-e-Naz experimental field located 10 km from Sari, Iran, with 16 m elevation from the sea surface, 36°37′ latitude and 53°11′ longitude. Details of the experiment include the application rates, the time schedule of spraying and the number of applications as shown in Tables 1 and 2.

TABLE-1
PESTICIDE CHARACTERIZATION

Active ingredient	Trade name	Class	Type of formulation	Active ingredient (%) (content of formulation)
Endosulfan	Thiodan	Organochlorine	E.C.	35
Mancozeb	Dithan M-45	Dithiocarbamate	W.P.	80
Pirimicarb	Pirimor	Carbamate	W.P.	50

TABLE-2
DETAILS OF EXPERIMENT CONDUCTED

Active ingredient	Rate	Date of application
Endosulfan	0, 0.75, 1.5, 3 (mL/L)	18 July 2003 28 July 2003
Mancozeb	0, 1, 2, 4 (g/L)	18 July 2003 28 July 2003
Pirimicarb	0, 0.25, 0.5, 1 (g/L)	8 July 2003 18 July 2003 28 July 2003

The plots were of 9 m^2 separated by a buffer row of 1 m, to prevent cross-contamination. Treatments were half, unit and double recommended doses of endosulfan, mancozeb and pirimicarb.

All treatments were laid out as randomized complete blocks with five replicates. Field applications were made with a backpack sprayer delivering 2 L of water per plot. Care was taken to spray the chemical as evenly as possible on each plot. During the crop growing season, the test field could be irrigated if necessary. No other pesticides are applied on the test field. During the growing season, sprays were carried out regularly upon observing the pest and symptoms.

Sampling: 7 days after last spray, samples (about 1 kg of fruit per replicate) were randomly collected and immediately transported to the laboratory in plastic bags and were stored at –20°C until analysis. From transplanting (21 June) up to sampling time (4 August), rainfall occurred 10.2 mm from 22 June till 22 July and 52.4 mm from 23 July till 23 August. Average maximum daily air temperature was recorded 29.4 and 30.6°C on these dates respectively. Also the average relative humidity was 73% in both July and August.

Extraction of the residue from tomato

Soxhlet extraction of the tomatos was achieved with 50 g of slide tomato in a thimble and extracted with 300 mL of *n*-hexane. The sample was refluxed for 4 h, with sufficient heat to cause refluxing about five times an hour.

UV-Spectrophotometry

The analytical procedure to study mancozeb, endosulfan and pirimicarb in samples 7 days after exposure to the treated surfaces was by UV spectrophotometry.

Standard solutions were prepared as follows:

2 g, 1.5 g and 0.5 g mancozeb, endosulfan and pirimicarb were placed in three Erlenmeyer flasks, respectively. Added to each Erlenmeyer flask 1000 mL of the *n*-hexane solution and shaken by heat-shaker. The maximum absorption wavelengths of the pesticides were determined by spectrophotometer and were obtained at 278, 253 and 304 nm for mancozeb, endosulfan and pirimicarb, respectively.

In continuation of the analysis method, standard addition technique was used:

0.5 mL of extracted sample was poured into five tubes and then 1, 2, 3, 4 and 5 cc of the standard solutions were added to them, separately, for each pesticide. In the next stage, absorption rate was noted and linear regressions between standard solution and these amounts were accounted.

Analysis of the data

After calculating the linear regression between standard solution added to the samples (x) and absorption rates (Y), residue rate was determined with Beer-Lambert law (A = abC):

$$A_s = bV_xC_x/V_t + bC_sV_s/V_t \quad (1)$$

$$\alpha = bV_xC_x/V_t \quad (2)$$

$$\beta = bC_s/V_t \quad (3)$$

$$A_s = \alpha + \beta V_s \quad (4)$$

$$\alpha/\beta = V_xC_x/C_s \quad \Rightarrow \quad C_x = \alpha C_s/\beta V_x \quad (5)$$

In these formulae, C_s is standard concentration, V_x is volume of the sample, V_t is total volume of the volumetric flask, b is the cell path length and a is absorptivity coefficient of sample, α and β are intercept and slope of calibration curve respectively. The standard deviation of slope (S_β) and standard deviation about the regression (S_r) and other statistical terms were calculated as follows:

$$S_c = C_x\sqrt{(S_r/\alpha)^2 + (S_\beta/\beta)^2} \quad (6)$$

$$S_r = \sqrt{(S_{yy} - \beta^2 S_{xx})(n-2)} \quad (7)$$

$$S_\beta = \sqrt{(S_r)^2/S_{xx}} \quad (8)$$

$$S_{xx} = \Sigma^2_{x_i} - (\Sigma_{x_i})^2/n \quad (9)$$

$$S_{yy} = \Sigma^2_{y_i} - (\Sigma_{y_i})^2/n \quad (10)$$

The confidence level of sample concentration is:

$$CL = C_x \pm tS_{c\ sample}$$

RESULTS AND DISCUSSION

The residues were determined by using calibration curves. Attention to the calibration curve showed high regression coefficient in all the treatments (Figs. 1–3). The results of the field trials have been shown in Table-3. The residue values are averages of five replicates. In all the treatments, except pirimcarb, half recommended doses were more than the maximum residue level (MRL) established by the FAO/MRL which is set at 3, 2 and 0.5 mg/kg for mancozeb, endosulfan and pirimicarb, respectively (Figs. 4–6).

In this experiment pirimicarb residue level in 0.1% dose treatment was 1.74 mg/kg, 7 days after last spray (Table-3). Celma and Santaballa[5] get the same result

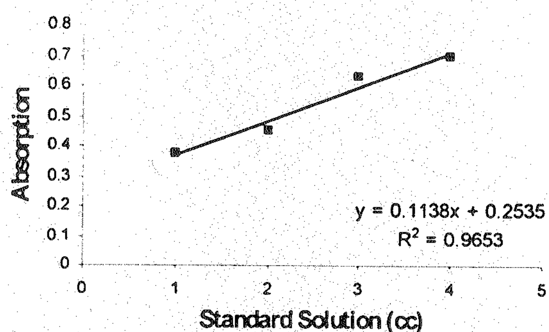

Fig. 1. Calibration curve of endosulfan

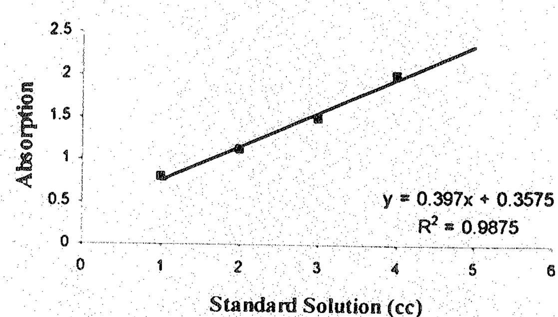

Fig. 2. Calibration curve of mancozeb

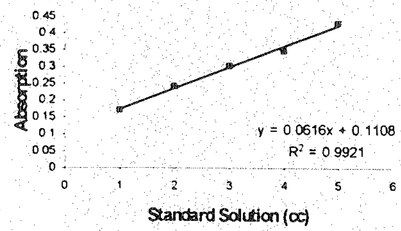

Fig. 3. Calibration curve of pirimicarb

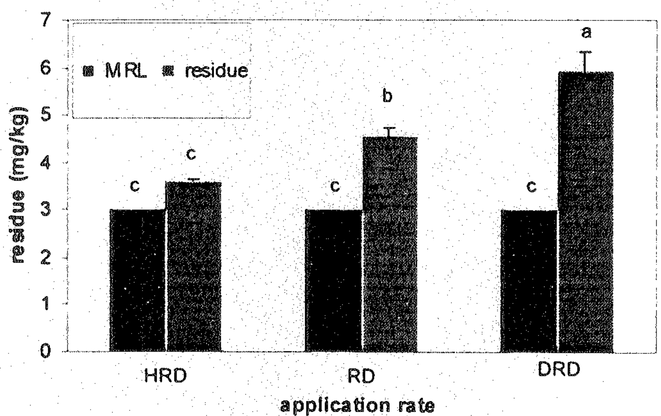

Fig. 4. Relationship between mancozeb residue in tomato and application rate. The same words have no significant difference at the 1% level (HRD: half recommended dose; RD: recommended dose; DRD: double recommended dose)

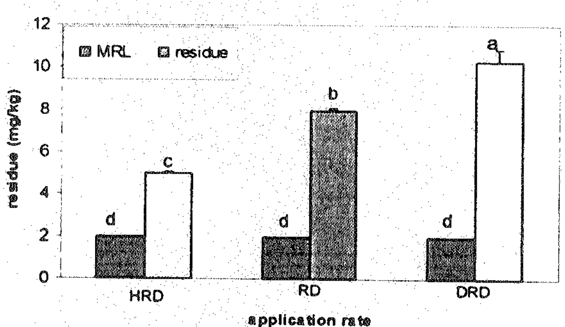

Fig. 5. Relationship between endosulfan residue in tomato and application rate. The same words have no significant difference at 1% level (HRD: half recommended dose; RD: recommended dose; DRD: double recommended dose)

in another experiment too. In this experiment trials were conducted in 1980 at Castellon and Valencia[5]. Samples for residue analysis were usually taken 7, 14 and 21 days after spraying with 0.1% dose of pirimicarb and were analyzed by GLC method. In oranges, samples of peel and whole fruit were analyzed separately. In 7 days PHI spray, pirimicarb level in the peel orange was in the range 0.74–1.07 mg/kg, which was not consistent with MRL of 0.5 mg/kg for oranges recommended by the 1981 JMPR on the basis of the Portuguese data[5]. Also the residue on clementines from the Castelon trial after 31 d (0.64 and 0.69 mg/kg) suggests that after 7 days an MRL of 0.5 mg/kg might be insufficient on this crop.

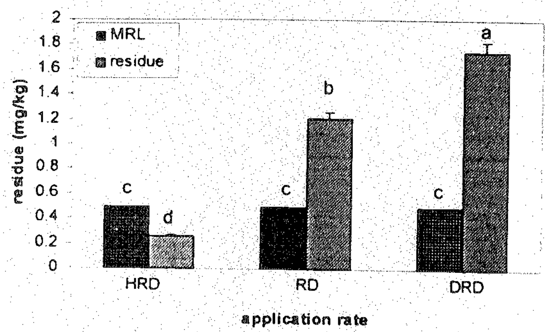

Fig. 6. Relationship between pirimicarb residue in tomato and application rate. The same words have no significant difference at 1% level (HRD: half recommended dose; RD: recommended dose; DRD: double recommended dose)

TABLE-3
PESTICIDE RESIDUES AND THEIR STANDARD DEVIATION (mg/kg), 7 D AFTER LAST APPLICATION IN TOMATO
(Mean of five replicates)

Treatment	HRD	RD	DRD	MRL (FAO/WHO)
Mancozeb	3.62 (± 0.93)	4.58 (± 0.65)	5.92 (± 2.06)	3.0
Endosulfan	5.02 (± 1.86)	7.98 (± 1.51)	10.12 (± 2.31)	2.0
Pirimicarb	0.26 (± 0.09)	1.21 (± 0.67)	1.74 (± 0.53)	0.5

HRD: half recommended dose; RD: recommended dose; DRD: double recommended dose

The progress in successfully reducing pesticide use could be made by developing low-input programs for the control of pathogens. In this experiment, the analyses of the same characteristics of tomato such as stem length, the safe plants number, the safe fruit number per plant and the yield were measured. The averages were compared using the Dancan's multiple range test. According to the results, significant difference was observed between non-sprayed, control and sprayed treatments at 1%, as this amount was much less than spray treatment for all the characteristics. But variance did not show significant difference between spray treatments (Figs. 7–10).

Consequently, with the use of low input pesticides (half recommended dose) the yield can reach levels comparable to those with the recommended dose. Trumble conducted a project about reducing pesticide use in celery through low-input pest management strategies in California[4]. Although the low-input program used significantly fewer pesticides than the grower's standard, there was no significant difference in yield or net profit between the treatments. This reduction in pesticide use can be made without sacrificing yield, quality or net profit. The grower's standard practice had an average yield of 2,731 marketable cartons per hectare (1,112 cartons per acre). The low-input IPM program yielded an average of 2,751 marketable cartons per hectare (1,105 cartons per acre). The net loss for the grower standard was $3,415 per hectare ($1,382 per acre), and the net loss for the low-input IPM program was $2,472 per hectare ($1.000 per

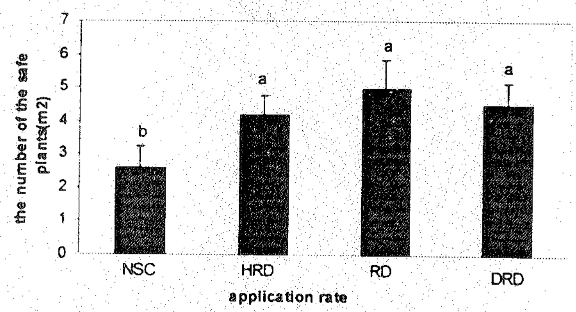

Fig. 7. Relationship between the number of safe plants (in m^2) and application rate of pesticides. The same words have no significant difference at the 1% level (NSC: non sprayed control; HRD: half recommended dose; RD: recommended dose; DRD: double recommended dose)

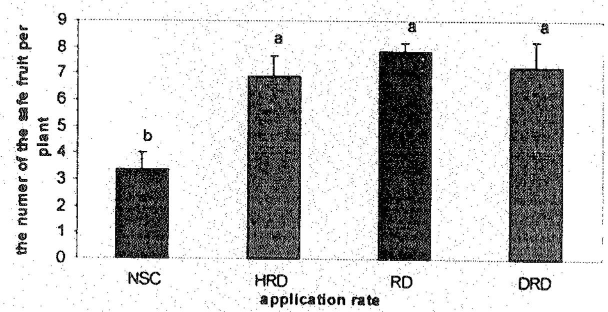

Fig. 8. Relationship between the number of the safe fruit per plant and application rate of pesticides. The same words have no significant difference at the 1% level (NSC: non-sprayed control, HRD: half recommended dose, RD: recommended dose, DRD: double recommended dose)

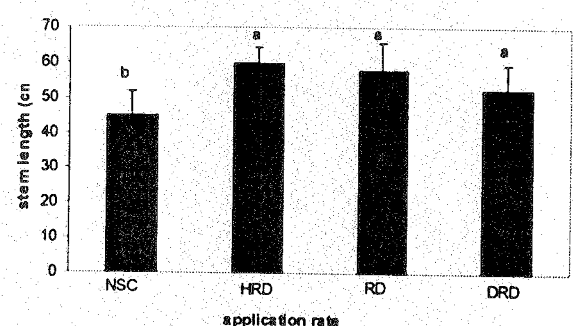

Fig. 9. Relationship between the stem length and application rate of pesticides. The same words have no significant difference at the 5% level (NSC: non sprayed control; HRD: half recommended dose; RD: recommended dose, DRD: double recommended dose)

acre). The net loss is attributable to the grower harvesting the field to meet a preexisting contract. Had the harvest been timed to when market prices were more favourable, the grower could have realized a net profit, with the low-input IPM generating a greater net profit. In addition to the more favourable economic results, the low-input IPM program has benefit for the environment.

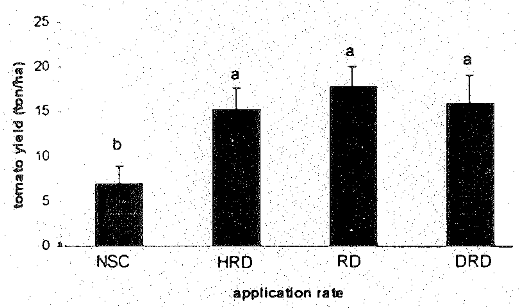

Fig. 10. Relationship between the tomato yield and application rate of pesticides. The same words have no significant difference at the 5% level (NSC: non sprayed control; HRD: half recommended dose; RD: recommended dose; DRD: double recommended dose)

TABLE-4
ANALYSIS OF VARIANCE BETWEEN PESTICIDE USE AND HAS BEEN SURVEYED FACTORS
(Mean of squares)

S.O.V.	Df	Safe plants (Nos./m^2)	Safe Fruits (per plant)	Stem length (cm)	Yield (ton/ha)
Block	4	1.17	0.55	38.68	11.6
Treatment	3	5.67**	21.64**	224.36*	110.07**
Error	12	0.31	0.53	43.94	6.21
Total	19	1.34	3.86	71.32	22.59

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