DEVELOPMENT OF FUTURE PROPHYLACTIC FOR INDIA

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Abstract

Currently, prophylactic treatment with malathion - dichlorvos and fumigation with aluminium phosphide are used in central storage. Rural storage has yet to improve to provide high safety. In view of this situation, search for potential prophylactic among organophosphorous and synthetic pyrethroid was vigorously made during more than a decade, involving bioefficacy, persistence, rural and central godown trials and residue data. Bioefficacy was carried against major cereal, legume and spice insects both from Coleoptera and Lepidoptera Orders. During the last 7 years, choice was adjudged on encouraging results of deltamethrin to suit as fabric and surface treatments. The paper also emphasises national status of insect pests in the country. Prophylactic spray has been compared along with economic advantages.

Introduction

Historical usage of DDT during early forties marked the beginning of an era in grain storage. BHC (HCH) followed later on and was in use, especially lindane up to arrival of malathion in 1954. The national necessity to create large scale food grain storage facilities was felt after 1967 and use of malathion was intensified. Toxicity, biological efficacy and residue of malathion were studied prior to large scale usage (Godavari Bai et al., 1964; Mookherjee et al., 1965). Initial dose was 50 mg/m^2 which was stepped to 100 mg/m^2 during early seventies and currently 150 mg/m^2. The additional studies on toxicities, persistence on different surfaces, type of seed, moisture content levels of grain, residue in food grain and development of resistance were conducted (Bhatia et al., 1971: Girish et al., 1971; Bindra and Udeaan, 1973). Malathion was found less toxic to moths (Yadav et al., 1979) and showed 37.8 times resistance to red flour beetle (Bhatia et al., 1971) necessitating search of an alternative prophylactic. Thereafter, several new organophosphorous insecticides (Yadav et al., 1980: Pawar and Yadav, 1982; Jain and Yadav, 1988) and pyrethroids (Yadav, 1987a) were tested and current status of conventional insecticides was reported (Yadav, 1987b).

Deltamethrin was found most toxic (Yadav, 1987a) and proved persistent on storage surfaces (Yadav and Jha, 1985). At 3 ppm deltamethrin dust proved effective under rural storage system and 20 mg/m^2 deposit was persistent on different surfaces (Yadav, 1986). The present paper deals with the evaluation of prophylactic value of deltamethrin under large scale storage system of wheat and rice along with residue data and economic aspect of application.

Materials and Methods

General: Rice and wheat stacks of normal rectangular size (9.1 x 6.1 x 4.9 m (height) were selected in the godowns of Food Corporation of India situated at Delhi (CTO, Gheora), Haryana (Dudahera) and Bombay (Borivli). Fresh rice and wheat were used during winter and summer, 1987 respectively. At Borivli, imported white and red US wheat was stored. Three stacks were used for each treatment. The total quantity of bags filled with

US white wheat were 3565 and 3025 treated with 15 and 25 mg/m^2 deltamethrin respectively and held under one shed. US red wheat filled in 4020 bags and held in separate shed was treated with 150 mg/m^2 malathion. Deltamethrin (K-othrine 2.5 WP) was sprayed thrice once in January, June and October, 1989. Malathion was sprayed 24 times during the year along with 12 sprays of dichlorvos (DDVP). Fumigation was done with aluminium phosphide (6g/T) allowing 5 days exposure under polyethylene cover (250 microns thick). DDVP was applied at the rate of 4.17 ml/stack. Threee fumigations were associated with deltamethrin during January, just to prespray, August and November, 1989. The climate at Delhi and Haryana has distinct summer and winter while at Bombay it is coastal. Dunnage in different godowns were either wooden frame or polyethylene sheet. At Gheora wheat stacks were without dunnage. Pre and post treatment observations on insect infestation were recorded from samples drawn initially and during storage period of 6 months or more. Spray treatment: Deposit of deltamethrin (K-othrine 2.5 WP) was applied with a foot sprayer. Surface area of a stack with 1536 bags was calculated to 204.4 m^2 based on 5 side of a stack. Curvature of bags and half of alleyway (0.5 m) was estimated to 20.4 m^2. Thus to spray a total of 225 m^2 @10 mg/m^2, 2250 mg of deltamethrin was needed using 90 g of 2.5 WP. Water suspension was prepared in 8 l and sprayed on all the four sides and top of the stack. Similarly, 15, 20 and 25 mg/m^2 deposits were made using 135, 180 and 225 g of 2.5 WP. Persistent test: Two discs (10 cm dia) of jute fabric and polyethylene (250 micron thick black film) were fixed on all the four sides of stack at 2 m height and at top with a pin prior to spray. After 15 min. of spray, the dried discs were removed to the laboratory. Assays on persistence were conducted after exposing the treated surface in petridish (10 cm dia.) against test insects. The mortality of insects released in 10 number was recorded after 24 h at 27 $\pm$ 1^{o}C and per cent kill was calculated. Test insect: Adults with 3-5 days age of Sitophilus oryzae Linn. Rhizopertha dominica Fab., mid stage larvae of Trogoderma granarium Everts reared on wheat were used in persistence tests. Adults of Tribolium castaneum Herbst aged 3-5 days were obtained from wheat flour + 5 per cent yeast. All the insects were reared at 27 $\pm$ 1^{o}C except T. granarium which was reared at 35^{o}C. Residue analysis: Grain samples were drawn from different bags with a sampler (25 cm) after inserting up to 15 cm. A few samples were also drawn after inserting sampler along the surface of bag representing 1 cm depth. Samples of grain were extracted with n-hexane in a soxlet apparatus, concentrated in a flask evaporator, cleaned through acetonitrile partitioning to remove fat and wax and recleaned through neutral alumina column (Jain et al., 1979). The insecticide was eluted from the column with solvent mixture of 5 per cent acetone in hexane. The elute was directly analysed by EC-GLC Tracor MT 220 model (Rahman et al., 1985), after injection of 3 μl. The average recovery was between 90 to 95 per cent from 0.1 and 0.5 ppm treated rice and wheat grain respectively. The sensitivity of method varied from 0.02-0.05 ppm.

Results

As seen from Table I all the four rice stacks treated with 10- 20 mg/m^2 of deltamethrin remained insect free upto five months corresponding to winter months. However, after 6 months, T. castaneum was observed arising mainly from the bottom of stack. The debris at bottom of stack could not be treated. This shortcoming was removed once the floor and crates were treated with 10 mg/m^2 in another experiment at Gheora during January, 1988. In total

Table I Incidence of insects in rice and wheat samples obtained from stacks treated with deltamethrin.

Months after treatment	CTO		Gheora		Dudahera
	20 mg/m^2	10 mg/m^2	20mg/m^2	10 mg/m^2	10 mg/m^2
Rice					
Initial	0	0	0	0	
1-5	0	0	0	0	
6	3	3	2	2	
Wheat					
Initial			3	3	7
0.5			4	3	
1			1	1	8
3			5	3	7
4			4	4	
6			3	3	
Malathion			3	2	

five stack of rice with 7680 bags were thus protected upto 6 months without any other fumigation or DDVP spray. However, one fumigation at the end of 6 months was advisable to arrest the insect development. Two stacks of wheat stored at Gheora indicated pretreatment infestation upto 3/kg which included T. castaneum, R. dominica, S. oryzae and Oryzaephilus surinamensis Linn. After the treatment with 20 and 10 mg/m^2 doses of deltamethrin, the infestation remained at the same level. A fumigation with aluminium phosphide @ 6 g/T was resorted and infestation dropped to 1/kg. During the next 3rd, 4th and 6th months of storage number of insect in both the treatment varied between 3-5/kg. Comparatively malathion treated stacks revealed 2-3 insect/kg. Comparatively malathion treated stacks revealed 2-3 insect/kg. After 6 months of storage per cent infestation varied between 0.1-1.0 at high dose and 0.1-1.5 at low dose.

In case of wheat stored at Dudahera besides the above insects, T. granarium Everts was also found. Since the stack was 1.5 year old and fumigation was not possible to be carried, high infestation was expected. The initial sampling prior to treatment indicated 7 insects/kg. A large number of dead adults of R. dominica were sweeped for 10 days. However, after 1 and 3 months after treatment, 7-8 insects/kg were found. The per cent infestation ranged between 4.27-10.94.

Results of the treatment done at Borivli indicated comparative infestation levels in stacks sprayed with 15 and 25 mg/m^2 of deltamethrin along with malathion 150 mg/m^2 (Table II). While all the three treatments were initially infestation free, gradual rise in infestation was observed upto 170 days period. The infestation varied between 1.0-1.4 per cent during this period. Later on the infestation increased slowly and mean per cent infestation was 2.2, 2.0 and 2.0 with respective treatments after 380 days. In case of samples from malathion sprayed stacks presence of Ephestia (Cadra) cautella Walker, T. castaneum and R. dominica was noticed. The infestation levels in all the treatments being comparative, the efficacy needs to be adjudged from economic angle also.

As seen from Table III, jute and polyethylene surfaces with deposits of 10 and 20 mg/m^2 on rice stacks gave sufficient kill upto 80-150 days in R. dominica and T. granarium. On jute surface 76-77 per cent kill was observed in S. oryzae after 55 days, 100 per cent kill in R. dominica, after 80 days, 92-97 per cent kill in T. granarium larvae after 150 days and 65-80 per cent kill in T. castaneum after 190 days. On polyethylene, from both the deposits kill was 97-100 per cent in T. granarium and 70-100 per cent in T. castaneum after 190 days.

In case of 10 and 20 mg/m^2 of deltamethrin on wheat stacks (Table IV) very high kill in R. dominica was observed after 50 days and between 47-50 per cent in T. castaneum on jute surface during this period. The kill of T. castaneum was retained between 52-62 per cent on jute surface and 69-75 per cent on polyethylene. At Dudahera, mean kill from 14 stacks was 67 per cent on jute and 38 per cent on polyethylene surface against T. castaneum after 150 days.

Residue analysed in samples of rice and wheat from all the treated stacks (Table VI) indicated that the deposit levels of 10, 15, 20 and 25 mg/m^2 of deltamethrin did not show residue level beyond 0.02 ppm during 1-6 months

Table II Per cent infestation of wheat stored at Borivli (Bombay 1989-90)

Treatment	Dose mg/m^2	Days after treatment 20	110	170	260	320	380	Mean
Deltamethrin	15	0.6	0.3	1.0	1.7	6.5	3.0	2.2
Deltamethrin	25	0.0	0.4	1.0	7.5	5.8	3.4	2.0
Malathion	150	1.4	0.8	1.4	3.0	3.4		2.0

Insects - R. dominica, T. castaneum, S. oryzae, C. cephalonica, E. cautella, O. surinamensis
Initial infestation was 0.0 per cent.

Table III Per cent kill of insects exposed to deltamethrin deposit (rice stack) on jute and polyethylene surface.

Surface	Deposit mg/m^2	Days after treatment 20 S.o.	20 T.c.	55 S.o.	80 S.o.	80 T.g.	80 R.d.	110 T.g.	150 T.g.	190 T.c.
Jute	20	63	60	76	61	100	100	97	97	65
Jute	10	54	57	77	29	98	100	98	92	80
Polyethylene	20	-	-	-	-	-	-	97	-	70
Polyethylene	10	-	-	-	-	-	-	100	-	100

Two stacks of rice at CTO and Gheora were sprayed in Jan. 1987. Each data is mean kill from 10 tests from front, back, right, left and top sides of stack.
S.o. = S. oryzae; T.c. = T. castaneum; T.g. = T. granarium; R.d. = R. dominica

Table IV Per cent kill of insects exposed to deltamethrin deposits on jute and polyethylene surface (wheat stack)

Deposit mg/m^2	Surface	Godown	Days after treatment 50 R.d.	50 T.c.	150 T.c.
20	Jute	Gheora[1]	100	47	52
10	Jute	Gheora	94	50	62
20	Polyethylene	Gheora	100	68	75
10	Polyethylene	Gheora	99	73	69
10	Jute	Dudahera[2]	-	-	67
10	Polyethylene	Dudahera	-	-	38

1 - July, 1987 one stack for each dose; 2 - September, 1987 14 stacks. Each data is mean kill of 10 tests for Gheora and 28 tests for Dudahera.
R.d. = R. dominica; T.c. = T. castaneum

Table V Analysis of deltamethrin in rice and wheat samples drawn from treated stack.

Treated grain	Godown	Month after treatment	Deposit mg/m^2	Residue
Rice	CTO	1-6	20	ND
Rice	CTO	1-6	10	ND
Wheat	Dudahera	1-6	10	ND
Wheat	Gheora	1-6	10	ND
Wheat	Gheora	1-6	20	ND
Wheat	Borivli	1-6	15	ND
Wheat	Borivli	1-6	25	ND

ND = Non detectable

Table VI Cost of deltamethrin (2.5 WP), malathion (50 EC) and aluminium phosphide based on 1 stack of 150 T.

Insecticide/ fumigant	Dose mg/m^2	No. of treatment	Quantity (kg)	Cost (Rs.)
Deltamethrin	10	2	0.18	63.0
	15	2	0.27	94.5
	20	2	0.36	126.6
	25	2	0.45	157.5
Al. phosphide	6 g/T	3	2.70	351.0
Malathion	150	24	1.58	47.4

US $ equivalent to Rs. 18 (Approx.)

after application. However, efforts made to trace the residue in samples of rice closest to bag surface (1 cm) showed 0.02 ppm residue of deltamethrin. Wheat samples drawn from 150 mg/m^2 of malathion treated stacks indicated 0.085 ppm of residue.

Cost of deltamethrin (K-othrine 2.5 WP) at 10, 15, 20 and 25 mg/m^2 needed for two application was estimated to Rs. 63.0-157.5 (Table VI). The cost of aluminium phosphide (6 g/T) for 3 treatments is worked to Rs. 351.00. The cost of 150 mg/m^2 of malathion involving 24 application is estimated to Rs. 47.40.

The appropriate necessity of treatments vary in different ecological system of storage. However, currently 12-24 sprays of malathion, 6-12 sprays of DDVP and 3-4 fumigations with aluminium phosphide are needed. The labour cost of each spray or fumigation is Rs. 4.50/stack. The total cost of treatment with malathion, DDVP and aluminium phosphide as per need is estimated to Rs. 345-690/stack. Comparative cost involved in 2 sprays of deltamethrin and 3 fumigation is estimated to Rs. 495/stack. However, scope of curtailing one more fumigation exists and estimated cost comes to Rs. 375.50. The additional benefit is in arresting resistance associated with the prolonged use of malathion and DDVP.

Discussion and Conclusions

A single deposit of deltamethrin (10 mg/m^2) kept uninfested rice safe against insects upto 6 months in winter. However, wheat needed a prefumigation treatment along with 20 mg/m^2 deltamethrin. The treatment was found useful with infested also. These results of large scale trial under climatic condition of North India were comparable to coastal climate at Bombay. Wheat stored at Borivli, was also protected satisfactorily with 3 applications of deltamethrin (15 mg/m^2) in association with 3 fumigations. At present, comparative protection is achieved with combination of 24 sprays of malathion, 12 of DDVP and 4 fumigations. The data on persistent tests indicated prolonged efficacy both on jute and polyethylene surfaces. T. granarium, R. dominica and T. castaneum were killed upto 80-150 days after treatment. Yadav (1988), Sonelal et al., (1988) and Ramzan et al., (1987) also found deltamethrin to give similar persistent kill.

The residue of deltamethrin was found below 0.02 ppm throughout the storage period of 6 months. Webley (1981) also reported 0.05 ppm of deltamethrin from 12.5 mg/m^2 spray on polypropylene bags. Cost of deltamethrin was found comparable to cost of malathion-DDVP schedule which has indicated insect resistance also. The usage of deltamethrin in large scale storage system has become feasible.

Conclusions:

I Deltamethrin proved effective and persistent to protect rice and wheat

II The doses most suitable under the storage condition varied from 10-25 mg/m^2.

III Two applications of deltamethrin and 2 fumigations were most judicious and economical.

IV Unfavourable storage conditions under humid and warm regions needed 3 treatments and 3 fumigations.

Resistance to malathion-DDVP schedule observed in major insects is avoidable.

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CONCEPTION FUTURE DE LA PROPHYLAXIE EN INDE

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Résumé

Le système de stockage des semences et des denrées alimentaires en Inde a évolué après de nombreux essais au cours des deux dernières décennies. Dans les centrales de stockage, on utilise actuellement un traitement prophylactique au malathion et au dichlorvos ainsi que des fumigations au phosphure d'aluminium. Le stockage rural doit encore évoluer avant de fournir toutes les garanties nécessaires. Pour cela, la recherche de traitements prophylactiques s'est tournée, pendant plus d'une décennie, vers l'étude des organophosphorés et des pyréthrinoïdes de synthèse, ce qui a consisté à évaluer leur bio-efficacité, leur persistance, puis à effectuer des essais dans les entrepôts ruraux et des centres de stockage, ainsi qu'à mesurer leurs effets résiduels. Leur bio-efficacité à été étudiée sur la majorité des céréales, des légumineuses et des épices, à la fois sur les coléoptères et les lépidoptères. Au cours des sept dernières années, un choix s'est déterminé grâce aux résultats encourageants obtenus avec la deltaméthrine en tant que produit de protection insecticide efficace des toiles de sacs, des semences et des surfaces. Cet exposé souligne aussi l'étendue du problème des insectes des denrées dans le pays. Le rôle des traitements préventifs au moyen d'aérosols, dans les semences, les locaux et pour les tissus d'emballages a été comparé en termes d'efficacité et d'avantages économiques.