EFFICACY OF TRICALCIUM PHOSPHATE AS A LEGUME GRAIN PROTECTANT

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Since the publication by Majumder and Bano (1964) reporting the toxic effects of calcium phosphate salts to insect pests of stored grain, little further research has been undertaken on the potential of using mineral salts as insecticidal protectants. The mechanism for the reported toxic effects is still largely unexplained. Majumder (1974) reported that interactions of potentiation and antagonism were observed between the mineral salt tricalcium phosphate ($Ca_3(PO_4)_2$ or TCP) and various organic acids, amino acids, sugars, and vitamins. He suggested that some of these reactions possibly could be responsible for the adverse effects of this salt on insect development. Baker et al. (1976) reported that the effect of TCP on Tribolium castaneum (Herbst) and Tenebrio molitor L. was probably due to water loss rather than to disruptive mineral metabolism. Baker et al. (1978) found when using TCP as a 24 hr contact treatment on Tribolium castaneum that the branched-chain alkones, methylheptacosones and dimethylheptacosones produced were significantly reduced apparently as the result of absorption by the TCP. They suggested that TCP may have a contact toxicity or cause some metabolic aberration.

In 1972, Pratt et al. stated that the use of mineral salts offered a new promising method of insect control. They suggested that commodities could possibly be stored that were unsuitable or even toxic as insect diets but safe as food for man. Research on several species of stored product insects by Press et al. (1972), Highland (1975), Boczek et al. (1983a and 1983b) and Kruk et al. (1983) indicate that the use of TCP may offer this possibility of control.

In this paper we wish to present a report of two studies of effects of TCP on three common bruchids that attack grain legumes.

Material and Methods

Stock colonies of all three bruchids were maintained at 27 + 1°C and 60% RH in a 12-12 hr light-dark photoperiod. The bean weevil, Acanthoscelides obtectus (Say), and Callosobruchus chinensis (L.) were maintained on navy beans, Phaseolus vulgaris and were received in 1981 from the Pest Infestation Laboratory at Slough. The cowpea weevils, Callosobruchus maculatus (F.), originally from Fresno, California, have been maintained on cowpeas, Vigna unguiculata, at Savannah for more than 20 years. In these studies A. obtectus and C. chinensis were maintained on dry navy beans and C. maculatus was maintained on dry cowpeas purchased on the local market.

In the study on effects of TCP on production of F_1 adults and their developmental times, tests were conducted in 1 qt (946 ml) mason jars with screen lids. Each jar contained 250 g. of beans or cowpeas and were treated with TCP by shaking them together in a jar for 20 min. Treatments used were at the following TCP concentrations: 0.0, 0.01, 0.05, 0.1, 0.25% (w/w). Each treatment was replicated 5 times.

Fifty unsexed 2-4 day old adults were placed in each treatment jar. Jars were observed every other day to determine when the first F_1 adults emerged. Three weeks later the test was terminated and all the adults counted.

In a second study on the possible contact toxicity of TCP to adults of the three species, tests were conducted in 4 cm dia. PVC petri dishes. The bottom surface of these petri dishes were dusted with a thin layer (50 mg) of TCP. Ten unsexed individuals from each species were placed in treated petri dishes. Each test was replicated 10 times. Appropriate controls were maintained in untreated petri dishes. Observations were continued hourly until all insects were dead.

Tricalcium phosphate used in this study was classified Food Grade with an apparent bulk density of 0.48 and provided by the Monsanto Company, St. Louis, Missouri.

Results

The effects of TCP mixed as a protectant on legume seeds and then presented as a diet to the three bean bruchids are presented in Table 1. At a TCP dose of 0.05% the numbers of F_1 adults that emerged were greatly reduced and the development times were extended for C. maculatus and A. obtectus. At all the higher doses of TCP no F_1 adults were produced by the two species of Callosobruchus and only an occasional individual of A. obtectus was observed. The lowest dose 0.01% of TCP mixed with the beans reduced the number of F_1 adults that emerged. At doses of 0.1% and above no F_1 adults were produced by any species.

Data from tests on the contact action of TCP to the three bruchid species are presented in Table 2. The first mortality for C. chinensis and C. maculatus was noted within 2 hr and complete mortality was observed after 6 hr. The last individual A. obtectus died before the 8 hr examination.

In summary the following conclusions have been drawn: 1) Very low concentrations (1000-2500 ppm) of TCP can be used to protect beans against attack by these bruchids; 2) Concentrations of TCP have a fairly rapid contact insecticide action against these bruchids and 3) the bruchids tested appeared to be much more sensitive to TCP than most stored product insects and mites tested todate where the need concentration is in the range of 20,000-30,000 ppm (Majumder and Bano, 1964; Press et al. 1972; Highland, 1975; and Kruk et al. 1983).

Table 1. Average numbers and their developmental times of F1 progeny emerging from beans treated with various concentrations of TCP.

TCP Concentration % (w/w)	C. maculatus		C. chinensis		A. obtectus	
	No. of F1 adults	Development time (days)[1]	No. of F1 adults	Development time (days)[1]	No. of F1 adults	Development time (days)[1]
0.00	1684 ± 126	22.2 ± 0.2	217 ± 5	26.0 ± 0.0	338 ± 26	35.4 ± 0.2
0.01	1595 ± 155	23.8 ± 0.4	152 ± 21	26.6 ± 0.2	64 ± 16	41.2 ± 0.4
0.05	168 ± 75	27.2 ± 0.4	0	0	3 ± 1	42.0 ± 0.2
0.10	0	0	0	0	1 ± 1	0
0.25	0	0	0	0	0	0

[1] Mean ± S.E. of 5 replicates.

Table 2. Percent mortality of bean weevils per hour of exposure to TCP as a contact treatment.

Exposure time (hrs)	Percent Mortality [1]					
	C. maculatus		C. chinensis		A. obtectus	
	$\bar{x}$	S.E.	$\bar{x}$	S.E.	$\bar{x}$	S.E.
1	100		100		100	
2	89	± 3	98	± 13	100	
3	-		-		-	
4	65	± 5	36	± 7	98	± 13
5	25	± 6	16	± 5	96	± 16
6	0		0		50	± 6
7					22	± 5
8					0	

[1] Mean ± S.E. of 10 replicates (10 adults/rep.).

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Footnotes

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