III RESULTS AND DISCUSSION

A. Influence of organophosphorus insecticide on leaf area expansion

The leaf area expansion in response to different concentrations of methylparathion and phosphamidon spray is given in fig. 2 and fig. 3 respectively. It is very clear from the figure that M_1 (0.1% methyl parathion) concentration favoured the leaf area expansion and as the concentration increased it appeared that there was reduction in the leaf assimilatory tissue. This situation was true for all the three vegetable crops studied. However, no much difference was observed in guar plant. The data ingeneral indicates that methylparathion even at below recommended dose (0.1%) works good as far as the leaf area is concerned.

From fig. 3 we can very easily say that P_2 concentration (0.04% phosphamidon) shows promising results as far as leaf area is considered. But as the concentration increased, the leaf area was found to be decreased. The reduction in the leaf area at higher concentration was more hampered in case of tomato and okra whereas no much difference was observed in guar. From this study one thing is clear that these two organophosphorus pesticides favour leaf area expansion when used in lower concentration. As such phosphamidon has been shown to be growth stimulating pesticides by the manufacturer. (Handout by Hindustan Ciba-Geigy Ltd., Bombay).

From Table 1 it is also clear that among both the pesticides used, methylparathion favoured growth at below recommended dose (0.1%) while phosphamidon favouredat recommended dose (0.04%). From this we can safely say that methylparathion can be used at below recommended

FIGURE - 2

Effect of different concentrations of methylparathion on leaf area expansion in tomato, okra and guar

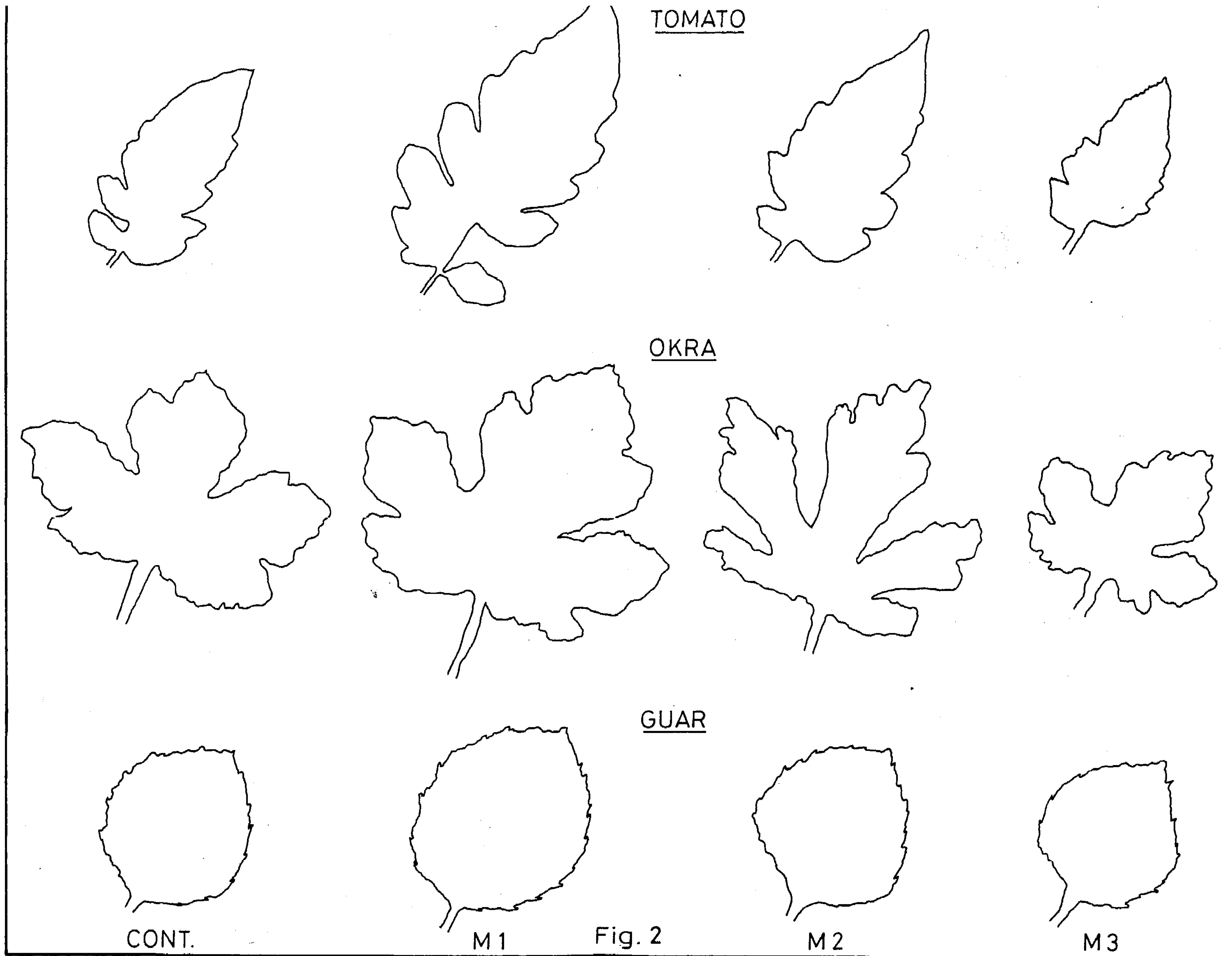


Fig. 2

FIGURE - 3

Effect of different concentrations of phosphamidon on leaf area expansion in tomato,okra and guar

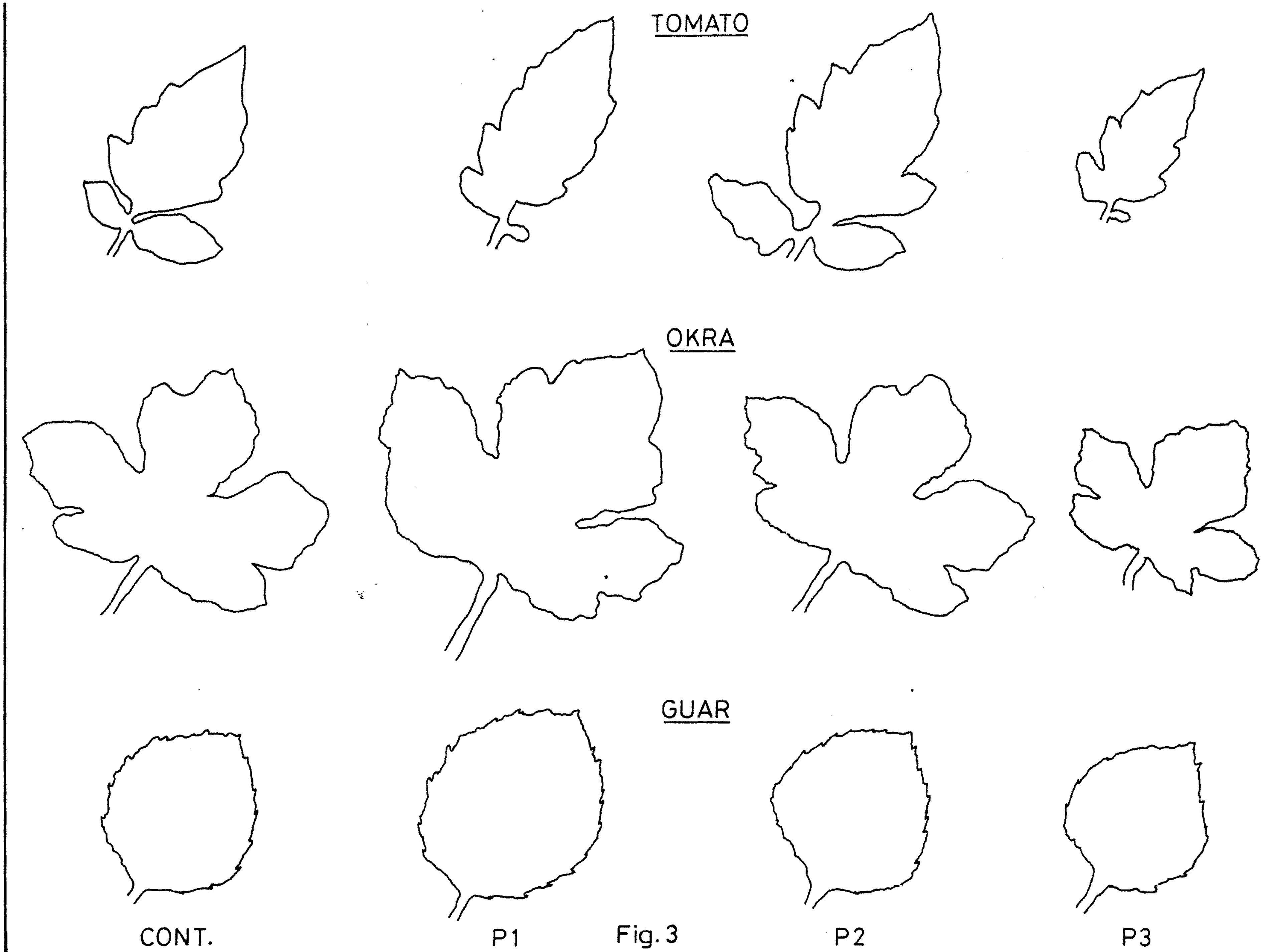


Fig. 3

Table 1 : Effect of different concentrations of phosphamidon and methylparathion foliar application on leaf area expansion in the leaves of tomato, okra and guar plants.

Pesticides	Tomato	Okra Leaf area in cm^2	Guar
Control	13.0	32.0	34.0
<u>Phosphamidon</u>			
P_1 (0.02%)	15.0	40.0	18.0
P_2 (0.04%)	22.0	29.0	13.0
P_3 (0.06%)	6.0	15.0	11.0
<u>Methylparothion</u>			
M_1 (0.1%)	26.0	40.0	20.0
M_2 (0.15%)	16.0	30.0	16.0
M_3 (0.2%)	10.0	15.0	12.0

The values are mean of three determinations.

Leaf area was analysed one month after spray.

P_3 concentration (0.06% phosphamidon) the reduction in RWC on 1st day after spray was 1% and it was almost equal to that of control on 7th day after spray. If we observe the fate of RWC, it is clear that lower concentrations favour the water intake while higher concentrations do not. The situation in methylparathion sprayed plants was more or less the same where the water intake of plants was increased. Whereas with the increasing concentration of methylparathion the RWC level was lowered down. RWC analysed on 7th day after spray showed increase in RWC at M_2 and M_3 concentrations (0.15 and 0.2% methylparathion respectively) while at M_1 (0.1% methylparathion) it was decreased.

When we compare RWC of control with phosphamidon sprayed leaves of okra it appeared that there was reduction in RWC of leaves when analysed on 1st day after spray and increased on 7th day after spray at P_1 and P_2 concentrations (0.02% and 0.04% phosphamidon respectively) with concomitant decrease at P_3 concentration (0.06% phosphamidon). In methylparathion sprayed leaves the RWC level on 1st day after spray though showed increase, it was of not much significance. However, the increase in RWC content on 7th day after spray was significant at M_1 concentration (0.1% methylparathion). Where it showed about 8% increase than control. At M_2 (0.15% methylparathion) concentration there was no decrease or increase in RWC while at M_3 (0.2% methylparathion) concentration it was decreased by 7% as compared to control on 7th day after spray.

In guar RWC level at P_1, P_2 and P_3 concentrations (0.02%, 0.04% and 0.06% phosphamidon resp.) was found to be increased by 7%, 5% and dose which will certainly help the plants to increase the productivity. Similarly it will also help in minimizing the environmental pollution problem. The another interesting point observed was control of sucking pest. This is effective at 0.1% methylparathion (Data not included). Therefore, use of methylparathion at this concentration may be recommended for the crops under investigation. Since phosphamidon works good at recommended concentration, both to control the pest and to favour the crop growth, it should be tried on some other plant where it would show control of the pest and luxurient growth even at below recommended concentration.

B Response of water status to organophosphorus insecticides

It is now well established that some of the pesticides enhance transpiration rate by enhancing stomatal opening and desiccate the plant, on the other hand several chemicals suppress the stomatal opening and reduce the water needs of plants (Das,V.S.R. 1977). In this respect the study of response of water status to organophosphorus insecticides was thought worthwhile and hence attempted.

The relative water content (RWC) of phosphamidon sprayed tomato leaves is given in Table 2. It is very clear from the table that RWC analysed on 1st day after spray showed increase by 4% at P_1 (0.02% phosphamidon) concentration. The same when analysed on 7th day after spray showed further increase in RWC. At P_2 (0.04% phosphamidon) concentration the RWC level on 1st day after spray was decreased by 4% and on 7th day after spray it was increased by 4%. However, at

Table 2 : Effect of different concentrations of phosphamidon and methylparathion foliar application on relative water content (RWC) in the leaves of tomato, okra and guar plants.

Pesticides	Tomato Analysis after 1st day	Tomato Analysis after 7th day	Okra Analysis after 1st day	Okra Analysis after 7th day	Guar Analysis after 1st day	Guar Analysis after 7th day
Control	83.47	(Average)	79.09	(Average)	79.05	(Average)
Phosphamidon						
P_1 (0.02%)	87.47	96.75	71.37	83.54	87.0	76.94
P_2 (0.04%)	79.38	87.42	77.51	85.06	85.93	73.29
P_3 (0.06%)	82.25	83.73	82.64	76.75	86.46	75.11
Methylparothion						
M_1 (0.1%)	87.00	81.94	80.39	87.62	78.89	75.88
M_2 (0.15%)	84.20	86.31	81.52	79.25	84.47	81.02
M_3 (0.2%)	81.36	90.16	81.39	72.46	82.28	78.20

The values (%) are mean of three determinations.

6% respectively than that of control on 1st day after spray. Whereas on 7th day after spray RWC was found to be reduced by 3%, 6% and 4% respectively at P_1, P_2 and P_3 concentrations (0.02%, 0.04%, 0.06% phosphamidon respectively.

In methylparathion sprayed guar plants the reduction in RWC at M_1 (0.1% methylparathion) was observed both on 1st day after spray (1%) and on seventh day after spray (4%). Contrary to this at M_2 concentration RWC was increased by 5% on 1st day after spray and by 2% on 7th day after spray. Similarly at M_3 concentration (0.2% methylparathion) it was increased by 3% on 1st day after spray and decreased by 1% on 7th day after spray. From this it is very clear that higher concentrations of organophosphorus pesticides disfavour the water intake of plant. The reason why even K^+ uptake through the transpiration stream of water was found to be lower at higher concentrations of pesticidal spray (present investigation). As such there is positive correlation between relative water content and K^+ content (Lauchli and Pfluger, 1978).

C Stomatal response to organophosphorus pesticides

A number of pesticides are used in agriculture for protection against diverse pests. The residues left over the sprayed surface of crop plants have become a matter of concern with respect to health hazards to men and animals and environmental pollution (Finlayson and McCarthy, 1973). Methylparathion and phosphamidon an organophosphorus pesticides are widely used as an insecticide and the residual effect of these pesticides has been known to remain in the environment for a long time

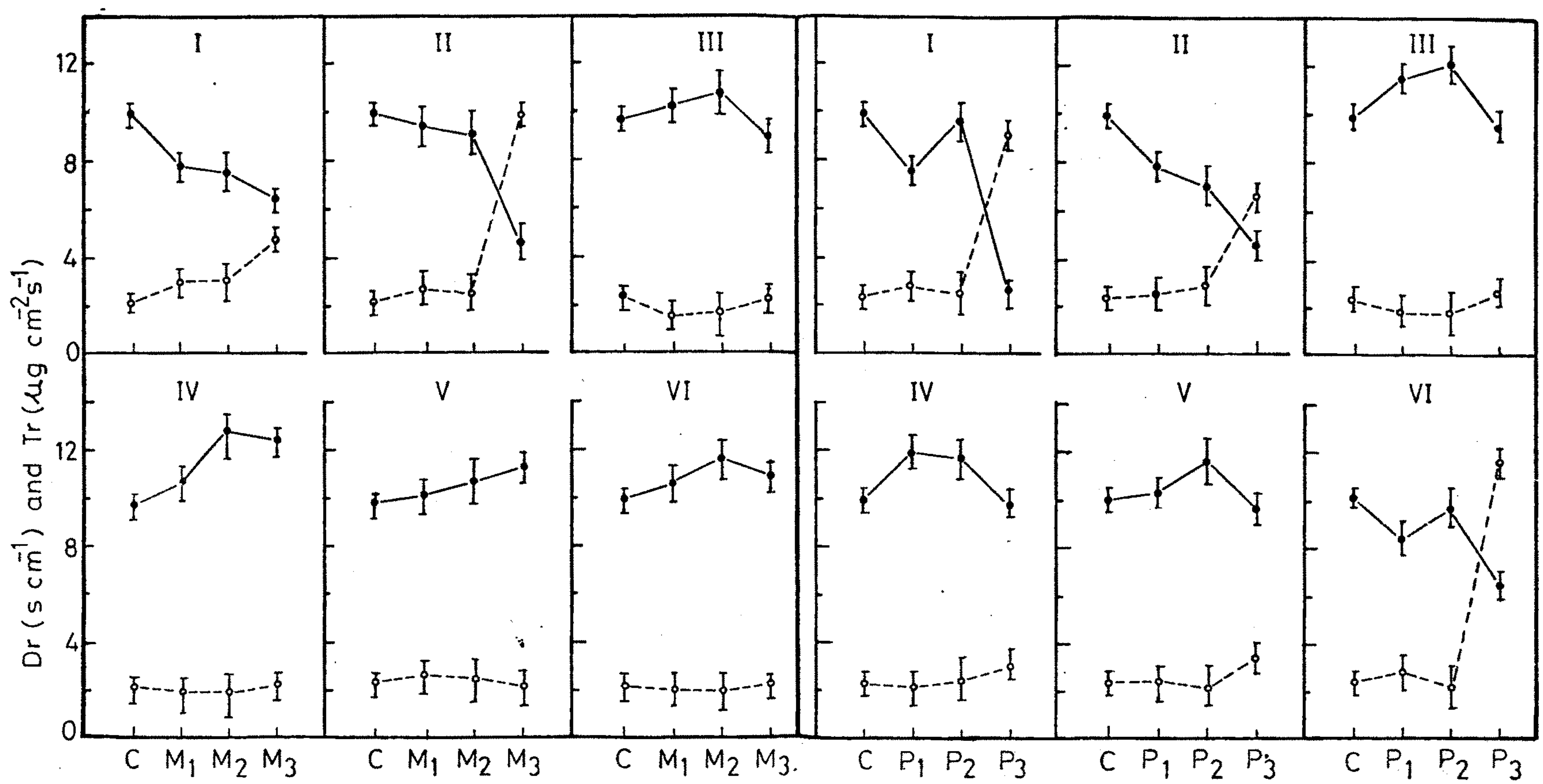
(Sharma and Chopra 1970, Deshpande and Swamy 1987). Residue level of any pesticide may affect the plant growth, stomatal regulation and metabolism. Since stomata play pivotal role in gaseous diffusion process, the effect of these insecticides as a spray on stomatal regulation in tomato, okra and guar plants was studied.

The response of diffusive resistance for water and transpiration rate in the leaves of tomato plants sprayed with methylparathion and phosphamidon is shown in fig. 4. The diffusive resistance and transpiration rate with the increase in concentration of methylparthion, indicated the stomatal closure in response to insecticidal spray. This effect was found more persistant on the second day in plants sprayed with 0.2% methylparthion. However on the third day, the stomatal regulation at higher concentration was similar to that of control plants. The comparative situation of stomatal parameters on the 3rd, 4th and 5th day after spray revealed that, after initial decrease in transpiration rate at all the concentrations of 1st and 2nd day of spray, there was a stimulation in transpiration rate in all the concentrations of methylparathion. However, from 5th day onwards the plants attained normal stomatal regulation in which the diffusive resistance and transpiration rates were very close to the control plants.

Contrary to this, stomatal behaviour was totally checked, immediate after one hour of 0.06% phosphamidon spray. This effect was slowly nullified on subsequent days. However, it favoured transpiration by decreasing diffusive resistance in the plants sprayed with 0.02% and 0.04% phosphamidon. Further at 6th day, transpiration was found

FIGURE - 4

Effect of differnt concentrations of methylparathion and phosphamison on diffusive resistance (DR) for water and transpiration rate (TR) in Lycopersicon esculentum leaves



●—● Transpiration rate (Tr), o---o Diffusive resistance for H_2O (Dr)

C — Control M — Metacid -50 P — Phosphamidon

$M_1 = 0{\cdot}1\%$, $M_2 = 0{\cdot}15\%$, $M_3 = 0{\cdot}2\%$ $P_1 = 0{\cdot}02\%$, $P_2 = 0{\cdot}04\%$, $P_3 = 0{\cdot}06\%$

Fig. 4

checked in 0.06% phosphamidon sprayed plants where symptoms of necrosis were observed. The necrosis appeared here was due to burning action of phosphomidon and not due to enhanced transpiration rate at 3rd, 4th and 5th day. However, the desiccation of leaves caused due to increase in transpiration rate by foliar application of herbicides such as 2,4,5-T and paraquat has been observed in woody weeds (Rao and Das, 1977) and in Parthenium hysterophorus (Patil and Hegde, 1986).

With the increase in concentrations of both methylparathion and phosphamidon the diffusive resistance for CO_2 was found increased (Table 3). However, the effect was more pronounced in phosphamidon sprayed plants. Further it was also noticed that the plants slowly attained normal diffusive resistance for CO_2 after six days of insecticidal spray. But the effect still persists at higher concentrations even after six days of methylparathion and phosphamidon spray. This clearly indicates that concentrations used above the recommended doses certainly affect the stomatal regulation and possibly bring constraint in the gaseous diffusion process. The data also suggest that changes in stomatal behaviour, brought in by insecticidal spray last for 6 days, but the higher concentrations may require few more days to attain normal behaviour. This can very well be correlated with the residual level left over the sprayed surface. As such residual content of methyl parathion and phosphamidon is known to remain in the environment for long time (Attri and Rattan Lal 1974, Rajukkannu et al. 1976, Deshpande and Swamy 1987) and then degraded slowly either due to high light intensity and temperature (Chattopadhyay, 1985) or through the metabolic process of plants.

Table 3 : Effect of different concentrations of phosphamidon and methylparathion foliar application on diffusive resistance (Dr) for CO_2 in *Lycopersicon esculentum* leaves.

Pesticides	(Diffusive resistance for CO_2 $S\ cm^{-1}$)					
	Immediate after 1 h spray	2nd day	3rd day	4th day	5th day	6th day
Control	1.44	(Average value for all 6 days)				
Phosphamidon						
P_1 (0.02%)	1.30	1.46	1.91	1.48	1.48	1.17
P_2 (0.04%)	1.69	1.64	1.94	1.44	1.49	1.40
P_3 (0.06%)	1.12	1.69	1.70	1.94	1.75	1.67
Methylparothion						
M_1 (0.1%)	1.19	1.48	1.43	1.52	1.36	1.32
M_2 (0.15%)	1.16	1.78	1.70	1.83	1.46	1.47
M_3 (0.2%)	1.0	1.51	1.51	1.80	1.61	1.53

The values ($S\ cm^{-1}$) are mean of three determinations at average humidity 36.25 ± 1.5%, Leaf temp. 30 ± 2°C and PAR 1900 $\mu E\ m^{-2} s^{-1}$

The stomatal behaviour under the influence of methylparathion and phosphamidon spray in guar is given in Table 4. It is very clear from the table that methylparathion induces stomatal closure which can be seen from increased diffusive resistance and decreased transpiration rate. When we assess the stomatal regulation at 0.1% methylparathion spray with the advancement of days, it appears that diffusive resistance slowly comes down and tries to attain normal level after 5th day of spray in case of upper surface. Whereas when we examine diffusive resistance of lower surface, initially we found increase in diffusive resistance than that of control. On second day after spray it was further increased and thereafter falls down to attain normal behaviour. This indicates that insecticidal spray causes temporary disturbances in stomatal behaviour and then recorrects it. The situation in 0.15% methylparathion spray was more or less the same as that in case of 0.1% spray, whereas at 0.2% methylparathion spray the plant showed highest value of diffusive resistance indicating thereby closure of stomata. This closing was certainly higher than that observed in earlier sprays. In this case, even after 5th day of spray plant has not showed normal functioning of stomata. This may possibly be due to the higher concentration used for spray.

The stomatal response to phosphamidon in guar plants is not much fascinating, except that with the increase in phosphomidon concentration there is increase in diffusive resistance of upper surface, while no much difference is observed in diffusive resistance of lower surface. The horizontal screening of stomatal regulation with the advancement of days after spray showed normal behaviour of the stomata irrespective of the concentrations used.

Table 4 : Effect of different concentrations of phosphamidon and methylparathion foliar spary on diffusive resistance (DR) and transpiration rate (TR) in <u>Cyamopsis tetragonoloba</u>.

Pesticide	Surface	Days after spray									
		1		2		3		4		5	
		DR	TR	DR	TR	DR	TR	DR	TR	DR	TR
Control	L	5.26	4.29	(Average value for 5 days)							
	U	5.12	4.44								
Phosphamidon											
P_1(0.02%)	L	5.66	3.91	3.64	5.62	4.21	4.99	3.84	3.56	3.84	3.56
	U	6.02	3.59	5.40	3.92	4.36	4.86	9.78	1.45	9.78	1.45
P_2(0.04%)	L	4.19	4.87	3.96	5.22	5.39	3.97	3.74	3.69	3.74	3.69
	U	15.16	1.96	5.11	4.08	5.59	3.87	5.59	2.87	5.62	2.85
P_3(0.06%)	L	4.66	4.06	3.12	6.27	2.53	8.86	3.07	4.42	3.07	4.40
	U	16.24	1.30	6.04	4.80	2.84	7.85	6.98	1.99	4.22	4.12
Methylparathion											
M_1 (0.1%)	L	10.95	2.22	42.45	0.67	4.45	5.17	3.89	3.48	3.89	3.48
	U	78.33	0.31	77.35	0.43	6.05	2.43	14.70	0.94	14.70	0.94
M_2 (0.15%)	L	11.76	1.77	3.82	5.30	2.63	2.63	2.65	5.21	3.41	6.92
	U	44.96	0.84	12.25	2.05	7.97	9.78	2.20	5.61	2.58	7.19
M_3 (0.2%)	L	28.80	1.35	86.82	0.09	17.27	0.82	2.47	5.38	2.49	5.45
	U	58.16	0.39	120.00	0.04	51.16	0.48	10.80	1.29	10.90	1.25

The values of DR ($S\ cm^{-1}$) and TR ($ug\ cm^{-2}s^{-1}$) are the means of three determinations at average humidity 36.2 ± 1.5%, Leaf temp. 30 ± 2°C and PAR 1900 $\mu\ Em^{-2}s^{-1}$.

The values of diffusive resistance for CO_2 calculated by summing the reciprocals of diffusive resistance and multiplying by the factor 1.65 (Jarvis, 1971) are given in Table 5. It is clear from the table that there is almost more than three times increase in diffusive resistance for CO_2 at 0.1% and 0.15% and more than 7 times at 0.2% methylparathion spray in guar over control. This increase was corrected by the plants at lower concentrations of methylparathion with the advancement of days after spray within 2 days. Whereas they required more time to recorrect it at higher concentration (0.2%) of methylparathion spray. Contrary to this stomatal behaviour was not much disturbed by the phosphamidon spray.

The diffusive resistance and transpiration rate studied under the influence of pesticides in okra is given in Table 6. The data depicted in table clearly shows that higher concentrations viz. 0.15% and 0.2% of methylparathion have caused increase in diffusive resistance of upper surface and with the advancement of days after spray, the values reached to a normal level after 5th day of spray. Highest diffusive resistance was noted at 0.2% methylparathion spray. This is obvious because plants do not cope up with the stronger dose of pesticides and in order to survive they adopt themselves by closing the stomata. This results into an increase in diffusive resistance and decrease in transpiration rate. However, in phosphamidon sprayed plants no much difference was observed in diffusive resistance and transpiration rate as compared to control. However, highest concentration has shown increase in the diffusive resistance of upper surface upto 4th day after spray and later on it was corrected with the advancement of days.

Table 5 : Effect of different concentrations of phosphamidon and methylparathion foliar spray on diffusive resistance (Dr) for CO_2 in <u>Cyamopsis tetragonolobo</u>.

Pesticides	Days after spray				
	Immediate after 1 h	2nd	3rd	4th	5th
Control	1.61	(Average value for 5 days)			
<u>Phosphamidon</u>					
P_1 (0.02%)	1.82	1.35	1.33	1.72	1.72
P_2 (0.04%)	1.69	1.39	1.71	1.39	1.39
P_3 (0.06%)	2.26	1.28	0.84	1.33	1.11
<u>Methylparathion</u>					
M_1 (0.1%)	6.02	17.24	1.61	1.91	1.91
M_2 (0.15%)	5.81	1.82	1.23	2.21	1.74
M_3 (0.2%)	12.19	31.44	8.06	1.25	

The values of Dr ($S\ cm^{-1}$) are mean of three determinations at average humidity 36.2 ± 1.5%, Leaf temp. 30 ± 2°C and PAR 1900 $\mu E\ m^{-2}\ s^{-1}$.

Table 6 : Effect of different concentrations of phosphamidon and methylparathion foliar spary on diffusive resistance (DR) and transpiration rate (TR) in <u>Abelmoschus esculentus</u>.

Pesticide	Surface	Days after spray									
		1		2		3		4		5	
		DR	TR	DR	TR	DR	TR	DR	TR	DR	TR
Control	L	1.87	10.08	(Average value for 5 days)							
	U	2.61	7.67								
Phosphamidon											
P_1(0.02%)	L	1.53	12.52	1.86	9.61	2.21	9.08	2.71	5.56	1.69	11.065
	U	3.44	7.06	8.14	3.95	12.78	2.79	6.70	2.50	5.79	5.505
P_2(0.04%)	L	3.25	7.22	2.17	8.90	2.40	8.26	3.08	4.57	2.71	3.06
	U	3.46	6.07	3.27	5.78	3.71	6.00	6.13	2.46	3.36	5.92
P_3(0.06%)	L	2.86	7.11	2.13	8.63	2.02	9.54	3.64	11.38	2.51	7.87
	U	4.62	4.42	4.63	3.96	8.09	8.79	13.30	1.12	4.62	4.19
Methylparathion											
M_1 (0.1%)	L	6.63	3.74	1.98	8.08	2.22	9.54	2.01	9.71	2.11	9.62
	U	19.46	1.25	23.64	1.89	14.46	3.31	4.77	4.74	3.9	7.28
M_2 (0.15%)	L	4.99	4.11	2.00	8.87	2.81	8.14	1.93	9.02	2.37	8.58
	U	25.36	0.82	26.56	0.28	16.80	3.56	3.44	5.22	5.11	4.39
M_3 (0.2%)	L	28.80	4.94	2.58	7.34	2.14	9.48	2.27	6.12	2.20	7.80
	U	58.16	0.27	31.44	1.16	4.31	4.95	3.99	4.19	4.15	4.57

The values of DR (S cm^{-1}) and TR (ug $cm^{-2}s^{-1}$) are the means of three determinations at average humidity 36.2 ± 1.5%, Leaf temp. 30 ± 2°C and PAR 1900 μ $Em-2_s-1$.

The diffusive resistance for CO_2 in okra calculated by using the formula of Jarvis (1971) is given in Table 7. It is vividly clear that the diffusive resistance for CO_2 is increased with the increasing concentrations of pesticides. The maximum increase was observed in methylparathion sprayed plants than that of phosphamidon sprayed one. When we scale diffusive resistance for CO_2 with the advancement of days it appears that diffusive resistance of CO_2 slowly comes down and attains the normal level on 5th day after spray. The effect was retained more at higher concentrations of pesticides. Among the two pesticides studied methyl parathion appeared more effective in increasing the diffusive resistance in okra plant.

Based on the information obtained from studies on stomatal physiology several chemicals were successfully employed to regulate the water requirements of plants. The suppression of stomatal opening reduces the water needs of plants while enhanced stomatal opening on the other hand leads to increased transpiration and desiccation (Das,1977). Paraquat and 2,4,5-Trichlorophenoxyacetic acid (2,4,5-T) are some examples of herbicides which kill the plants by enhancing transpirational water loss by forced opening of the stomata (Rao et al.,1977). Stomatal behaviour also formed the basis of sensitivity of weeds to herbicides. Thiocarbamates (EPTC and molinate) inhibited transpiration in C_4 crop plants and resulted in their better water management. The transpiration in C_3 weeds was enhanced by thiocarbamates leading to their desiccation and death (Das and Santakumari, 1975). Thus under crop weed association, thiocarbamate compounds are extremely useful in promoting growth of plants alone.

Table 7 : Effect of different concentrations of phosphamidon and methylparathion foliar spray on diffusive resistance (Dr) for CO_2 in <u>Abelmoschus</u> <u>esculentus</u>.

Pesticides	Days after spray				
	Immediate after 1 h	2nd	3rd	4th	5th
Control	0.69	(Average value for 5 days)			
<u>Phosphamidon</u>					
P_1 (0.02%)	0.66	0.946	1.17	1.20	0.82
P_2 (0.04%)	1.04	0.81	0.91	1.28	0.93
P_3 (0.06%)	1.11	0.91	1.00	1.78	1.01
<u>Methylparathion</u>					
M_1 (0.1%)	3.08	1.14	1.19	0.88	0.85
M_2 (0.15%)	2.60	1.86	1.49	0.77	1.00
M_3 (0.2%)	12.00	2.38	0.87	0.90	0.89

The values of Dr (S cm^{-1}) and TR (ug $cm^{-2}s^{-1}$)are the means of three determinations at average humidity 36.2 ± 1.5%, Leaf temp. 30 ± 2°C and PAR 1900 $\mu E\ m^{-2}\ s^{-1}$.

The compounds which reduce transpiration and improve water efficiency of plants are known as antitranspirants (Das and Raghavendra, 1979). Several herbicides such as alachlor, butachlor reduced transpiration by restricting stomatal opening. Alachlor even improved the yield of maize plants inspite of reduction in transpiration (Santakumari et al., 1977). All these above observations hold good for insecticidal spray, where stomatal closing was observed. Apart from this the maximum increase in diffusive resistance was noticed at higher concentration of insecticidal sprays, because of which transpiration rate was arrested. However, at lower concentration, though the transpiration rate was arrested initially, it was corrected later on by the plants and the overall growth under lower concentrations (0.1% and 0.15% in case of methylparathion and 0.02% and 0.04% in case of phosphamidon) was found to be good.

Thus in agronomic point of view, present investigation conveys that organophosphorus insecticides should always be used either in the recommended concentrations or in the below recommended concentrations for these vegetable crops. Little ignorance in the use of concentrations above the recommended doses may seriously affect the plant metabolism and would cause environmental pollution by persisting residual problem. Further study in detail is required to establish plant and pesticidal relationship with respect to stomatal regulation.

D. Influence of organophosphorus pesticides on organic constituents

Response of organic constituents to foliar application of organophosphorus pesticides viz. methylparathion and phosphamidon has been studied in tomato, okra and guar. The organic constituents studied are chlorophylls, polyphenols and carbohydrates.

1. Total chlorophylls :

The total chlorophyll content was analysed on 1st and 7th day after spray and tabulated in Table 8. It is clear from the table that in tomato the chlorophyll content was increased by 16.4% and by 107.62% on 1st and 7th day after spray respectively at P_1 (0.02%) concentration. At P_2 (0.04%) chlorophyll content on 1st day after spray was reduced by 1.18% while it was increased by 84.58% on 7th day after spray. Contrary to this at P_3 (0.06%) concentration the chlorophyll content was reduced by 17.42% and by 21.49% respectively on 1st and 7th day after spray. Thus the data clearly indicates that lower concentration of phospha midon (0.02%) stimulates chlorophyll synthesis while inhibits at higher concentration (0.06%).

Influence of foliar application of methylparathion on chlorophyll content in tomato plant revealed that there was reduction at M_1 (0.1%) concentration by 4.4% on 1st day after spray and stimulation by 43.96% on 7th day after spray. Similarly a drastic reduction was observed at M_3 (0.2%) concentration on 1st day by 15.08% as compared to control. M_2 (0.15%) concentration appeared to be favourable for chlorophyll synthesis both on first day and on seventh day after spray. The increase in chlorophyll content above the control was 3.07% and 97.22% on 1st and 7th day after spray respectively.

Table 8 : Effect of different concentrations of phosphamidon and methylparathion foliar application on total chlorophyll content in the leaves of tomato, okra and guar plants.

Pesticides	Tomato Analysis after		Okra Analysis after		Guar Analysis after	
	1st day	7th day	1st day	7th day	1st day	7th day
Control	193.55	(Average)	147.48	(Average)	187.16	(Average)
Phosphamidon						
P_1 (0.02%)	225.38	401.86	110.55	114.43	157.23	212.40
P_2 (0.04%)	191.26	357.26	183.32	149.68	163.04	202.24
P_3 (0.06%)	159.84	151.94	139.36	111.13	160.13	207.32
Methylparothion						
M_1 (0.1%)	185.03	278.64	156.07	155.68	118.29	204.61
M_2 (0.15%)	199.51	381.72	154.97	149.74	264.33	173.99
M_3 (0.2%)	164.36	284.29	137.16	150.21	188.97	204.58

The values (mg 100^{-1}g fresh tissue) are mean of three determinations.

In okra the control value for chlorophylls was 147.48 mg 100^{-1} g fresh wt. It has been reduced by 25.04% and 22.40% respectively on 1st and 7th day after spray at P_1 (0.02%) concentration. Similarly the reduction in chlorophyll content was also noted on 1st day as well as on 7th day after spray at P_3 (0.06%) concentration. Whereas P_2 (0.04%) concentration appeared to be favourable for chlorophyll synthesis. Here the increase was 24.30% and 1.49% respectively on 1st and 7th day after spray.

When we compare methylparahion sprayed okra plants with control for chlorophyll content, it appeared that M_1 and M_2 (0.1% and 0.15% respectively) concentrations have little stimulation in chlorophyll synthesis on 1st and 7th day after spray whereas M_3 (0.2%) concentration was found to be inhibitory. Though M_3 concentration showed increase in chloro phyll synthesis on 7th day after spray, it is not significant. This clearly indicates that higher concentrations of methylparathion and phosphamidon inhibit chlorophyll synthesis.

In guar none of the phosphamidon concentrations have shown increase in chlorophyll synthesis on 1st day after spray when compared to control. But on seventh day after spray all P_1, P_2, P_3 concentrations (0.02%, 0.04% and 0.06% respectively) showed increase over control by 13.48%, 8.06% and 10.77% respectively. In case of methylparathion M_1 (0.1%) concentration on 1st day did not show increase in chlorophyll content whereas M_2 and M_3 concentrations (0.15% and 0.2% respectively) did show. This increase was 41.23% and 0.97% respectively on 1st day after spray. The chlorophyll content in M_1 and M_3 concentrations (0.1%

and 0.2% respectively) was almost same while in M_2 (0.15%) it was reduced by 7.04% over control on 7th day after spray.

From the above results one thing is clear that lower concentrations stimulate chlorophyll synthesis while higher concentrations inhibit it. Secondly chlorophyll content when analysed on 1st day showed reduction in chlorophyll content and then slowly it was increased with the advancement of days after spray. This indicates that insecticide may slowly absorb in the leaf tissue either by symplastic movement through the living tissue or by apoplast movement through cuticular tissue and then possibly it governs the metabolic activities in the plant such as increase in chlorophyll content.

2. Polyphenols :

The polyphenol content from pesticide sprayed leaves of tomato, okra and guar is given in Table 9 and represented histographically in figs. 5 and 6.

It is clear from the figures that with the increasing concentration of phosphamidon, the polyphenol content was found to be increased over control on 7th day after spray in tomato. While in okra and guar the trend is reverse than that of tomato where the phenolic contents were increased on first day after spray over control with the increasing concentration of phosphamidon (Fig. 5).

The polyphenol content in methylparathion sprayed tomato plants (Fig. 6) revealed marked increase in phenol level on seventh day after

Table 9 : Effect of different concentrations of phosphamidon and methylparathion foliar application on polyphenol content in the leaves of tomato, okra and guar plants.

Pesticides	Tomato Analysis after		Okra Analysis after		Guar Analysis after	
	1st day	7th day	1st day	7th day	1st day	7th day
Control	0.664	(Average)	0.514	(Average)	1.189	(Average)
Phosphamidon						
P_1 (0.02%)	0.54	0.80	0.80	0.87	1.40	1.02
P_2 (0.04%)	0.63	1.15	0.88	0.40	1.54	1.15
P_3 (0.06%)	0.80	1.0	0.45	0.55	1.47	1.08
Methylparothion						
M_1 (0.1%)	0.57	0.72	0.50	0.32	1.14	1.15
M_2 (0.15%)	0.45	1.37	0.40	0.37	1.16	1.14
M_3 (0.2%)	0.59	1.20	0.92	0.61	1.09	1.10

The values (g/100 g fresh tissue) are mean of three determinations.

FIGURE - 5

Effect of different concentrations of phosphamidon on polyphenol content in the leaves of tomato, okra and guar

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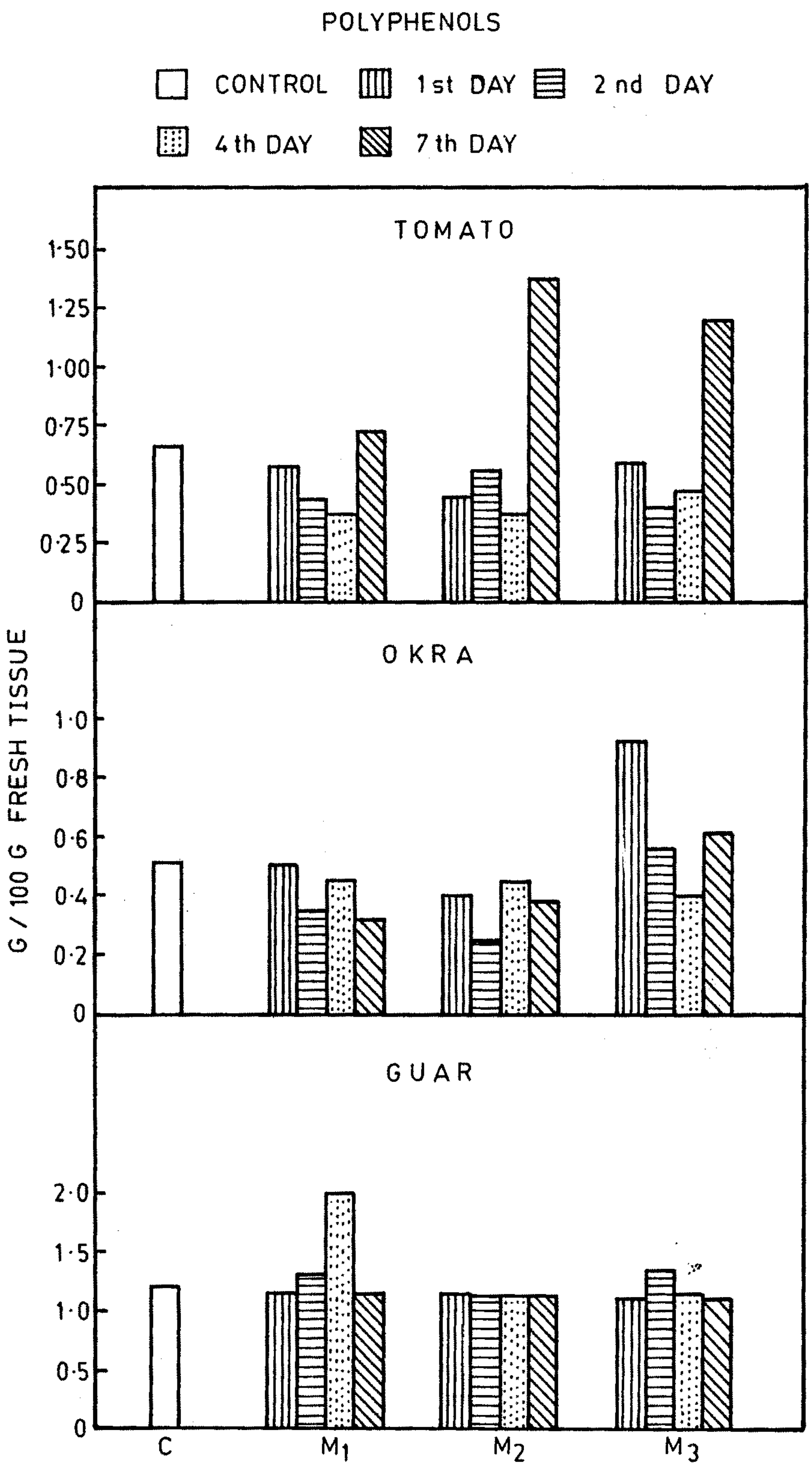
POLYPHENOLS
CONTROL
1st DAY
2nd DAY
4th DAY
7th DAY
TOMATO
1·50
1·25
1·00
0·75
0·50
0·25
0
OKRA
1·0
0·8
0·6
0·4
0·2
0
GUAR
2·0
1·5
1·0
0·5
0
G / 100 G FRESH TISSUE
C
M1
M2
M3

Fig. 5

FIGUR - 6

Effect of different concentrations of methylparathion on polyphenol content in the leaves of tomato,okra and guar

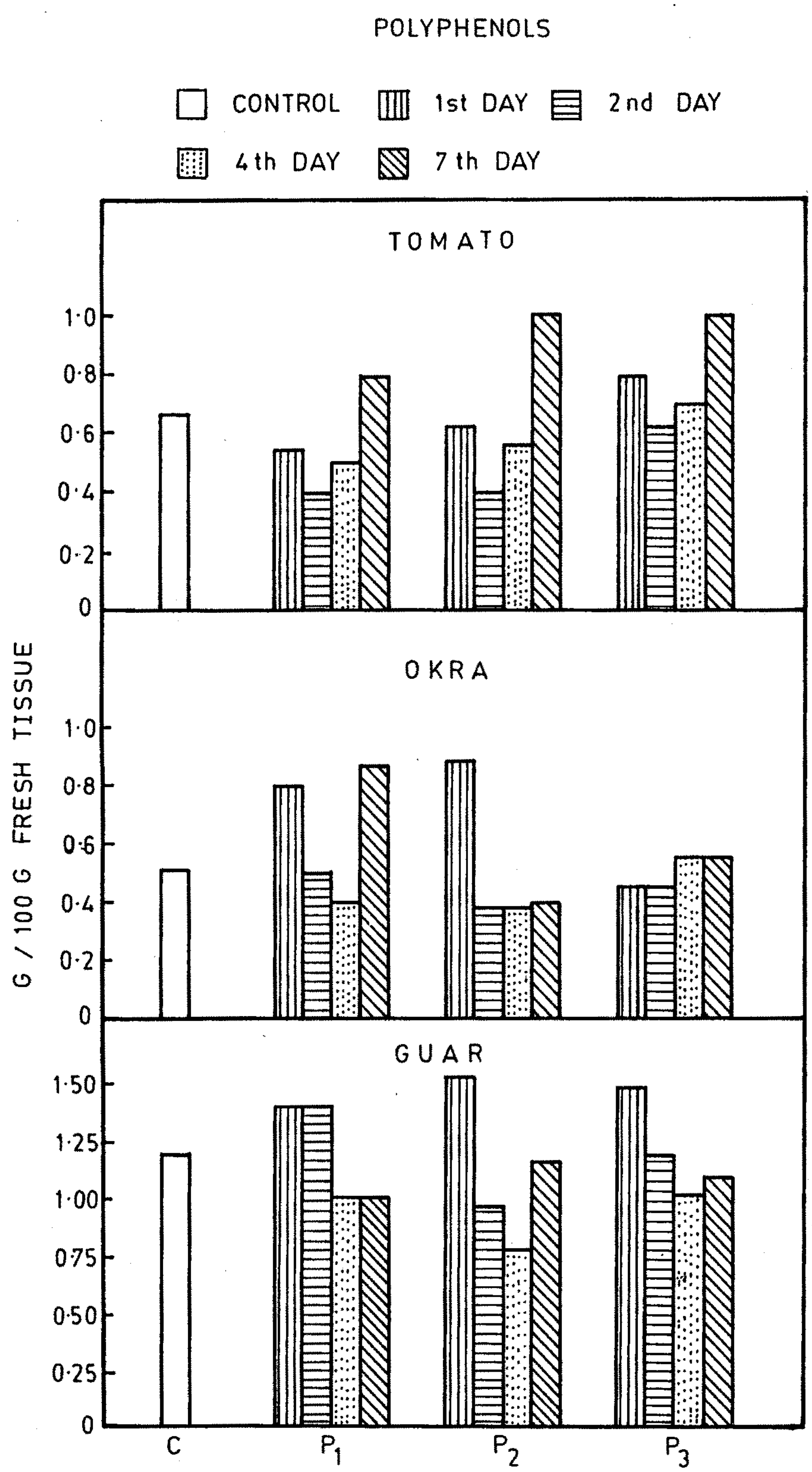
POLYPHENOLS
CONTROL
1st DAY
2nd DAY
4th DAY
7th DAY
TOMATO
OKRA
GUAR
G / 100 G FRESH TISSUE
1·0
0·8
0·6
0·4
0·2
0
1·50
1·25
1·00
0·75
0·50
0·25
C
P1
P2
P3

Fig.6

spray in all the concentrations used. The maximum being noted at M_2 concentration (0.15%). However, in okra and guar no significant increase in polyphenol content over control was observed.

Generally accumulation of polyphenols acts as a mechanism of resistance against the pathogen (Wang, 1961). Similarly there are several reports that phenol accumulation takes place in all infected plants (Farkas and Kiraly, 1962; Parthasarathy et al., 1970; Prasad and Sahambi, 1980; Arya et al. 1981; Srinivasan, 1983). In the present investigation we have observed that all the concentrations of methylparathion and phosphamidon used for spray on tomato, okra and guar favoured polyphenol synthesis. Moreover lower concentrations of both the pesticides worked good in case of tomato plant in stimulating polyphenol content.

With this situation, if we accept the view of Wang (1961) then we may safely say that because of the stimulation of polyphenols by lower concentrations of these insecticides there may not be fungal attack on these plants or in other words the plant become resistant to pathogen attack. However, it needs further study to elucidate plant pathogen and polyphenol relationship under the influence of pesticidal spray. At present we can only say that stimulation of polyphenol by these insecticides may possibly develop resistance against pathogen too.

3 Carbohydrates

a) Reducing sugars :

The values of reducing sugars analysed from the tomato plants indicate that lower concentration of phosphamidon (0.02%) stimulate reducing sugar synthesis whereas higher concentration inhibit it (Table 10) Similarly in case of methylparathion, sprayed plants, the reducing sugar level was found to be increased over control both on first and seventh days after spray at 0.1% concentration. In case of 0.15% (M_2) and 0.2% (M_3) concentrations, the values of reducing sugars decreased on 1st day after spray as compared to control but increased when analysed on 7th day after spray. In case of 0.2% methylparathion spray this increase was more than double than that of control.

In okra, not much significant increase in sugar level was noted both at P_1 and P_2 concentration sprayed plants on 1st day (Table 10). Little increase over control was seen in case of P_2 concentration on 7th day. But drastic increase was noted at P_3 concentration sprayed plants on 1st and 7th days after spray.

In case of M_1 concentration sprayed okra plants, decrease in sugar level was seen on 1st day as compared to control however, it was increased with the advancement of days after spray. This increase was about 1.5 times more as compared to control. But the trend observed at M_1 was exactly reverse in case of M_2 and M_3 concentrations.

In guar plants phosphamidon spray stimulated the sugar level both on 1st and 7th days after spray over control (Table 10). This increase was 2.77, 2.53 and 2.65 times more over control respectively at P_1, P_2 and P_3 concentrations. Contrary to this methylparathion spray failed to stimulate level of reducing sugar in these plants except lower concentration (0.1%) had little stimulation on 7th days after spray.

Table 10 : Effect of different concentrations of phosphamidon and methylparathion foliar application on reducing sugar content in the leaves of tomato, okra and guar plants.

Pesticides	Tomato Analysis after 1st day	Tomato Analysis after 7th day	Okra Analysis after 1st day	Okra Analysis after 7th day	Guar Analysis after 1st day	Guar Analysis after 7th day
Control	1.18	(Average)	0.058	(Average)	0.090	(Average)
<u>Phosphamidon</u>						
P_1 (0.02%)	1.65	2.30	0.063	0.05	0.11	0.25
P_2 (0.04%)	1.00	1.75	0.063	0.10	0.125	0.228
P_3 (0.06%)	0.45	0.70	0.40	0.40	0.119	0.239
<u>Methylparothion</u>						
M_1 (0.1%)	1.30	1.6	0.038	0.088	0.075	0.11
M_2 (0.15%)	0.06	1.19	0.075	0.038	0.05	0.055
M_3 (0.2%)	0.85	2.70	0.10	0.063	0.060	0.070

The values (g/100 g fresh tissue) are mean of three determinations.

b) Starch :

Starch content analysed from phosphamidon and methylparathion sprayed tomato, okra and guar plants is given in Table 11.

The values of starch content in tomato clearly show that there is no increase in starch content on 1st and 7th days after spray in case of P_1 concentration. In case of P_2 and P_3 concentrations increase in starch content was observed on first day after spray. But it was decreased on 7th day as compared to first day. This pattern was more or less the same in case of methylparathion sprayed tomato plants. Little increase over control was observed in case of M_2 and M_3 concentrations on first day. But on seventh day the starch content was below the control level in all the concentrations of methylparathion.

In case of okra all the three concentrations selected for spray have stimulated the starch content on 7th day after spray over control. In case of P_1 and P_2 concentrations starch content of first day is found below the control level. But in case of P_3 concentration drastic increase was found on the first day. This increase was 1.59 times more over control. But the pattern is reverse in case of methylparathion sprayed plants. In case of M_1 and M_2 concentrations the level of starch was found to be increased over control on first day and it showed decrease on 7th day after spray. Only in case of M_3 concentration the level of starch is found to be decreased as compared to control. On first day and on seventh day after spray it was slightly stimulated over control.

Table 11 : Effect of different concentrations of phosphamidon and methylparathion foliar application on starch content in the leaves of tomato, okra and guar plants.

Pesticides	Tomato Analysis after		Okra Analysis after		Guar Analysis after	
	1st day	7th day	1st day	7th day	1st day	7th day
Control	4.71	(Average)	6.44	(Average)	10.76	(Average)
<u>Phosphamidon</u>						
P_1 (0.02%)	4.3	3.18	3.76	15.80	15.05	5.51
P_2 (0.04%)	5.09	2.55	4.98	13.57	13.73	10.07
P_3 (0.06%)	7.56	5.02	10.28	13.68	14.39	7.79
<u>Methylparothion</u>						
M_1 (0.1%)	4.68	1.56	8.68	4.98	17.68	8.86
M_2 (0.15%)	4.79	2.56	6.89	3.55	14.52	6.45
M_3 (0.2%)	4.98	4.55	5.61	8.53	16.40	9.25

The values (g/100 g dry tissue) are mean of three determinations.

In case of guar, phosphamidon spray has shown stimulation of starch content on first day after spray in all the three concentrations over control. But the level was found decreased on 7th day after spray. The pattern is same in case of methylparathion sprayed plants. Here also all the three concentrations have shown stimulation of starch content over control on first day. However, on seventh day after spray it was below the control level.

In general no consistency in the carbohydrate content of all these plants under pesticidal spray was noted. This is possibly because most of the time during analysis of sugar by using alkaline copper tartarate and arsenomolybdate reagent the assay mixture either developed precipitate or it could not develop proper colour to measure the absorbance on spectrophotometer at 560 nm wavelength. This problem was evoked only with the pesticide sprayed plants and not with control (non sprayed) plants. This has prompted us to argue that possibly these pesticides bring constraint in the event of sugar analysis by interfering the reactions taking place in the development of colour. This is obvious because most of the organophosphorus insecticides undergo fast decomposition at pH 8 to 9 and the reagent alkaline copper tartarate used to detect sugars itself is highly alkaline and it might be reacting with the insecticide present in the leaf tissue as a residue.

This requires further experimentation.

E. Mineral nutrition status of leaf tissue in response to foliar application of organophosphorus insecticides

Plant nutrition is by and large concerned with the provision of plants with nutrients as well as nutrients uptake and their distribution in plants. The essential nutrients required by higher plants are exclusively of inorganic nature. The supply and absorption of these inorganic constituents is needed for growth and metabolism. However, many a times plants have to face some unfavourable conditions like water and salt stress, pollution stress, disease stress etc. during which the possibility of disturbances in mineral nutrition cannot be ruled out. Moreover, in order to overcome pest and disease attack, plants are oftenly subjected to pesticidal treatment. Sometimes, they are used in above recommended doses without knowing their danger. Under such circumstances it is thought worthwhile to check up the nutrient budget in the leaf tissue of vegetables like tomato, okra and guar.

This has been attempted by spraying different concentrations of organophosphorus pesticides viz. methylparathion (metacid-50) and phospha midon (dimecron). Elemental composition analysed after 1st, 2nd, 4th and 7th day of spray is discussed below.

1. Sodium (Na^+)

Though Na^+ is generally not required by green plants, the recent work reports that Na^+ contributes to the osmotic potential of cell and thus has a positive effect on the water regime of plants (Mengel and Kirkby, 1982). Hence it was analysed.

The values of Na^+ content are represented histographically in fig. 7. The data in general revealed that phosphamidon spray on tomato plant stimulated Na^+ uptake at all the concentrations on 1st day after spray. Na^+ content at 0.02% phosphamidon spray on first day after spray was almost double than that of control. While it was reduced with increasing concentrations of phosphamidon but the reduction in Na^+ content was not below the control level. When we look towards Na^+ uptake with the advancement of days after spray, the situation at 0.04% and 0.06% spray was more or less the same where even at 7th day after spray Na^+ uptake was more as compared to 2nd and 4th day after spray.

The pattern of Na^+ uptake in methylparathion sprayed tomato plants revealed that, like that of phosphamidon, methylparathion also enhanced Na^+ uptake over control at 0.1% spray when analysed on 1st day after spray. But at 0.15% and 0.2% spray Na^+ uptake was stimulated on second day after spray and the maximum level was found in plants sprayed with 0.2% methylparathion. This clearly indicated that both the pesticide sprays favoured Na^+ intake of which phosphamidon contributed more for it.

In okra both phosphamidon and methylparathion sprays have not shown any enhancement in Na^+ uptake. But very little stimulation over control was noticed on second and fourth day after spray in all the concentrations of phosphamidon and methylparathion. This may possibly be due to presence of mucilage in the plant tissue.

FIGURE - 7

Effect of different concentrations of phosphamidon and methylparathion on Na^{+} content in the leaves of tomato, okra and guar

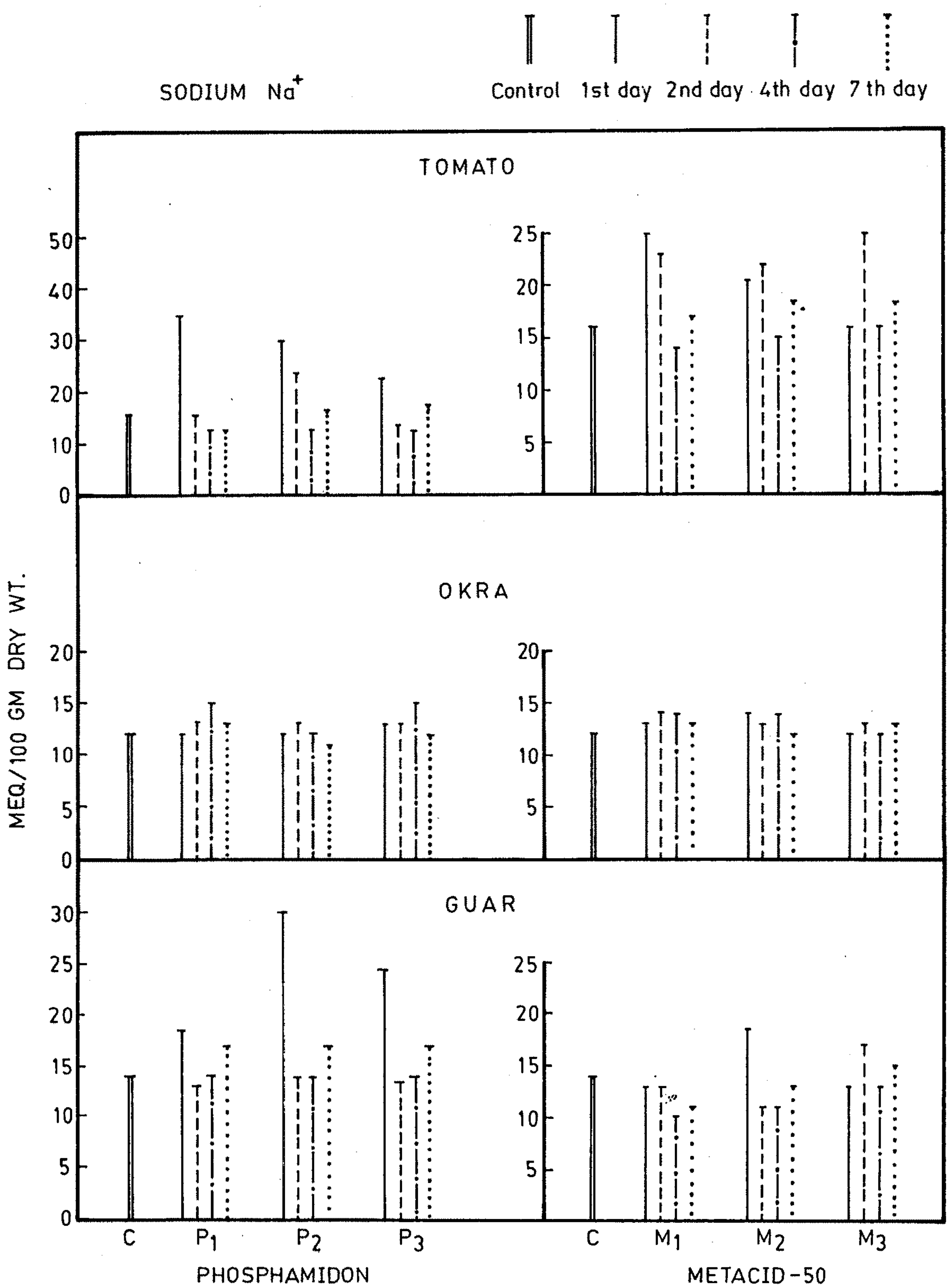
SODIUM Na⁺
Control
1st day
2nd day
4th day
7 th day
TOMATO
OKRA
GUAR
MEQ/100 GM DRY WT.
C
P1
P2
P3
PHOSPHAMIDON
M1
M2
M3
METACID-50

Fig.7

The stimulation of Na^+ intake in guar was found appreciably more at 0.04% phosphamidon spray, on 1st day. From the data it is very clear that phosphamidon appeared to be more favourable pesticide for guar in maintaining osmotic potential by absorbing more Na^+. This is possible only when we select 0.04% concentration for spray. 0.02% spray also shows the same pattern. But use of lesser concentration needs to probe in studying threshold requirement of Na^+ to maintain proper turgor in plant tissue of guar. Among the three concentrations used, 0.15% methyl-parathion appeared to be favourable for Na^+ uptake by the guar plants whereas no much response was shown by these plants when sprayed with 0.1% methylparathion. Even with 0.2% methylparathion spray, guar showed stimulation in Na^+ uptake at 2nd day after spray. This indicates the sturdyness of guar plants to withstand high dose of pesticide.

2. Potassium (K^+)

It is an essential element for all living organisms and is the most important cation not only in regard to its content in plant tissue but also with respect to its physiological and biochemical functions. Histograms represented in fig. 8 indicate the level of K^+ in leaf tissue of tomato, okra and guar at the different concentrations of phosphamidon and methylparathion.

It is very clear from the histogram that K^+ uptake is stimulated by all the concentrations of phosphamidon and methylparathion in tomato plants. However the maximum uptake was noticed on the second day after spray at 0.04% phosphamidon and at 0.15% methylparathion. This clearly indicates that these two concentrations of both the insecticides

FIGURE - 8

Effect of different concentrations of phosphamidon and methylparathion on K^+ content in the leaves of tomato, okra and guar

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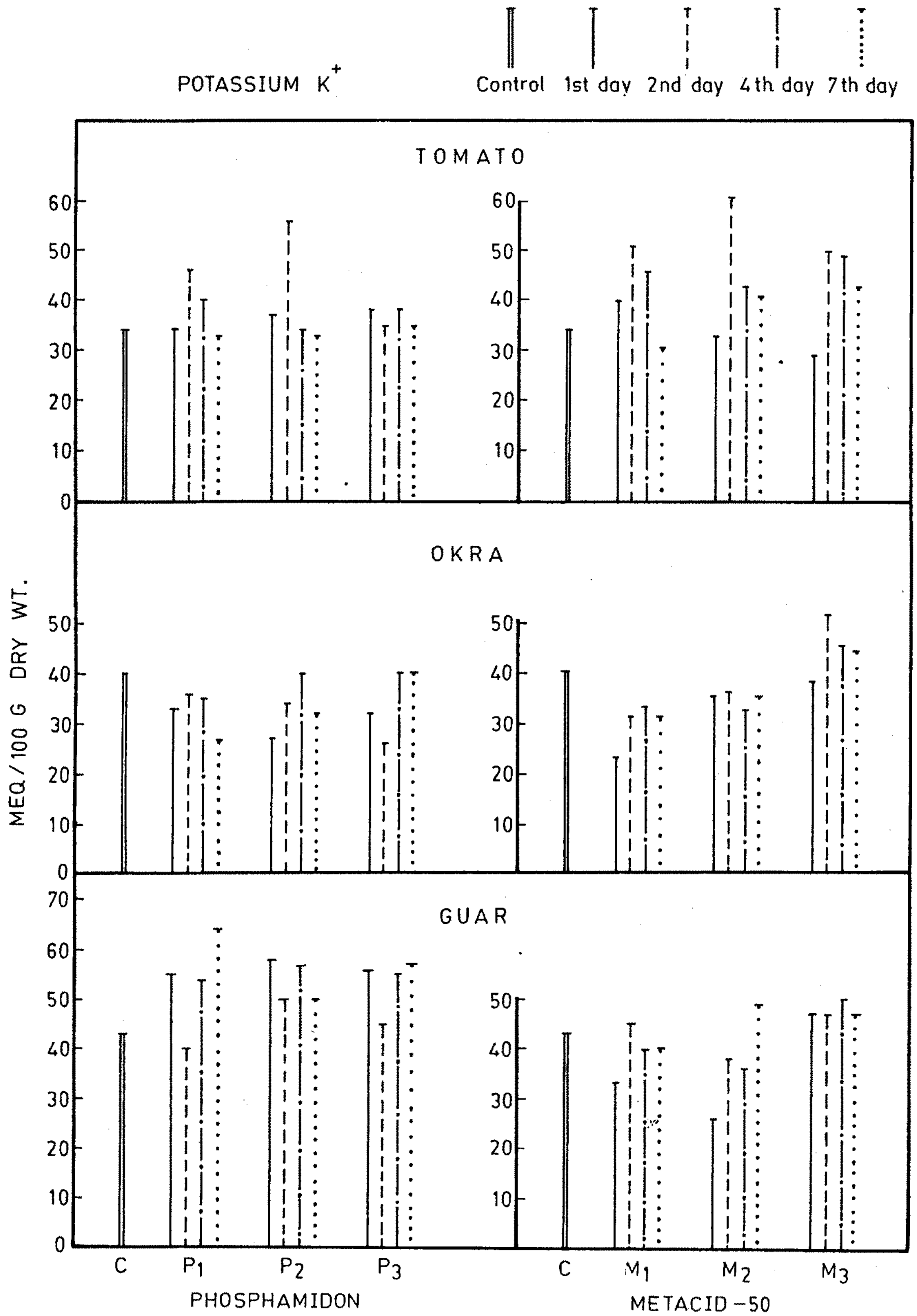
POTASSIUM K+
Control
1st day
2nd day
4th day
7th day
TOMATO
OKRA
GUAR
MEQ / 100 G DRY WT.
0
10
20
30
40
50
60
70
C
P1
P2
P3
PHOSPHAMIDON
C
M1
M2
M3
METACID -50

Fig.8

favour K^+ uptake. Increase in K^+uptake was 64.70% over control in 0.04% phosphamidon sprayed plants while it was 79.41% in 0.15% methylparathion sprayed tomato plants on 2nd day after spray. From this it is clear that recommended concentration of methylparathion works good for tomato plant as far as K^+ uptake is concerned. When we look towards higher concentrations (above recommended dodes) inhibition of K^+ uptake was found in phosphamidon sprayed plants as compared to methylparathion one. When we scale K^+ content with the advancement of days after spray, level of K^+ was declined which possibly be attributed to the residual content of pesticides. However this observation holds good for phosphamidon and not for methylparathion. Another interesting point observed here was that, in none of the cases K^+ uptake has gone down below control level.

The situation of K^+ uptake in okra was found to be altogether different than that of tomato. Here none of phosphamidon as well as methylparathion concentrations have stimulated K^+ uptake. All the K^+ values observed in okra under both the pesticidal spray, were below the control level except at 0.2% methylparathion sprayed plants where second, fourth and seventh day after spray showed more K^+ uptake.

Like that of tomato all the concentrations of phosphamidon showed efficient uptake of K^+ in guar plants. Whereas not much difference was observed in methylparathion sprayed plants. However, little enhancement in K^+ uptake at 0.2% methylparathion sprayed plants was noticed.

The data in general reveals that lower concentrations of both the pesticides favour K^+ uptake. Inhibition of K^+ uptake in okra possibly be due to mucilage content in the leaf tissue. K^+ is of utmost importance for water status of plants. Higher K^+ uptake may be attributed to RWC of the leaves of tomato, okra and guar. As such uptake of water in cells and of tissue is frequently the consiquence of active K^+ uptake. (Lauchli and Pfluger, 1978). Low water loss of plants well supplied with K^+ is due to a reduction in transpiration rate (Brag, 1972), which not only depends upon the osmotic potential of mesophyll cells but also is controlled to a large extent by opening and closing of the stomata. Investigations of Fischer and Hsiao (1968) and Humble and Hsiao (1969) have revealed that K^+ plays a significant role in stomatal opening and closing. Convincing evidences for this relationship have been provided by electron probe analysis studies of Humble and Raschke (1971). Using this technique it has been possible to measure K^+ content of guard cells of open and closed stomata.

3. Calcium (Ca^{2+})

It is commonly the major cation of the middle lamella of the cell walls, of which calcium pectate is a principal constitutent. Calcium has therefore an important bearing on the mechanical strength of tissue (Rasmussen, 1967). Hence it was analysed from the leaves of vegetables like tomato, okra and guar sprayed with different concentrations of organophosphorus insecticides like methylparathion and phosphamidon. The values are recorded in fig. 9.

FIGURE - 9

Effect of different concentrations of phosphamidon and methylparathion on Ca^{2+} content in the leaves of tomato, okra and guar

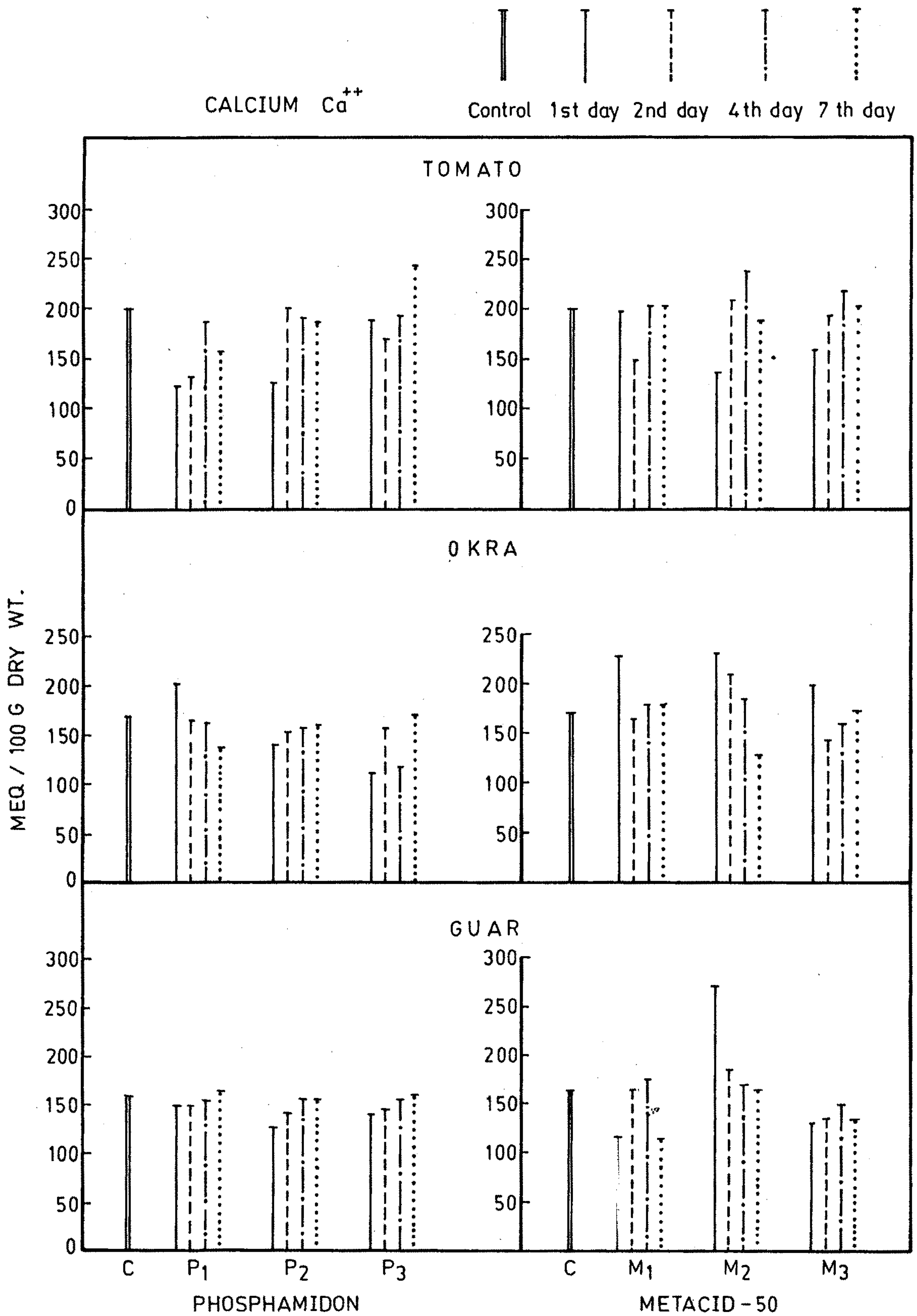
CALCIUM Ca^{++}
Control
1st day
2nd day
4th day
7 th day
TOMATO
OKRA
GUAR
MEQ / 100 G DRY WT.
300
250
200
150
100
50
0
C
P1
P2
P3
C
M1
M2
M3
PHOSPHAMIDON
METACID-50

Fig. 9

Ca^{2+} uptake in tomato under the influence of phosphamidon spray clearly indicated that at 0.02% spray there was a gradual increase in Ca^{2+} content with the advancement of days after spray. Maximum Ca^{2+} content was observed on 4th day after spray and thereafter the level declined. However, all these values are below the control value. At 0.04% phosphamidon spray maximum Ca^{2+} content was found on second day after spray while at 0.06% no consistency was recorded in Ca^{2+} content. But surprisingly Ca^{2+} level was found to be increased on 7th day after spray. It is very clear from the data that in all these concentrations 0.04% spray maintains steady uptake of Ca^{2+}.

The assessment of Ca^{2+} uptake under the influence of methyl-parathion in tomato plants has shown maximum Ca^{2+} level on 4th day after spray in all the concentrations used and thereafter declined on 7th day after spray. All these observations clearly suggest that as long as pesticidal persistence is there it favours Ca^{2+} uptake and once it degrades then it looses its hold. As such residual effect of organophosphorus pesticides was found to be persistant for more than eight days. (Sharma and Chopra, 1970; Patil and Dethe, 1984).

In okra Ca^{2+} content in all the concentrations of phosphamidon was below the control level except at 0.02% spray on 1st day after spray. The assessment of Ca^{2+} level with the advancement of days after spray showed varied pattern of Ca^{2+} uptake. At 0.02% spray the trend of Ca^{2+} uptake was appeared to be decreasing, at 0.04% it was increasing while in 0.06% neither of the two. This clearly indicates that there is inconsistency in Ca^{2+} uptake. However, increased trend of Ca^{2+} uptake at 0.04% spray appeared to be good as far as okra is considered. In methyl parathion sprayed okra plants Ca^{2+} uptake was triggered immediately on first day after spray at all the concentrations. Increase in Ca^{2+} uptake was above the control level at all the concentrations. At 0.1% and at 0.2% methylparathion spray the trend of Ca^{2+} uptake was more or less the same, where on the 1st day there was increase, followed by decrease on 2nd day and then once again increase on 4th and 7th day after spray. But at 0.15% spray there was a gradual decline in Ca^{2+} uptake with the advancement of days after spray. This clearly indicates that possible persistence of residual content lowers the Ca^{2+} level.

In guar not much difference in Ca^{2+} uptake was observed with increasing concentration of phosphamidon as well as with the advancement of days after spray. However, the trend of Ca^{2+} uptake was found to be increasing in all the concentrations with respect to advancement of days after spray. The situation under methylparathion spray in guar as regards to Ca^{2+} uptake is like that of okra. Here 0.15% spray favoured stimulation of Ca^{2+} uptake immediately on 1st day after spray and then showed gradual decline. This stimulation was above the control level.

Thus response shown by all the plants for Ca^{2+} uptake clearly indicates that there is some consistency in the ion uptake at lower and recommended concentrations of phosphamidon and methylparathion while no consistency was noticed in plants sprayed with the above recommended dose.

4. <u>Magnesium</u> (Mg^{2+})

Magnesium is generally taken up by plants in lower quantities than Ca^{2+} and K^{+}. The content of Mg^{2+} in plant tissue is usually in the order of 0.5% of dry matter. In plant tissue a high proportion of total Mg^{2+} often over 70% is diffusible and associated with inorganic anions and organic acid anions such as malate, citrate. Mg^{2+} is also associated with indiffusible anions including oxalate and pectate (Kirkby and Mengel 1967). Most well known role of Mg^{2+} is its occurrence at the centre of chlorophyll molecule. One major role of Mg^{2+} is as a cofactor in almost all enzymes activating phosphorylation process. (Mg^{2+} forms a bridge between pyrophosphate structure of ATP or ADP and enzyme molecule). A key reaction of Mg^{2+} is the activation of RuBPcase. Thus looking to the importance of Mg^{2+} in plant tissue, the level of its uptake under the influence of organophosphorus pesticide foliar spray was studied. The data is represented in fig. 10.

Mg^{2+} content analysed in tomato after giving one phosphamidon spray of different concentrations viz. 0.02%, 0.04%, 0.06% v/v upto 7th day after spray clearly revealed that Mg^{2+} content at lower concentration of phosphamidon (0.02%) on 1st day after spray showed decline in its uptake as compared to control. Whereas with the advancement of days after spray, its level slowly increased and on 7th day again it came down More or less similar is the situation in the next higher concentration (0.04%) of phosphamidon. At highest concentration (0.06%) there was linear increase in the Mg^{2+} uptake even upto 7th day after spray. When we compare Mg^{2+} content in control and in pesticide sprayed plants

FIGURE - 10

Effect of different concentrations of phosphamidon and methylparathion on Mg^{2+} content in the leaves of tomato, okra and guar

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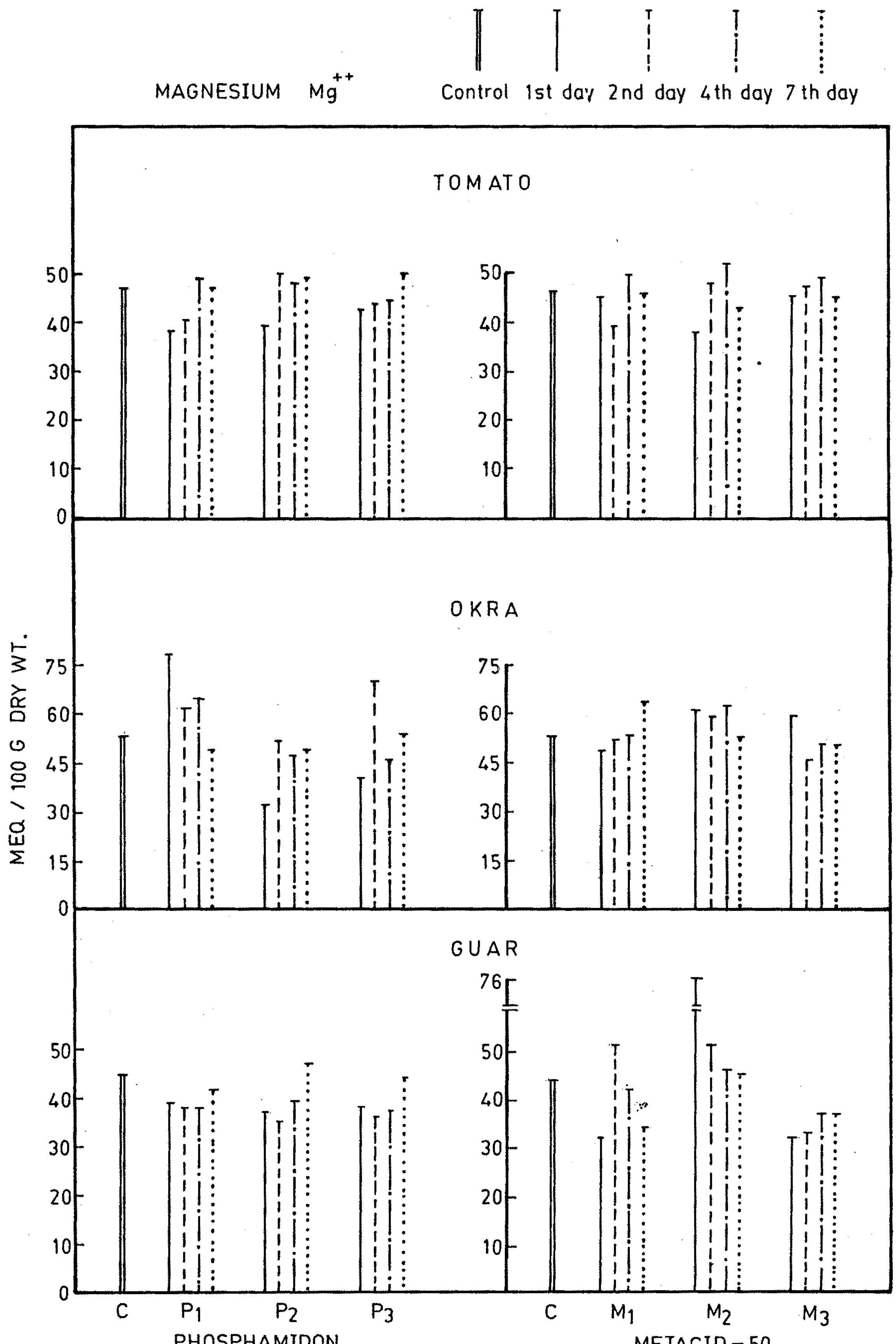


MAGNESIUM Mg++
Control 1st day 2nd day 4th day 7th day
TOMATO
OKRA
GUAR
MEQ / 100 G DRY WT.
C
P1
P2
P3
PHOSPHAMIDON
C
M1
M2
M3
METACID - 50

Fig.10

it appears that the proper absorption of pesticide only can promote the Mg^{2+} level. But immediate after spray, the response of Mg^{2+} to pesticidal spray was found to be negative.

The fate of Mg^{2+} in methylparathion sprayed tomato plants was more or less on the same pattern as that has been observed in case of phosphamidon sprayed plants. One thing is clear, irrespective of control values, the Mg^{2+} level appeared to be good at lower concentration of phosphamidon (0.04%) and methylparathion (0.15%).

When we see the situation of Mg^{2+} level in okra we found that there is marked difference than that of tomato. Here phosphamidon (0.02%) foliar spray enhanced the Mg^{2+} content in the leaf and it slowly came down on 7th day after spray. In case of methylparathion sprayed okra plants, 0.15% foliar application appeared more stimulatory dose as far as Mg^{2+} uptake is concerned. When we compare both pesticides for Mg^{2+} uptake it is found that phosphamidon (0.02%) is stimulatory in action.

In guar all the concentrations of phosphamidon suppressed Mg^{2+} content than the control. Here none of the concentrations of phosphamidon has favoured Mg^{2+} uptake to take it up over the control. However 0.04% phosphamidon sprayed plants when analysed on seventh day after spray showed little stimulation. When we look towards methylparathion sprayed plants for Mg^{2+} uptake, it appeared that there was a marked stimulation on 1st day in 0.15% methylparathion sprayed plants and then there was a gradual decline with the advancement of days. In both methylparathion and phosphamidon sprayed plants, Mg^{2+} level appeared to be good in 0.15% methylparathion sprayed plants.

5. Iron (Fe^{2+})

Iron plays an important role in enzyme systems in which haem functions as prosthetic group. Similarly the possible involvement of iron in protein metabolism has been suspected from the findings of a number of authors, who have observed that in Fe^{2+} deficiency, protein fraction decreases simultaneously with an increase in level of soluble organic nitrogenous compounds (Possingham, 1956 and Perur et al.,1961). This observation has prompted us to study the Fe^{2+} content in leaf tissue of day to day vegetables under the influence of pesticidal spray.

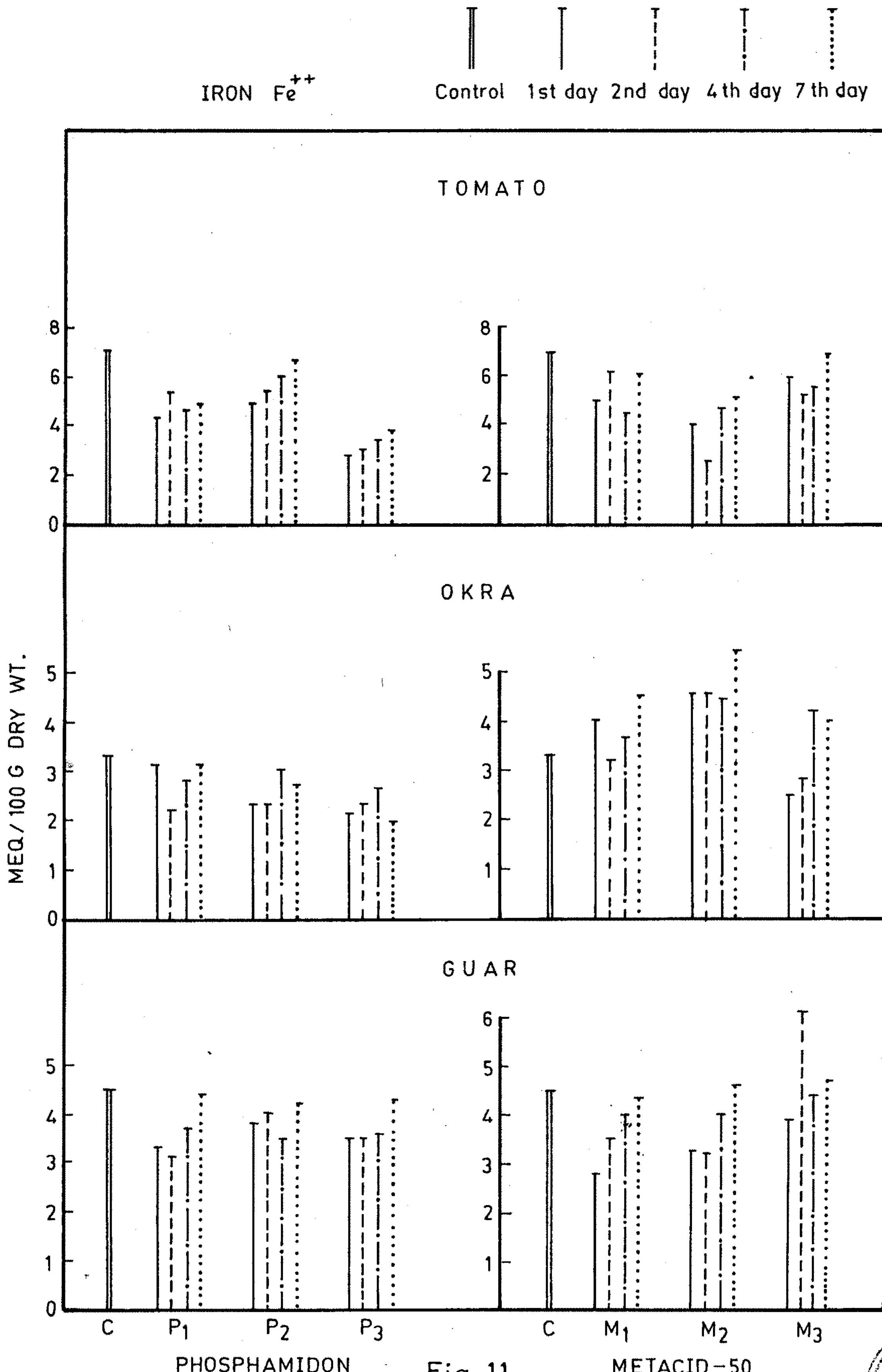
The Fe^{2+} values analysed from the leaf tissues of tomato, okra and guar after employing a single foliar application with varying concentrations of methylparathion and phosphamidon are represented histographically in Fig. 11.

Fig. 11 clearly indicates that okra and guar alone responded nicely only to methylparathion spray as compared to phosphamidon spray. Furthermore, lower concentrations viz. 0.1% and 0.15% of methylparathion in case of okra and 0.2% in case of guar have found to be good for Fe^{2+} uptake. Amongst the three vegetables, guar showed comparatively good response of Fe^{2+} uptake to phosphamidon while others have not.

FIGURE - 11

Effect of different concentrations of phosphamidon and methylparathion on Fe^{2+} content in the leaves of tomato, okra and guar

11



IRON Fe^{++}
Control
1st day
2nd day
4 th day
7 th day
TOMATO
OKRA
GUAR
MEQ / 100 G DRY WT.
C
P1
P2
P3
PHOSPHAMIDON
M1
M2
M3
METACID-50

Fig. 11

6. Manganese (Mn^{2+})

Like that of Mg^{2+}, Mn^{2+} is also equally important mineral element. It activates decarboxylases and dehydrogenases of TCA cycle and brings about oxidation of IAA by activating IAA oxidase. (Mumford et al., 1962, Tayler et al.,1968). It is also involved in oxidation reduction processes in photosynthetic electron transport system. Its role in PS II has been reported by Bishop (1971). Hence it was studied in the present investigation. Its uptake in leaf tissue under pesticidal influence has been shown in Fig. 12.

Except guar both okra and tomato plants failed to stimulate Mn^{2+} content over control. However, guar has shown good response of Mn^{2+} uptake at 0.02% phosphamidon as compared to 0.04% and 0.06% phosphamidon sprayed plants. In case of methylparathion, lower concentrations (0.1% and 0.15%) in guar have shown somewhat better Mn^{2+} uptake. The level of Mn^{2+} on 4th day after spray in 0.1% methylparathion sprayed guar plants showed maximum Mn^{2+} content, while it was maximum on 7th day in 0.15% methylparathion sprayed guar plants.

7. Zink (Zn^{2+})

Zink is one of the metals closely involved in nitrogen metabolism of plants (Mengel and Kirkby, 1982). Zink deficiency shows sharp decrease in the level of RNA and the ribosome content of cells (Price et al.,1972). It is also required in the synthesis of tryptophan (Tusi, 1948) and tryptophan is a precursor of IAA, which may be influenced indirectly by zink.

FIGURE - 12

Effect of different concentrations of phosphamidon and methylparathion on Mn^{2+} content in the leaves of tomato, okra and guar

93

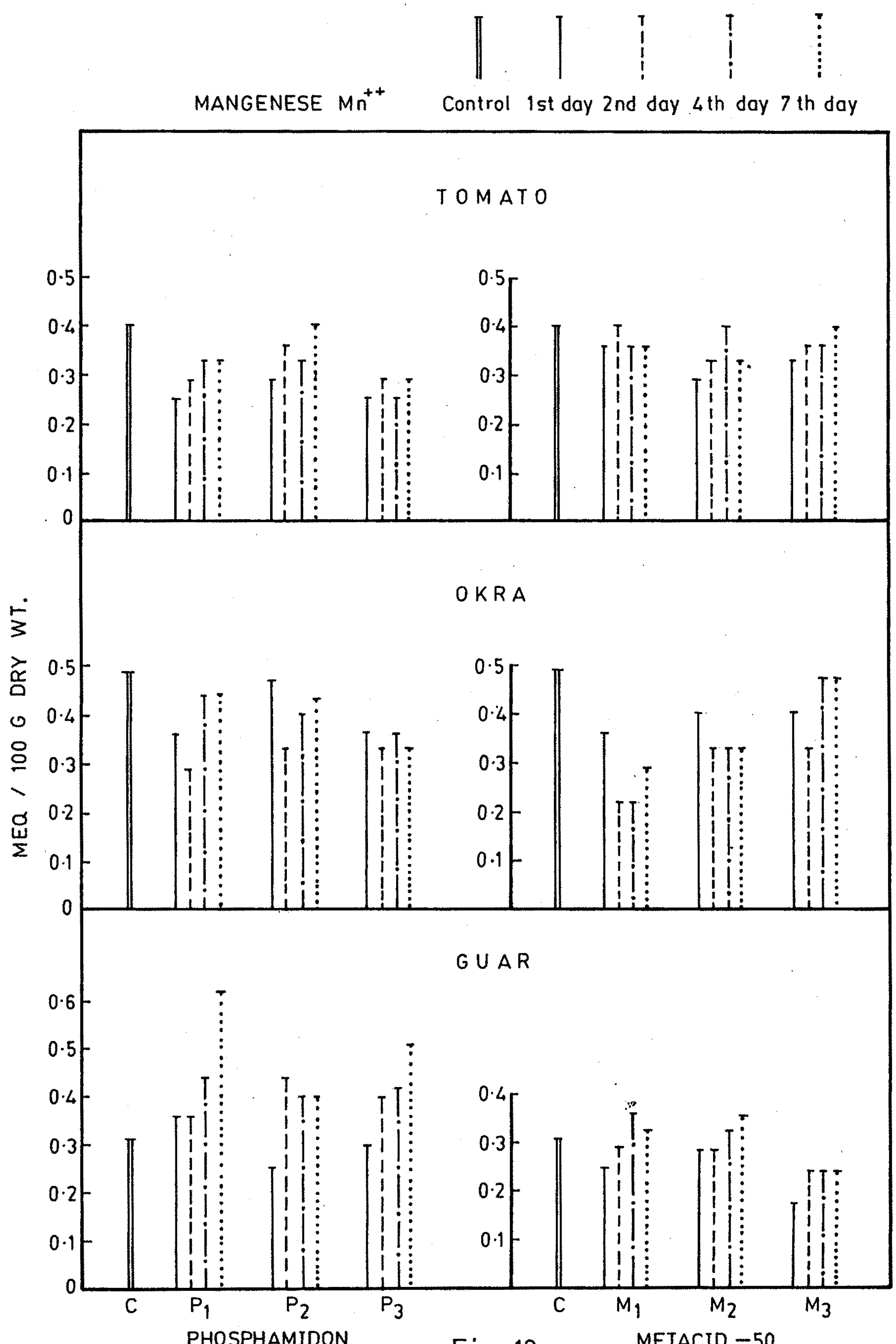

MANGENESE Mn++
Control
1st day
2nd day
4th day
7 th day
TOMATO
OKRA
GUAR
MEQ / 100 G DRY WT.
0·1
0·2
0·3
0·4
0·5
0·6
C
P1
P2
P3
M1
M2
M3
PHOSPHAMIDON
METACID −50

Fig. 12

Looking to these important functions of zink, it has been analysed from the pesticide sprayed tomato, okra and guar plants. The values are depicted in Fig. 13.

It is very clear from the figure that the maximum uptake of Zn^{2+} was noticed in tomato leaves as compared to okra and guar. Zn^{2+} level at 0.04% phosphamidon spray is comparatively good in tomato plants. But in case of methylparathion spray, with the increase in the concentration Zn^{2+} level declined. Similar situation was noticed in okra in phosphamidon sprayed plants. When we look toward methylparathion sprayed okra plants, good response of Zn^{2+} uptake was noticed at 0.2% spray. But no much difference was found in the uptake of Zn^{2+} both under phosphamidon and methylparathion sprayed guar plants. However, in all the cases there is variation in zink uptake, with the advancement of days after spray and with the increase in pesticide concentration.

8. Copper (Cu^{2+})

Copper generally participates both in protein and carbohydrate metabolism. Further, there is a specific requirement for Cu^{2+} in symbiotic nitrogen fixation. It is a constituent of chloroplast protein plastocyanin which forms part of electron transport chain linking two photochemical systems of photosynthesis (Bishop, 1966 and Boardman, 1975). Additional evidence also suggest that Cu^{2+} may play a part in the synthesis or the stability of chlorophyll and other plant pigments (Mengel and Kirkby, 1982). All these observations have led us to look into the level of Cu^{2+} in leaf tissue of tomato, okra and guar under pesticidal influence.

FIGURE - 13

Effect of different concentrations of phosphamidon and methylparathion on Zn^{2+} content in the leaves of tomato, okra and guar

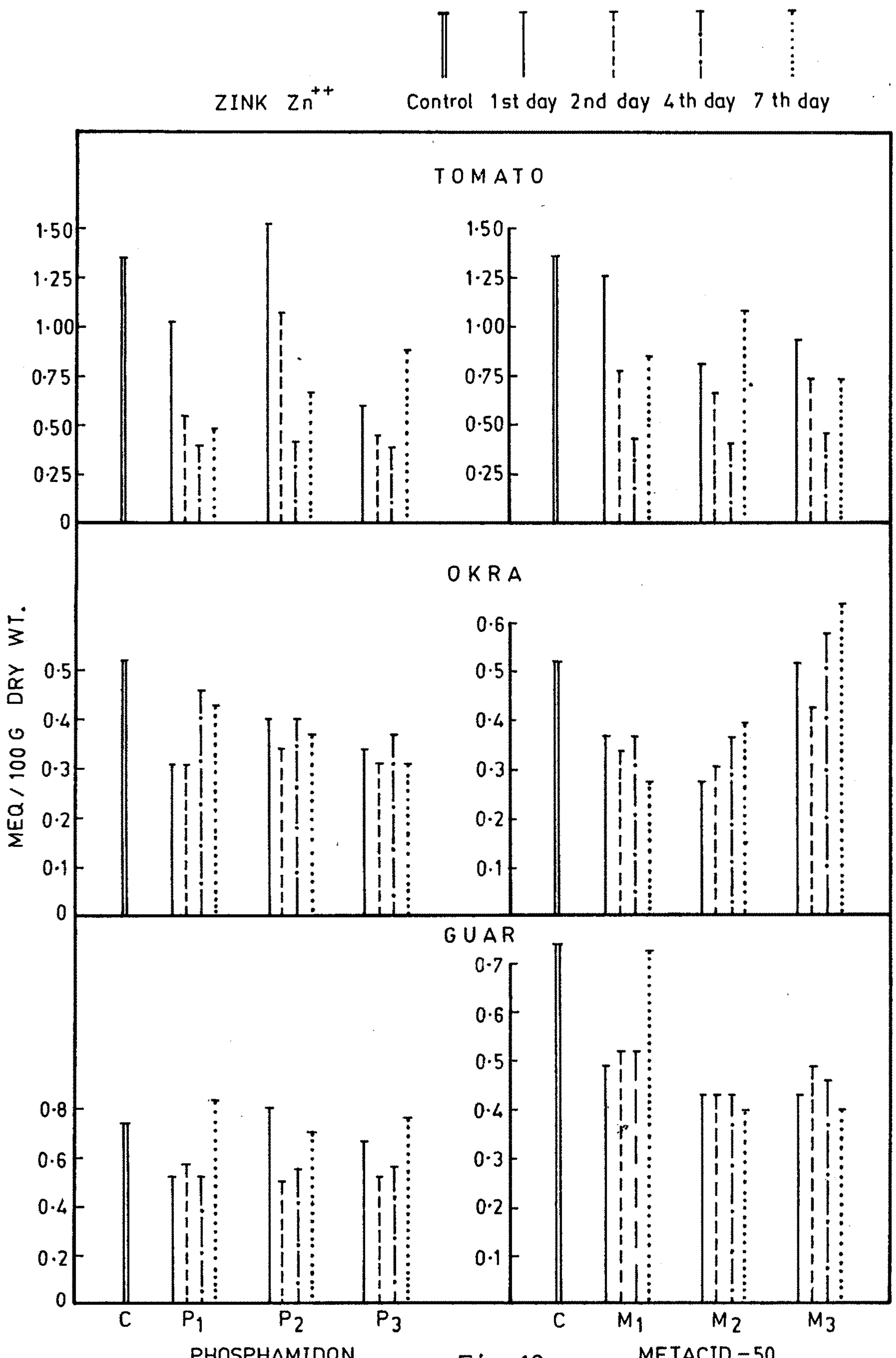

ZINK Zn^{++}
Control
1st day
2nd day
4th day
7th day
TOMATO
OKRA
GUAR
MEQ / 100 G DRY WT.
1·50
1·25
1·00
0·75
0·50
0·25
0
0·6
0·5
0·4
0·3
0·2
0·1
0·7
0·8
C
P_1
P_2
P_3
M_1
M_2
M_3
PHOSPHAMIDON
METACID – 50

Fig. 13

The values of Cu^{2+} are represented in Fig. 14. It is very clear from the figure that there is no much difference in Cu^{2+} uptake in tomato under both the pesticidal influence. None of the concentrations have shown stimulatory response of Cu^{2+} uptake over control.

In okra, though the level of Cu^{2+} increased with the advancement of days after spray, the values are below the control values in case of phosphamidon sprayed plants. While in methylparathion sprayed plants, increase in Cu^{2+} uptake was found on 2nd day after spray in all the concentrations.

In guar maximum uptake of Cu^{2+} was noticed on 7th day after spray in all the concentrations of phosphamidon whereas in case of methylparathion sprayed plants Cu^{2+} uptake was more on 1st day of pesticide application at 0.1% foliar spray.

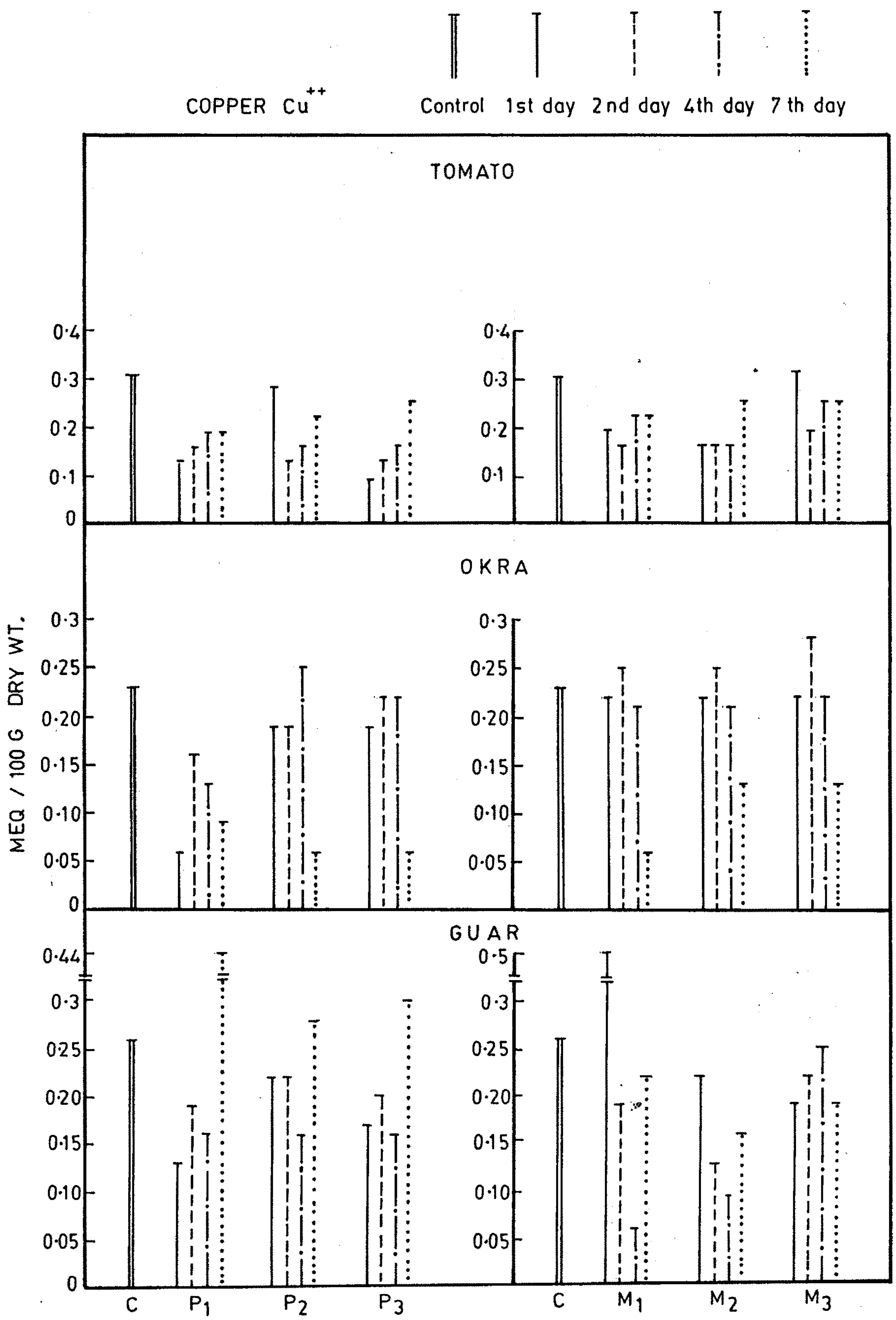
F. Residual analysis in tomato

Organophosphorus pesticides are finding extensive use in agriculture as the trend is to suppliment and replace organochlorine pesticide. Among the organophosphate insecticides, phosphamidon and methylparathion have been found to be broad spectrum insecticides that control many pests including borers, grasshoppers, jassids, aphids, bugs, beetles when used in low concentrations ranging from 0.02 to 0.05% (phosphamidon) and 0.1 to 0.15% (methylparathion). However, without knowing the danger, farmers from rural area use the concentrations which are above the recommended doses. This is because of illiteracy.

FIGURE - 14

Effect of different concentrations of phosphamidon and methylparathion on Cu^{2+} content in the leaves of tomato, okra and guar

97



COPPER Cu++
Control
1st day
2nd day
4th day
7 th day
TOMATO
OKRA
GUAR
MEQ / 100 G DRY WT.
0·4
0·3
0·2
0·1
0
0·25
0·20
0·15
0·10
0·05
0·44
0·5
C
P1
P2
P3
M1
M2
M3
PHOSPHAMIDON
METACID -50

Fig.14

In studying an insecticide it is not only its toxicity to insects that is important but also other aspects like the deposits and residues on the plants and their dissipation for safe human consumption. Hence it was essential to conduct studies on phosphamidon and methylparathion with regards to deposit and residues. This has prompted us to undertake the study to see the residual level on tomato plant by using methyl parathion and phosphamidon sprays.

The tomato plants bearing fruits were sprayed, with 0.06% phosphamidon and 0.2% methylparathion separately. Whereas the control plants were sprayed with equal volume of water. The spray was employed with the help of air pneumatic pressure pump to runoff point. The leaves and fruits were harvested immediately one hour after spray and on 7th day after spray for residual analysis. The residual analysis was performed by using paper chromatography and thin layer chromatography.

The persistence of phosphamidon in tomato leaves and fruits immediately 1 hour after spray and on seventh day after spray is represented in Fig. 15 and Fig. 16. The results of residue analysis indicated that the persistence of phosphamidon was in appreciable amount immediately 1 hour after spray both in leaves and fruits. However, it was slowly degraded and on 7th day after spray the residual content left over was very low. This can clearly be had from faint appearance of spot on paper chromatogram. Hence it is clear from the figures that initial deposit of phosphamidon was higher both in leaves and fruits and then it was dissipated with the advancement of days after spray. Prasad and Ramasubbaiah (1982) have also studied persistence of phosphamidon in

FIGURE - 15

Representation of paper chromatogram of phosphamidon separated on Whatman No. 1 chromatogram (1 h after spray)

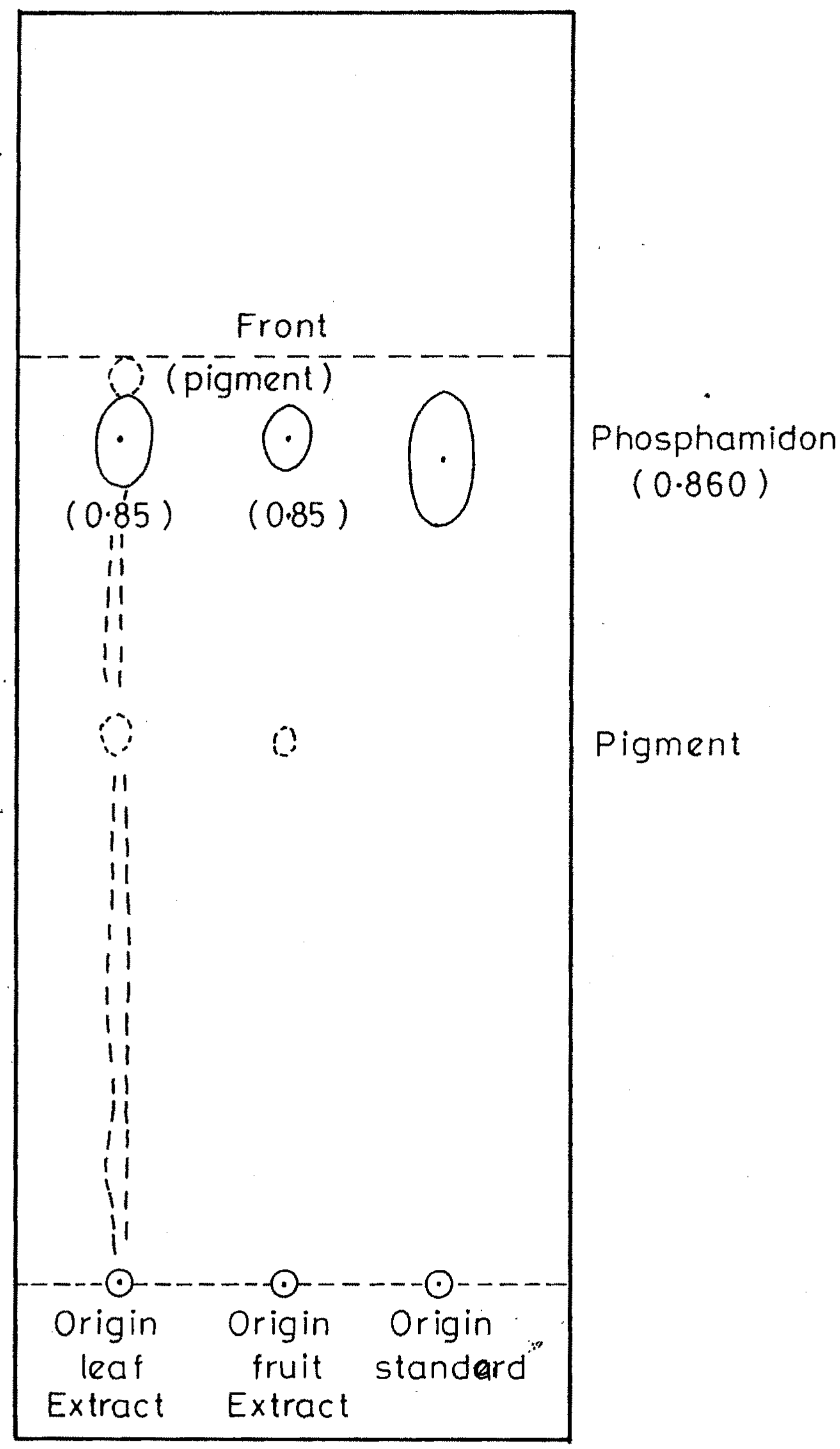


Fig. 15 Representation of paper chromatogram of phosphamidon (1 hr. after spraying).

FIGURE - 16

Representation of paper chromatogram of phosphamidon separated on Whatman No. 1 chromatogram

(7th day after spraying)

50

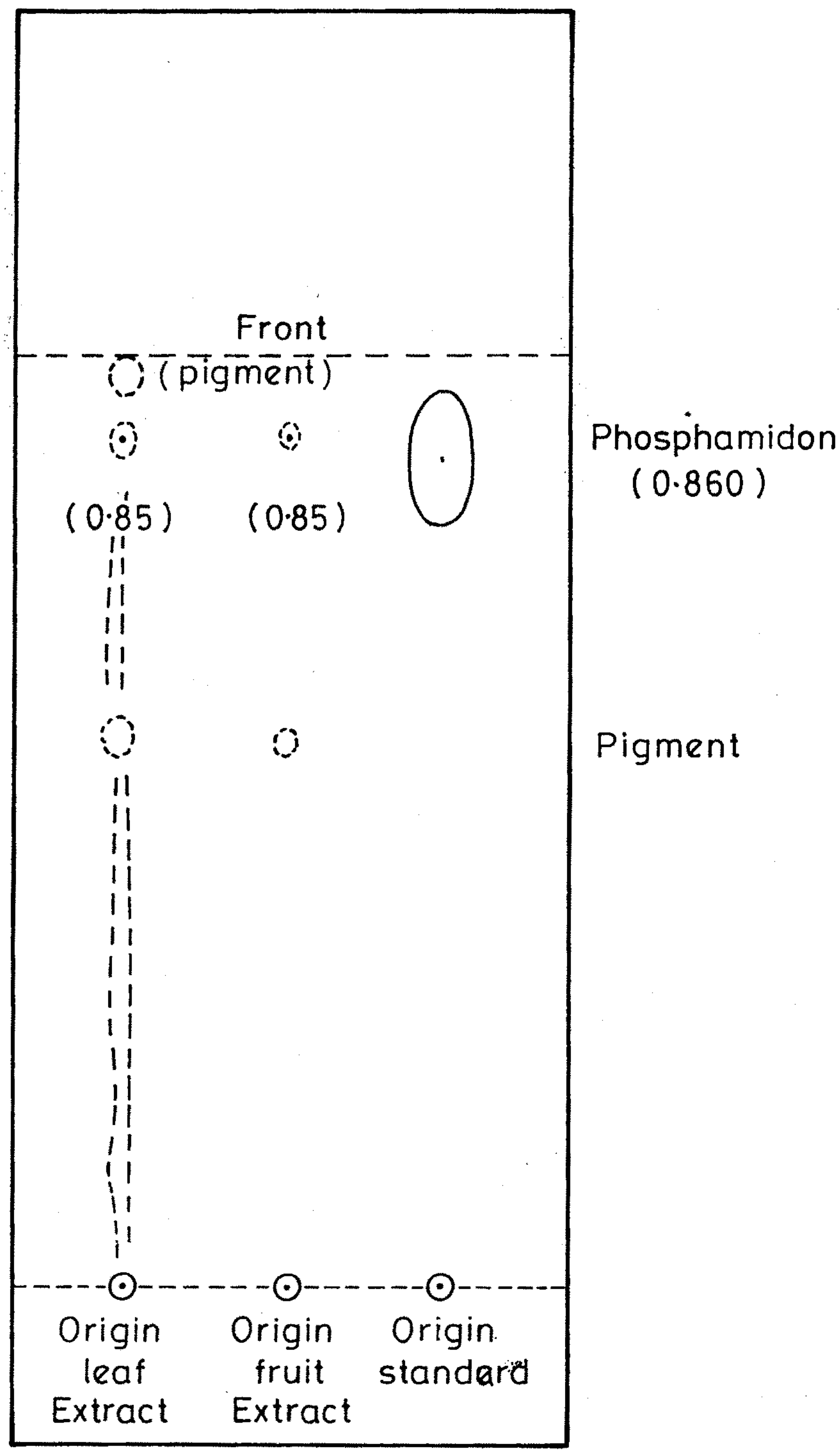


Fig. 16 Representation of paper chromatogram of phosphamidon. (7th day after spraying).

okra and reported that deposite of phosphamidon (0.03%) was 6 ppm on fruits immediate after spray and it came down to 0.5 ppm in 10 days after spraying. At 0.05% concentration the initial deposit was 8 ppm and was reduced to 0.5 ppm within 10 days after spraying. The tolerance limit for phosphamidon is 0.5 ppm as laid down by FDA (Food and Drug Administration) of USA. So okra fruits are safe for human consumption 10 days after spraying. Patil and Dethe (1984) have also studied the residual content of phosphamidon and monocrotophos in green chillies by microbioassay method. They have reported that initial deposit of monocrotophos was 16.82 ppm as against 6.7 ppm in phosphamidon, when sprayed in the concentration 0.08% monocrotophos (4 sprays) and 0.02% phosphamidon (4 sprays). Dissipation of monocrotophos was faster than phosphamidon. According to them, 10 and 8 days as awaiting periods were desirable between last spraying and plucking of green chillies in monocrotophos and phosphamidon respectively.

In the present investigation the concentration used is above the recommended dose and even it shows the persistence of its residue in a sizable amount when analysed qualitatively on 7th day after spray. Hence the suitability of its consumption after 7th day of spraying is uncertain, which needs quantitative analysis.

Persistence of methylparathion has also been studied in tomato plant with the help of thin layer chromatography. The photographs of TLC plates showing detection of methylparathion immediately 1 h after spray and on 7th day after spray are given in Plate 3 and 4 respectively.

PLATE - 3

T.L.C. plate showing
persistence of metacid-50 residue
in the leaves of tomato

A: standard
B: Leaf extract (1st day)
C: Leaf extract (7th day)

PLATE - 4

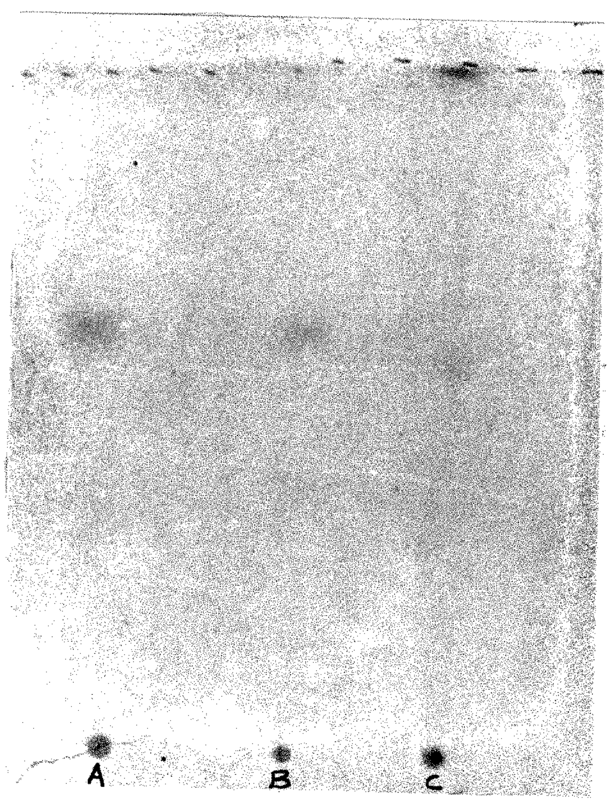
T.L.C. plate showing

persistence of metacid-50 residue in tomato

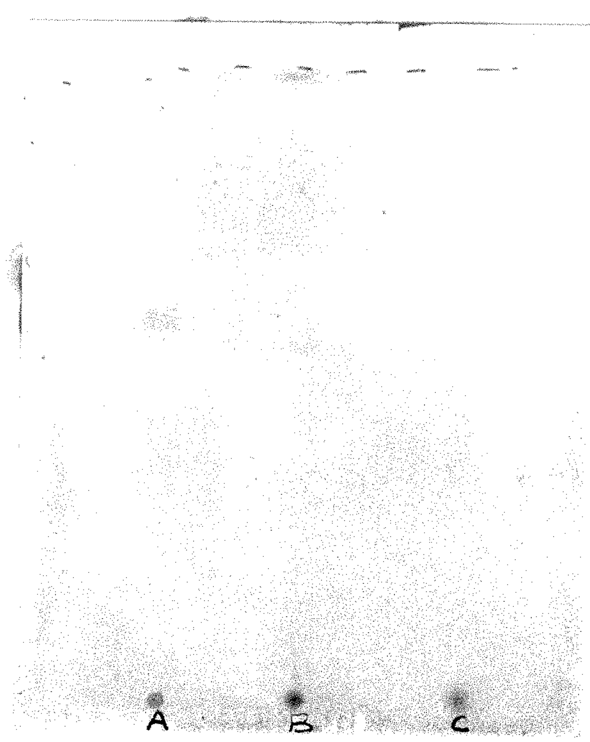
A: Standard

B: Fruit extract (1st day)

C: Fruit extract (7th day)



Point of origin


A
B
C
Point of origin

Similarly the detection of spot on the plate itself by using UV light and different reagents is given in Table 12.

Like that of phosphamidon, here also a prominent spot of methyl-parathion appeared on TLC plate immediately 1 h after spray and then it was dissipated slowly with the advancement of days after spray. This can clearly be seen on TLC plate where a trace of residue was seen in the form of illdeveloped spot. This clearly suggests that residual deposit dissipates within 7 days. However, it is essential to know whether the amount detected on 7th day after spray is below or above the tolerance limit.

Atri and Lal (1972) have studied residues and residual toxicity of ethyl and methylparathion on cabbage and reported that residues on cabbage heart never exceeded the tolerance limit of 1 ppm whereas on the leaves the residues required nearly 10 days with the lower dose of ethylparathion and 8 days with the same dose of methylparathion to reach the level of tolerance. About 24 days and 17 days were required with the higher dosage of ethyl and methylparathion respectively to reach the level of tolerance. According to them methylparathion residues were less persistent than ethylparathion.

Residual analysis of methylparathion in brinjal (Solanum melongena) and bitter gourd (Momordica charantia) has also been studied by Manzoor and Manzoor (1975) and reported that dissipation of residual content was faster in the month of May-July while slow in August to September.

Table 12 : Colors of insecticide spots located by different methods on the same plate.

Insecticide	Color of the spot		
	Viewed under UV light	Sprayed with $AgNO_3$ reagent in ammonia	Sprayed with $PdCl_2$ reagent and warmed
Methylparathion	Dark	Yellow	Yellowish brown
Phosphamidon	Dark	-	Grey

After Tewari and Harpalani (1977)

$AgNO_3$ reagent : 1% solution of silver nitrate, prepared by dissolving 1.0 g of reagent grade $AgNO_3$ in redistilled ethanol containing 5.0 ml of concentrated ammonia solution and made up to 100 ml with ethanol.

$PdCl_2$ reagent : 0.5% solution of palladium chloride in 0.1 N HCl and after drying in air, is heated at 80°C for 20 min.

Rajukkannu et al (1978) have studied residues of 4 different pesticides viz. methylparathion quinalphos, phosalone and fenitrothion in/on okra. The concentrations used for all the pesticides were 1 kg/1000 lit/ha and sprayed 4 times from the time of flowering at 15 days intervals. Their experiment on residual analysis revealed that by 7 days after the final application of all insecticides residues were below tolerance levels.

In the present investigation the concentration of methylparathion used was higher than the recommended dose and hence there is every possibility of residual deposit which may be more than the tolerance limit. This requires quantification of residual content by more sofisticated equipments. At present we can only say that the methylparathion residue in tomato dissipates with the advancement of days after spray and looking to the available literature it is equally important to train the illiterate people for proper use of pesticides, at recommended or below recommended concentrations.