Effects of Cleaning Peanuts on Insect Damage, Insect Population Growth and Insecticide Efficacy[1]

Frank H. Arthur[2]

ABSTRACT

Farmers stock peanuts were either cleaned by removing foreign material and reducing loose-shell kernels (LSK) or left uncleaned before being treated with insecticides, stored, and artificially infested with several stored peanut insect pest species. The uncleaned peanuts contained only 2.8% foreign material. After 8 and 10 months the percentage of insect-damaged cracked pod kernels was 1.7 to 3.4 X greater in cleaned treated peanuts than in uncleaned treated peanuts, and there was a direct inverse relationship between the number of LSK and the percentage of damaged cracked pod kernels. After 8 and 10 months, the percentage of damaged cracked pod kernels in each class of peanuts, cleaned and uncleaned, was 1.6-5.7 X greater in peanuts treated with 52 ppm malathion than in peanuts treated with either 25 ppm chlorpyrifos-methyl or 25 ppm chlorpyrifos-methyl + 4 ppm methoprene. A significant difference in insect populations between cleaned and uncleaned peanuts occurred in untreated peanuts after two months, when almond moth and Indianmeal moth populations were greater in uncleaned peanuts. Thus, even a small amount of foreign material may provide a hospitable habitat for insect population growth. There were no significant differences in either insect damage or insect populations between chlorpyrifos-methyl and chlorpyrifos-methyl + methoprene.

Key Words: Storage, loose-shell kernels, LSK.

The three major insect pests species of stored peanuts, the almond moth, *Cadra cautella* (Walker); the Indianmeal moth, *Plodia interpunctella* (Hubner); and the red flour beetle, *Tribolium castaneum* (Herbst) feed only on loose shelled kernels (LSK) and kernels inside cracked pods. They cannot usually penetrate solid pods. Stored peanuts usually contain varying amounts of LSK and foreign material (weeds, twigs, rocks, dirt, etc). The LSK are highly susceptible to insect damage (9) and quality deterioration during storage (11). Excessive amounts of foreign material may inhibit aeration through the peanut stack (6). Cleaning peanuts prior to storage is recommended, but in many cases peanuts are not cleaned before storage, especially in loads with a low percentage of LSK and foreign material.

Arthur and Redlinger (2) showed that cleaned peanuts experienced a greater percentage of damaged cracked pod kernels than peanuts containing combinations of either 5% LSK-10% foreign material (FM) or 10% LSK 20% FM. However, total insect populations were greater in both LSK-FM combinations than in the clean peanuts. Because the insect pests can apparently shift between the two available food sources, it is important to determine the degree of correlation between LSK and cracked pod kernels. In addition, there are no published data concerning the effects of small amounts of foreign material on insect population growth. Such information would be extremely useful in insect pest management programs.

Methoprene, isopropyl (E,E) 11-methoxy-3,7,11-trimethyl-2-4-dodecadieneoate, is an insect growth regulator (IGR) labelled for direct application to stored peanuts at the rate of 10 ppm. This insecticide is not widely used by the peanut industry, because it is more expensive than traditional insecticide such as malathion. Also, a time delay is required for insects to ingest the toxin, though methoprene may have some contact toxicity (12).

Some of the advantages of methoprene include low mammalian toxicity and long residual activity against insect pests. Reducing the application rate of methoprene and combining it with a more traditional insecticide may alleviate the time delay involved with using methoprene as a peanut protectant.

One possible combination treatment is the organophosphate insecticide chlorpyrifos-methyl, 0,0-dimethyl 0-(3,5,6-trichloro-2-pyridyl) phosphorothioates, and methoprene. Chlorpyrifos-methyl is registered for small grains and has been evaluated as a protectant of stored peanuts (3,1), and the proposed labelled rate for stored peanuts is 25 ppm. Therefore, the objectives of this test were: 1) to determine if insect damage in cracked pod kernels is directly correlated with the number of available LSK; 2) to determine if a small amount of foreign material would affect insect population growth; and 3) to determine if a combination of 25 ppm chlorpyrifos-methyl + 4 ppm methoprene would be a more effective protectant than 25 ppm chlorpyrifos-methyl alone.

Materials and Methods

This test was conducted at the USDA Stored Product Insects Research and Development Laboratory, Savannah GA. Approximately 1,818 kg of Segregation II runner variety farmers stock peanuts were cleaned using a cleaner purchased from the Federal-State Inspection Service. This machine removed most of the LSK and all of the foreign material. The amount of foreign material in the uncleaned peanuts was 2.8± 0.6% by weight. An additional 1,818 kg of peanuts were left uncleaned. Chlorpyrifos-methyl applied at the rate of 25 ppm and a combination of 25 ppm chlorpyrifos-methyl + 4 ppm methoprene were evaluated against a standard treatment of 52 ppm malathion, diethyl [(dimethoxy phosphinothioyl) thio] butanedioates and an untreated control. Chlorpyrifos-methyl was formulated from a 43.2% E (1.82 kg AI/3.785 L); methoprene was formulated from a 65.7% E (2.27 kg AI/3.785 L); and malathion was formulated from a 57.7% EC (2.27 kg AI/3.785 L).

The experimental design was a two-way factorial with cleaning and insecticide treatment as main effects. The insecticides were applied 21-24 October 1987, at the rate of 125 ml of formulated spray per 90 kg of peanuts (one replicate). This rate is proportional to the field spray rate for malathion, 18.92 L of formulated spray per 13,636 kg of peanuts. Untreated controls were sprayed with distilled water. Each insecticide treatment was replicated four times in both cleaned and uncleaned peanuts. A modified spray system equipped with a Teejet nozzle #730023 was used to treat the peanuts as they fell from a conveyor into a hopper cart. After each replicate was treated it was mixed by transferring the peanuts three times from one hopper-bottom cart to another. The 90 kg were then divided into six cardboard boxes containing approximately 15 kg each. All boxes were transferred to an insulated metal shed and stored under ambient conditions.

After storage, 200 almond moth eggs, 200 Indianmeal moth eggs, and 50 one to two week old adult red flour beetles were put in each box. All insects were obtained from pesticide-susceptible colonies maintained at

[1]This paper reports the results of research only. Mention of a pesticide or a proprietary produce does not constitute a recommendation or endorsement by the USDA.

[2]U.S Department of Agriculture, Agricultural Research Service Stored-Product Insects Research and Development Laboratory, P.O. Box 22909, Savannah, GA 31403.

the laboratory. Peanuts were sampled at 1, 2, 4, 6, 8, and 10 months post-application, and a different box from each class, cleaned and uncleaned, was sampled at each interval. When a box was sampled two 1 kg samples were taken, one from the surface and one from the whole box. Surface samples were taken by removing the entire top layer of the box to a depth of 7.6 cm. Whole-box samples were taken by using a peanut sample divider to continually halve the remaining peanuts to obtain approximately 1 kg. All live insects in each 1 kg sample were recorded, then half of each sample was held under laboratory conditions (28 C, 40% RH) for 42 days. The 500 g samples were then again examined for live insects and the counts were combined with those obtained initially. All LSK and kernels from 100 cracked pods in the remaining 500 g from each sample were examined for insect damage. After sampling, new insects from the stock cultures were reintroduced into the remaining boxes and samples were processed as described above.

Data for insect damage and insect populations from both samples (top and bottom) in one box were averaged. Data were analyzed using the GLM Procedure of the Statistical Analysis System (10) to determine significant differences between cleaned and uncleaned peanuts and among insecticide treatments within each class of peanuts. The relationship between the numbers of LSK and cracked-pod kernel damage in untreated peanuts was estimated using the separate data in each sample (top and bottom) in each class of peanuts. The Regression Procedure of SAS was used to describe this relationship by calculating a series of linear equations for each sample date.

Results

The analysis showed that cleaning and insecticide treatment were highly significant ($F = 98.7$, df = 1,336, $P = 0.01$ and $F = 255.8$, df = 3,336, $P = 0.01$, respectively), but there was no significant interaction between the two ($F = 2.4$, df = 3,336, $P = 0.06$). Damaged, cracked-pod kernels in untreated peanuts steadily increased during the test, but there were no significant difference between cleaned and uncleaned peanuts for the first six months (Table 1). After 8 months the percentage of damaged, cracked-pod kernels in cleaned peanuts was significantly greater than the percentage of damaged kernels in uncleaned peanuts. Two months later, damage in cleaned and uncleaned peanuts increased to 12.0 ± 0.68 and 8.0 ± 0.44%, respectively.

The average number of LSK in the 500 g samples from cleaned and uncleaned untreated peanuts was 7.0 ± 0.27 and 17.0 ± 0.77, respectively. The relationship between the number of LSK and the percentage of damaged, cracked-pod kernels is illustrated in a series of graphs (Fig. 1). The graphs show the progressive increase in cracked-pod kernel damage, but more importantly, they show a direct inverse relationship between the number of LSK and the percentage of damaged, cracked-pod kernels. Samples from uncleaned peanuts had less cracked pod kernel damage than samples from cleaned peanuts. There was a linear correlation between the number of LSK and the percentage of damaged, cracked-pod kernels, particularly during the final six months.

Within each class of peanuts, cleaned and uncleaned, there were no significant differences among the three chemical treatments for the first six months (Table 1). After 8 months the percentage of insect-damaged, cracked-pod

Table 1. Percentage of insect-damaged kernels in cracked pods from cleaned and uncleaned peanuts treated with insecticides.

Insecticide Treatment[1]	Insect-damaged kernels (%) at Month Post-Treatment[2]					
	1		2		4	
	cleaned	uncleaned	cleaned	uncleaned	cleaned	uncleaned
control	0.6 ± 0.19a	0.3 ± 0.14a	3.0 ± 0.36a	2.6 ± 0.30a	3.6 ± 0.41a	3.3 ± 0.38a
CM	0.1 ± 0.06b	0.1 ± 0.07b	0.3 ± 0.22b	0.2 ± 0.20b	0.7 ± 0.37b	0.4 ± 0.22b
CM+methoprene	0.3 ± 0.10ab	0.1 ± 0.08a	0.7 ± 0.35b	0.3 ± 0.14b	1.1 ± 0.43b	0.5 ± 0.25b
malathion	0.7 ± 0.20a	0.5 ± 0.22a	*1.5 ± 0.23b	*0.7 ± 0.18b	1.8 ± 0.37b	1.3 ± 0.27b
	6		8		10	
	cleaned	uncleaned	cleaned	uncleaned	cleaned	uncleaned
control	5.4 ± 0.74a	4.6 ± 0.63a	*8.0 ± 0.86a	*4.7 ± 0.37a	*12.0± 0.68a	*8.0 ± 0.44a
CM	0.8 ± 0.32b	0.3 ± 0.20b	*1.7 ± 0.49c	*0.4 ± 0.12c	* 2.7± 0.65d	*0.8 ± 0.15c
CM+methoprene	1.4 ± 0.51b	0.8 ± 0.31b	*3.0 ± 0.33bc	*0.9 ± 0.39c	* 4.6± 0.34c	*1.8 ± 0.56c
malathion	1.9 ± 0.28b	1.4 ± 0.23b	*3.6 ± 0.53b	*2.1 ± 0.27b	* 7.5± 0.48b	*4.5 ± 0.31b

[1]Control = distilled water; cm = chlorpyrifos-methyl at 25 ppm, cm + methoprene = CM at 25 ppm + methoprene at 4 ppm; malathion = malathion at 52 ppm.

[2]Mean ± SEM, means within rows followed by the same letter are not significantly different (P + 0.05, Duncan's Multiple Range Test [PROC GIM, SAS Institute].

*Means between columns are significantly different (P = 0.05, Duncan's Multiple Range Test).

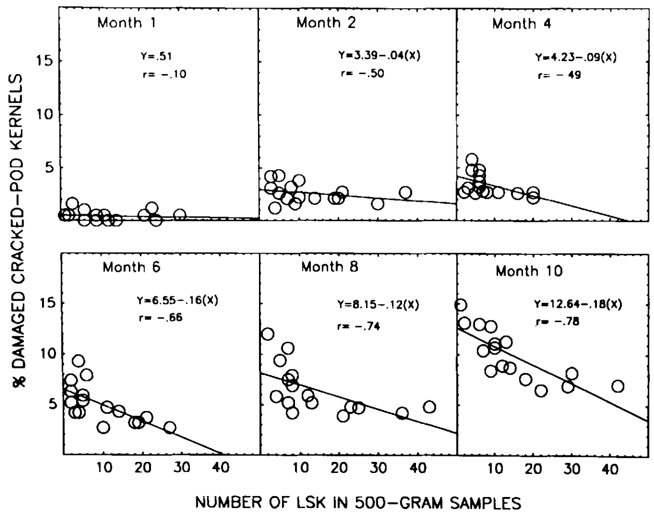

Fig. 1. Linear regression for the percentage of damaged cracked pod kernels against the number of LSK in the sample (Y = % damage, r = correlation coefficient).

kernels was significantly greater in cleaned and uncleaned peanuts treated with malathion than in cleaned and uncleaned peanuts treated with chlorpyrifos-methyl. Two months later, cracked pod kernel damage in malathion-treated cleaned and uncleaned peanuts increased, but the level of damaged in cleaned and uncleaned peanuts treated with chlorpyrifos-methyl remained relatively low. Cracked-pod kernel damage in peanuts treated with chlorpyrifos-methyl + methoprene was never significantly different from that in peanuts treated with chlorpyrifos-methyl alone. With the exception of the malathion treatment after two months, there were no significant differences in cracked-pod kernel damage between cleaned and uncleaned peanuts for the first six months (Table 1). In all three chemical treatments, the percentage of damaged, cracked-pod kernels was significantly greater in cleaned peanuts than in uncleaned peanuts after 8 and 10 months.

Loose shell kernels in uncleaned peanuts were very susceptible to insect damage (Table 2). By the end of the test, the level of damage in untreated peanuts had increased to 64.1±5.63%. After 4 months, LSK damage was significantly greater in peanuts treated with malathion than in peanuts treated with chlorpyrifos-methyl, and remained so for the duration of the test. LSK damage in peanuts treated with chlorpyrifos-methyl + methoprene was never significantly lower than LSK damage in peanuts treated with chlorpyrifos-methyl alone.

After two months, almond moth populations in uncleaned peanuts were significantly greater than almond moth populations in cleaned peanuts (Table 3). The same was true for Indianmeal moth population (Table 4). Within each class of peanuts, cleaned and uncleaned, there were few significant differences in insect populations among the three chemical treatments. At 10 months, red flour beetle populations in cleaned and uncleaned peanuts treated with malathion were significantly greater than red flour beetle populations in cleaned and uncleaned peanuts treated with chlorpyrifos-methyl (Table 5). Live insects were rarely found in peanuts treated with either chlorpyrifos-methyl or chlorpyrifos-methyl + methoprene, and there were no significant differences in insect populations between these two treatments.

Discussion

The direct relationship between the number of LSK and the percentage of damaged, cracked-pod kernels is not surprising, because these are the only kernels accessible to stored peanut insect pests. Reducing LSK prior to storage may not affect the total amount of peanut kernels damaged by insects, because the pests can shift to the cracked-pod kernels. However, it is still advisable to limit the amount of LSK that are present during storage, because of the susceptibility of LSK to both insect damage and quality deterioration. At the conclusion of the test, the percentage of insect-damaged LSK and cracked-pod kernels was

Table 2. Percentage of insect-damaged loose-shell kernels in uncleaned peanuts treated with insecticides.

	Insect-damaged LSK (%) at Month Post-Treatment[2]					
Insecticide Treatment[1]	1	2	4	6	8	10
control	5.3 ± 4.16a	34.9 ± 4.51a	37.8 ± 3.73a	50.0 ± 1.89a	55.4 ± 2.87a	64.1 ± 5.63a
CM	0.0 ± 0.00a	2.7 ± 1.88b	7.5 ± 3.54c	6.5 ± 3.15c	10.5 ± 2.15c	14.4 ± 1.71c
CM+methoprene	0.0 ± 0.00a	5.9 ± 3.27b	5.2 ± 4.14c	7.3 ± 4.29c	14.6 ± 3.46c	21.3 ± 2.57bc
malathion	5.9 ± 3.87a	8.5 ± 3.24b	22.0 ± 2.78b	23.8 ± 4.10b	26.4 ± 4.06b	30.9 ± 4.73b

[1]Control = distilled water, CM = chlorpyrifos-methyl at 25 ppm; CM + methoprene = CM at 25 ppm + methoprene at 4 ppm; malathion = malathion at 52 ppm.

[2]Mean ± SEM, means within rows followed by the same letter are not significantly different (P = 0.05, Duncan's Multiple Range Test).

Table 3. Number of live almond moths in 1 kg samples from cleaned and uncleaned peanuts treated with insecticides.

Insecticide Treatment[1]	Number of Almond Moths at Month Post-Treatment[2]					
	1		2		4	
	cleaned	uncleaned	cleaned	uncleaned	cleaned	uncleaned
control	0.7 ± 0.37a	0.2 ± 0.16a	*12.6 ± 2.10a	*23.0 ± 4.30a	1.4 ± 0.42a	3.7 ± 1.73a
CM	0.0 ± 0.00b	0.2 ± 0.00a	0.0 ± 0.00a	0.0 ± 0.00b	0.0 ± 0.00b	0.0 ± 0.00b
CM+methoprene	0.0 ± 0.00b	0.0 ± 0.00a	0.0 ± 0.00a	0.0 ± 0.12b	0.0 ± 0.00b	0.0 ± 0.00b
malathion	0.0 ± 0.00b	0.0 ± 0.00a	6.7 ± 5.21ab	0.6 ± 0.50b	0.5 ± 0.19b	0.0 ± 0.00b
	6		8		10	
	cleaned	uncleaned	cleaned	uncleaned	cleaned	uncleaned
control	0.2 ± 0.16a	2.2 ± 1.98a	2.1 ± 0.89a	6.0 ± 2.16a	0.3 ± 0.26a	0.1 ± 0.12a
CM	0.0 ± 0.00a	0.0 ± 0.00a	0.8 ± 0.23a	0.2 ± 0.16a	0.1 ± 0.12a	0.1 ± 0.12a
CM+methoprene	0.8 ± 0.00a	0.1 ± 0.12a	0.0 ± 0.00a	0.3 ± 0.18a	0.6 ± 0.26a	0.1 ± 0.12a
malathion	0.0 ± 0.00a	0.0 ± 0.00a	3.1 ± 1.44ab	5.5 ± 2.53a	0.3 ± 0.18a	0.1 ± 0.12a

[1]Control = distilled water; CM = chlorpyrifos-methyl at 25 ppm; CM + methoprene = CM at 25 ppm + methoprene at 4 ppm; malathion = malathion at 52 ppm.

[2]Mean ± SEM, means within rows followed by the same letter are not significantly different (P = 0.05, Duncan's Multiple Range Test).

*Means between columns are significantly different (P=0.05, Duncan's Multiple Range Test).

Table 4. Number of live Indianmeal moths in 1 kg samples from cleaned and uncleaned peanuts treated with insecticides.

Insecticide Treatment[1]	Number of Indianmeal Moths at Month Post-Treatment[2]					
	1		2		4	
	cleaned	uncleaned	cleaned	uncleaned	cleaned	uncleaned
control	1.4 ± 0.32a	0.7 ± 0.25a	*11.1 ± 3.09a	*24.5 ± 5.28a	6.2 ± 1.68a	5.6 ± 1.95a
CM	0.0 ± 0.00a	0.01 ± 0.00b	0.0 ± 0.00b	0.0 ± 0.00b	0.0 ± 0.00b	0.0 ± 0.00a
CM+methoprene	0.0 ± 0.00b	0.0 ± 0.00b	0.1 ± 0.12b	0.1 ± 0.12b	0.0 ± 0.00b	0.8 ± 0.00a
malathion	0.0 ± 0.00b	0.0 ± 0.00b	0.0 ± 0.00b	0.0 ± 0.00b	0.2 ± 0.16b	0.0 ± 0.00a
	6		8		10	
	cleaned	uncleaned	cleaned	uncleaned	cleaned	uncleaned
control	1.1 ± 0.40a	2.2 ± 1.01a	4.9 ± 1.52a	6.5 ± 1.51a	0.0 ± 0.00a	2.0 ± 1.45a
CM	0.0 ± 0.00a	0.0 ± 0.00b	0.4 ± 0.37b	0.0 ± 0.48b	0.1 ± 0.12a	0.0 ± 0.00a
CM+methoprene	0.8 ± 0.40a	1.2 ± 0.49ab	0.5 ± 0.27b	0.5 ± 0.27b	0.1 ± 0.12a	0.1 ± 0.12a
malathion	0.0 ± 0.00b	0.2 ± 0.16b	1.7 ± 0.37b	1.7 ± 0.31a	0.3 ± 0.26a	0.6 ± 0.26a

[1]Control = distilled water; CM = chlorpyrifos-methyl at 25 ppm; CM + methoprene = CM at 25 ppm + methoprene at 4 ppm; malathion = malathion at 52 ppm.

[2]Mean ± SEM, means within rows followed by the same letter are not significantly different (P = 0.05, Duncan's Multiple Range Test).

*Means between columns are significantly different (P=0.05, Duncan's Multiple Range Test).

Table 5. Number of live red flour beetles in 1 kg samples from cleaned and uncleaned peanuts treated with insecticides.

Insecticide Treatment[1]	Number of Red Flour Beetles at Month Post-Treatment[2]					
	1		2		4	
	cleaned	uncleaned	cleaned	uncleaned	cleaned	uncleaned
control	1.5 ± 0.38a	0.5 ± 0.27a	2.0 ± 0.38a	0.8 ± 0.29a	0.5 ± 0.27ab	0.2 ± 0.25a
CM	0.0 ± 0.00b	0.0 ± 0.00b	0.0 ± 0.00b	0.0 ± 0.00b	0.0 ± 0.00b	0.0 ± 0.00a
CM+methoprene	0.0 ± 0.00b	0.0 ± 0.00b	0.0 ± 0.00b	0.0 ± 0.00b	0.0 ± 0.00b	0.0 ± 0.00b
malathion	0.6 ± 0.26b	0.1 ± 0.12b	0.0 ± 0.00b	0.1 ± 0.12b	0.1 ± 0.12b	0.1 ± 0.12a
	6		8		10	
	cleaned	uncleaned	cleaned	uncleaned	cleaned	uncleaned
control	0.0 + 0.00a	1.8 + 1.46a	1.8 ± 0.44a	2.5 ± 0.53a	9.1 ± 1.83a	6.5 ± 0.94a
CM	0.0 ± 0.00a	0.0 ± 0.00a	0.0 ± 0.00b	0.0 ± 0.00b	0.7 ± 0.31b	0.5 ± 0.33b
CM+methoprene	0.0 ± 0.00a	0.0 ± 0.00a	0.0 ± 0.00b	0.0 ± 0.00b	0.2 ± 0.36b	0.7 ± 0.31b
malathion	0.1 ± 0.12a	0.0 ± 0.00a	1.7 ± 0.37a	1.7 ± 0.31a	6.5 ± 1.05a	5.7 ± 1.74a

[1]Control = distilled water; CM = chlorpyrifos-methyl at 25 ppm; CM + methoprene = CM at 25 ppm + methoprene at 4 ppm; malathion = malathion at 52 ppm.

[2]Mean ± SEM, means within rows followed by the same letter are not significantly different (P = 0.05, Duncan's Multiple Range Test).

significantly lower in peanuts treated with chlorpyrifos-methyl than in peanuts treated with malathion, but the combination of chlorpyrifos-methyl + methoprene was no more effective than chlorpyrifos-methyl alone and showed little potential for use in a pest management program for stored peanuts.

Insects were regularly and systematically introduced to the treated peanuts throughout the storage season, but populations of all three species declined during the winter months. After temperatures warmed in the Spring, red flour beetle populations increased and almond moth and Indianmeal moth populations decreased. The red flour beetle is a mobile, aggressive predator that can severely limit moth populations by feeding on eggs and larvae (8). In my test, kernel damage steadily increased even though live moths were not recovered in extensive numbers during the latter months.

Almond moth and Indianmeal moth populations were most abundant in December, when nearly twice as many moths of each species were found in uncleaned, untreated peanuts than in cleaned, untreated peanuts. Even though the amount of foreign material in the uncleaned peanuts was rather low, results were similar to those obtained in an earlier test in which foreign material was added to farmers stock peanuts to produce lots containing 10 and 20% foreign material (2). Peanuts which contain less than 10% foreign material are not usually cleaned before storage (5), but results of my test show that even a small amount of foriegn material may provide a suitable habitat for insect population growth. Therefore, removing this extraneous material before peanuts are stored may help limit pest population growth, especially during the warm, fall months.

Insect control in stored peanuts is an important management concern, especially because malathion resistance has increased to the point that control failures are expected (13,7,4). Because malathion is no longer effective as a protectant, increased emphasis should be placed on improving the quality of stored peanuts through physical and non-chemical control. Thoroughly cleaning peanuts may limit moth populations during the initial months of storage, when infestations are most likely to develop. Insect pest populations are also developing resistance to both dichlorvos (7,4), which is commonly used as a headspace treatment in warehouses and processing plants, and to phosphine fumigant (14). With the current shortage of effective insecticides, management programs that would integrate non chemical controls with the currently available chemicals should be developed for stored peanuts.

Acknowledgment

The author would like to thank J. E. O'Bryan for his excellent technical assistance. J. H. Brower, W. V. Campbell, H. B. Gillenwater, J. G. Leesch, and M. A. Mullen reviewed earlier drafts of this manuscript.

Literature Cited

1. Arthur, F. H. 1989. Pests of stored peanuts: toxicity and persistence of chlorpyrifos-methyl. J. Econ. Entomol. 82:660-664.
2. Arthur, F. H. and L. M. Redlinger. 1988. Influence of loose-shell kernels and foreign material on insect damage in stored peanuts. J. Econ. Entomol. 81:387-390.
3. Arthur, F. H., L. M. Redlinger and R. A. Simonaitis. 1988a.

Chlorpyrifos-methyl as a protectant of farmers stock peanuts. Peanut Sci. 15:15-18.
4. Arthur, F. H., J. L. Zettler and W. R. Halliday. 1988b. Insecticide resistance among populations of almond moth and Indianmeal moth (Lepidoptera: Pyralidae) in stored peanuts. J. Econ. Entomol. 81:1283-1287.
5. Blakenship, P. D. and J. H. Young. 1982. Evaluation of cleaning farmers stock peanuts prior to marketing. Peanut Sci. 9:33-35.
6. Dickens, J. W. 1984. Screening Virginia-type farmers stock peanuts before storage. Peanut Sci. 11:13-16.
7. Halliday, W. R., F. H. Arthur and J. L. Zettler. 1988. Resistance status of red flour beetle (Coleoptera: Tenebriondae) infesting stored peanuts in the Southeastern United States. J. Econ. Entomol. 75:359-362.
8. LeCato, G. C. 1975. Interactions among four species of stored product insects in corn: a multifactored study. Ann. Entomol. Soc. Am. 68:677-679.
9. Redlinger, L. M. and R. A. Simonaitis. 1977. Field tests with pirimiphos-methyl as a protectant for farmers stock peanut. Peanut Sci. 8:121-124.
10. SAS Institute. 1987. SAS/STAT(R) Guide for personal computers, Version 6 Edition. SAS Institute, Inc., Cary, NC.
11. Sanders, T. H., J. S. Smith, Jr., J. A. Lansden and J. I. Davidson, Jr. 1981. Peanut quality changes associated with deficient warehouse storage. Peanut Sci. 8:121-124.
12. Vick, K. W., J. A. Coffelt, D. L. Silhacek and H. Oberlander. 1985. Methoprene and sex pheromone as control agents for the almond moth (Lepidoptera: Pyralidae) on peanuts stored in the shell. J. Econ. Entomol. 78:258-262.
13. Zettler, J. L. 1982. Insecticide resistance in selected stored-product insects infesting peanuts in the Southeastern United States. J. Econ. Entomol. 75:359-362.
14. Zettler, J. L., W. R. Halliday and F. H. Arthur. 1989. Phosphine resistance in insects infesting stored peanuts in the Southeastern United States. J. Econ. Entomol. 82:1508-1511.

Accepted October 21, 1989