Preharvest Infestation of Cowpeas by the Cowpea Weevil (Coleoptera: Bruchidae) and Population Trends during Storage in Florida

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J. Econ. Entomol. 78: 358–361 (1985)

ABSTRACT An examination of 62 one-bushel bags of cowpeas, representing 49 different fields, revealed an extremely low preharvest infestation level (mean 2.33 *Callosobruchus maculatus* [F.] adults) emerging per bushel per 2 weeks of storage. From similar initial infestation levels, populations either slowly dwindled away or after an 18-week delay increased exponentially.

INFESTATION in the field is well documented for four species of stored-product insects that feed within the seed and are not removed during harvest (Table 1). For these pests the combine can serve as a mass sampling tool that facilitates studies of extremely low population densities.

In the field before harvest, *Callosobruchus maculatus* (F.) lays eggs on cowpea pods and the larvae burrow through the chorion of the egg directly into the pod wall, and then through the pod wall and seed coat into the seed, where the larvae develop and pupate (Prevett 1961, Booker 1967, Schalk and Rassoulian 1973). When infestation in the field is important, pod resistance to oviposition or penetration, in addition to seed resistance, could be a viable management option for this storage pest.

The *C. maculatus* that infest cowpeas in the warehouse emerge later than those that infest cowpeas in the field, and this delay is temperature dependent. El-Sawaf (1956) reported developmental times from egg to adult of 140, 58, 43, and 24 days at 18, 21, 25, and 30°C; Howe and Currie (1964) reported 47, 36, and 24 days at 22.5, 25, and 30°C. Delays could thus easily be 14 to 42 days.

We have taken advantage of delays to quantify the levels of infestation before harvest and have demonstrated the validity of this approach by collecting cowpea samples directly from the combine during harvest and protecting them from further infestation. The population trends of *C. maculatus* during storage in 1-bu bags of cowpeas were followed also.

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Materials and Methods

The initial levels and population trends of *C. maculatus* infesting cowpeas received at a warehouse near Live Oak, Fla., for drying, cleaning, bagging, and storage were studied by periodically removing adult insects from 1-bu bags of cowpeas using the sieving table shown in Fig. 1. A 1-bu bag of cowpeas was placed on the platform with the open end towards the screen. As the cowpeas were slowly released from the bag, the suspended screen was moved back and forth. The cowpeas moved down the inclined, shaking screen and into the funnel (B) at the opposite end and the bruchids dislodged from the cowpeas fell into the funnel (A) below the screen and were collected in a jar of alcohol at the bottom (which is not shown in Fig. 1). The cowpeas were sieved every 2 weeks for the first 6 weeks of storage. During the second year of the study, cowpeas also were sieved every 2 weeks from the fourteenth to thirtieth week of storage. Preliminary observations had indicated that emergence was low before the eighteenth week of storage.

During both years, a 1-bu bag from each lot of cowpeas received at the warehouse was set aside for study. Since the average lot size was 200 1-bu bags (range 22–1,182 bags), a single bag represented on the average 0.5% of a lot. A total of 62 bags, 26 the first year and 36 the second, representing 49 different fields, were examined. Most of these cowpeas were a mix of the 'Iron' and 'Clay' cultivars, but during the first year 11 bags contained cowpeas of the 'Pinkeye Purplehull' cultivar.

During the second year of the study an additional 1-bu sample from 13 of 23 fields was col-

Table 1. Records of infestation of crops in the field by stored-product insects

Species	Crop	Location	Reference
Sitotroga cerealella (Oliver)			
Angoumois grain moth	Wheat	Maryland	Simmons (1927)
	Corn	South Carolina	Cartwright (1939)
	Rice	Louisiana	Douglas (1941)
	Corn	Louisiana	Floyd et al. (1959)
	Corn	Georgia	Blickenstaff (1960)
	Corn	Indiana	Russell (1962)
	Maize	Australia	Turner (1976)
Sitophilus zeamais Motschulsky			
Maize weevil	Corn	South Carolina	Cartwright (1939)
	Corn	Louisiana	Floyd et al. (1959)
	Maize	Kenya	Giles and Ashman (1971)
	Maize	Australia	Turner (1976)
Callosobruchus maculatus (F.)			
Cowpea weevil	Cowpeas	South Africa	Oosthuizen and Laubscher (1940)
	Cowpeas	Nigeria	Prevett (1961)
	Cowpeas	Nigeria	Booker (1967)
Acanthoscelides obtectus (Say)			
Common bean weevil	Beans	California	Larson (1932)

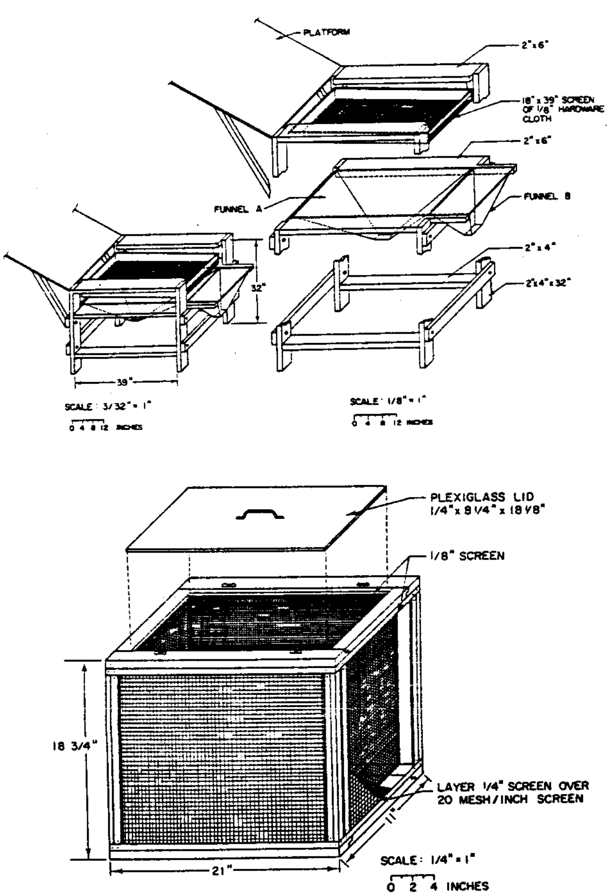

Fig. 1. Sieving table used to separate bruchids from cowpeas (top) and the double-walled screen cage used to protect cowpeas from bruchid oviposition during drying (bottom).

lected during harvest as the combine was emptied in the field (field samples). These samples were sealed in a double-walled screen cage (Fig. 1) to protect the cowpeas from further infestation during drying. After drying, these samples were taken to another location in the double-walled screen cages for bagging and monitoring of population levels. The remaining samples processed in the warehouse the second year (warehouse samples) also were taken to this location after drying and bagging to prevent any further infestation during population monitoring.

The GLM and TTEST procedures of the statistical analysis system (SAS Institute 1982) were used to analyze the data.

Results

Infestation in the field resulted in a mean number of 2.3 (SD = 6.0, $n = 166$) *C. maculatus* emerging from a bushel of cowpeas during a 2-week period. The range for the 62 bushels of cowpeas that were checked was 0 to 55, but in most cases fewer than 3 emerged (Fig. 2). Mean number emerging did not vary significantly ($P <$ 0.01) among the first three 2-week periods of storage (6.3 versus 2.8 versus 1.6; $P = 0.29$; F = 1.24; df = 2,160) nor between years (3.6 for first versus 1.4 for second; $P = 0.029$; $t = 2.213$; df = 108) or cultivars (4.9 for 'Pinkeye Purplehull' versus 2.6 for 'Iron-Clay'; $P = 0.26$; $t = 1.139$; df = 40). With statistically indistinguishable initial populations (1.3 versus 1.6 adults emerging per bushel per 2 weeks of storage; $P = 0.77$; $t = 0.292$; df = 86), two significantly different types of population trends were observed (Fig. 3): those with fewer than 60 adults emerging over the 30-week storage period because populations slowly dwindled away or those with more than 250 because populations increased ex-

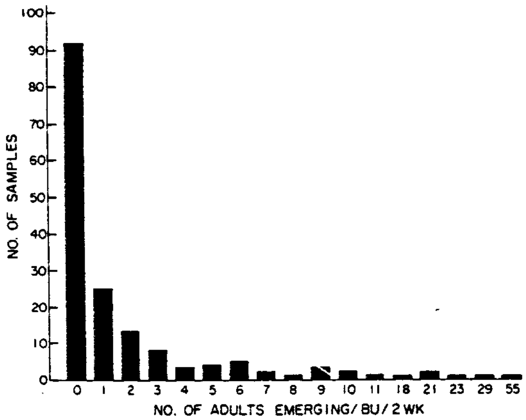

Fig. 2. Frequency distribution of the number of adult *C. maculatus* (F.) emerging from a bushel of cowpeas during a 2-week period. Data were not significantly different ($P < 0.01$) for the 2 years of the study ($P = 0.029$) or for the first three 2-week periods of storage ($P = 0.29$) and therefore these data have been pooled.

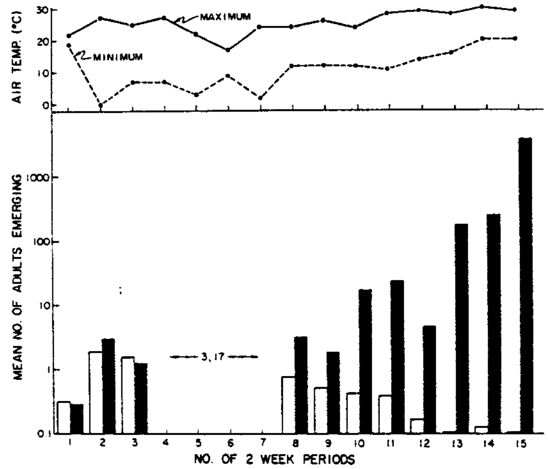

Fig. 3. Mean population trends during the second year of the study for the emergence of adult *C. maculatus* (F.) from cowpeas stored in 1-bu bags. Data for bags with fewer than 60 adults emerging during the 30-week storage period ($n = 27$, open bars) were plotted separately from data for bags with more than 250 adults emerging ($n = 9$, solid bars); between the sixth and fourteenth weeks, a mean of 3 and 17 adults emerged, respectively. Seasonal changes in the air temperatures in the vicinity of bags are also shown.

ponentially after an 18-week delay. A three-way analysis of variance showed that emergence varied significantly between trends ($P = 0.0001$; $F = 42.43$; df = 1,319) and over time ($P = 0.0001$; $F = 11.15$; df = 11,319), but not between warehouse and field samples ($P = 0.21$; $F = 1.59$; df = 1,319). The interaction between trends and time ($P = 0.0001$; $F = 32.08$; df = 11,319) and three-way interaction ($P = 0.0018$; $F = 2.80$; df = 11,319) were significant ($P < 0.01$), but not the interactions between type of sample and trends ($P = 0.042$; $F = 4.16$; df = 1,319) or time ($P = 0.38$; $F = 1.08$; df = 11,319). The emergence from field samples was thus not significantly different from that from warehouse samples for both trends over the entire storage period.

Discussion

This study demonstrates the need to consider infestation by *C. maculatus* before harvest and provides the methods for using very large samples to study these infestations by this and other storage pests. The emergence of an average of only 2.33 *C. maculatus* adults from a bushel of cowpeas within a 2-week period means that initial infestations were extremely low. This is equivalent to roughly 1 seed in 100,000 damaged by *C. maculatus*. The 1 or 2 bu of cowpeas per acre left in the field as a result of combine inefficiency were probably infested at the same levels and this may be important in carrying over the population from one crop year to the next.

The inability of adults to find mates at these low population densities may be part of an explanation for the divergent trends originating from statistically indistinguishable initial population levels. Low temperatures apparently delayed adult emergence and population levels remained low for the first 18 weeks of storage. The peak in adult emergence between the eighteenth and twenty-second week of storage was probably the second-generation offspring of *C. maculatus* infesting the cowpeas in the field. If so, all of the *C. maculatus* adults emerging before the eighteenth week of storage could have been from the initial field infestation and differences in emergence between the sixth and eighteenth week could have determined trend. The relationship between the discrete second- and third-generation peaks suggests a generation time of 6 weeks and a roughly 10-fold increase in population density during this period. The fourth generation may not have yet peaked at 30 weeks. Because the population trends of stored-product insects have rarely been studied under commercial storage conditions and since such studies were previously unavailable for *C. maculatus*, my studies are a critical first step towards understanding the population dynamics of *C. maculatus* in particular and stored-product insects in general.

Infestion in the field means that warehouse sanitation alone cannot control these storage pests. In fact, the infestation levels observed here were sufficient to obscure the effectiveness of a good warehouse sanitation program and might reduce incentive to practice good sanitation. Knowing that infestation in the field is important, there are other management options that can be considered before harvest for this and perhaps other storage pests. For example, insecticide applications before harvest and pod resistance factors might be viable options. Bagging, as opposed to bulk storage, of cowpeas subdivides the *C. maculatus* population, leaving some of the bags uninfested, but may also restrict the use of protectants. If insecticides are applied during bagging, these chemicals may degrade before beetles emerge, thus reducing effectiveness of the toxins, although low temperatures should slow breakdown. Rebagging would be required for further applications. At least some lots of cowpeas will require some kind of insect control measures if they are to be stored until spring. The delayed development of an infestation, originating in the field, can result in warehousers shipping cowpeas that seem to be insect-free, but arrive infested.

Acknowledgment

I thank two seed warehousers, Cheri Gregory Brodeur and Randy Dasher, and many farmers for their cooperation which made the project possible. The dedication of Lloyd R. Davis, Jr., in collecting the data is gratefully acknowledged. I also thank Jeannie Streeter for preparing the illustrations, and Sandy Mathewson for typing the manuscript.

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Received for publication 28 August 1984; accepted 9 November 1984.