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Short communication

Solar heating of seeds — a low cost method to control bruchid (*Callosobruchus* spp.) attack during storage of pigeonpea

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Abstract

Bruchids (*Callosobruchus* spp.) are major storage pests of legume crops grown in the tropics and sub-tropics including pigeonpea (*Cajanus cajan* (L.) Millsp.) and cause considerable economic losses. Solar heating of seeds in transparent polyethylene bags was found to effectively control bruchid damage in seeds of a medium-duration pigeonpea cultivar (ICPL 87119) during prolonged storage. During a week of observation, solar heating raised the temperature in seed bags to 65°C each day. Solar heat-treated seeds remained free from bruchid damage even after 41 weeks of storage. No reduction in seed germination was observed in the solar-heated seeds. The control treatment had up to 91% of bruchid damaged seeds and their germination was reduced to 42%. Farmers in semi-arid tropical and humid tropical regions may consider using solar heating as a safe and relatively inexpensive method for disinfesting seeds of pigeonpea.

Keywords: *Cajanus cajan*; Solar heating; Bruchids; Storage pests; Control methods

1. Introduction

Bruchids (*Callosobruchus* spp.) are important storage pests of grain legumes, and are known to cause considerable economic losses, especially in pulses grown in the tropics and sub-tropics (Ramzan et al., 1990; Srivastava and Pant, 1989). This is one of the reasons why farmers are often reluctant to grow legumes, as they have to dispose of their produce immediately after harvest, even though the market price may not be very remunerative at that time. Bruchid-damaged seeds do not germinate well and this affects plant stand and consequently yield. This is especially so when the time between harvest and next sowing season is very long, as is the case with several

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short-season legumes. For example, the interval between harvest time and planting of the next season crop of some early maturing pigeonpea [*Cajanus cajan* (L.) Millsp.] cultivars can be six to nine months as compared with two months for long-duration pigeonpea cultivars. Thus, an effective and inexpensive method needs to be developed for protecting farm-stored seeds from bruchids.

Several chemical and non-chemical methods of protecting seeds from bruchid attack are in vogue among farmers. Chemical methods such as fumigation or admixture of insecticides such as malathion, though effective, are hazardous. The major farm-level techniques generally used for bruchids are inert dusts, hermetic storage in metal bins or polyethylene-lined earthen structures, turning, and coating with neem and castor oils although their use is restricted and short term (Yadav, 1997). Sun-drying in an open yard is one of the common practices employed in the semi-arid tropics. However, spreading the seeds in the open also exposes them to a high risk of post-treatment infestation. As in the case of soil solarization (Chauhan et al., 1988), the heating from the sun's rays may be enhanced substantially if seeds are kept under polyethylene as in small transparent polyethylene bags. Solar heating can reduce bruchid damage in cowpea (Murdock and Shade, 1991) and beans (Chinwada and Giga, 1996), but no information is available on seed viability as affected by high temperature in polyethylene bags especially in the context of pigeonpea. As the relative sensitivity of legumes to temperature and moisture content varies, it is not known if this method would effectively control bruchids in pigeonpea without adversely affecting seed viability. This study reports temperature changes in small polyethylene bags exposed to sunlight in the semi-arid tropics, and its effect on bruchid survival, infestation and germination of pigeonpea seeds during subsequent storage.

2. Materials and methods

Eight polyethylene bags of 21×28 cm size and 100 μm thickness were filled with 1 kg seed 10% m.c. (w.b.) of a medium-duration pigeonpea variety ICPL 87119. The thickness of the layer of pigeonpea in the bags was about 4 cm. Twelve adult bruchids (*Callosobruchus maculatus* F.) in equal numbers of males and females were introduced in each bag, which was then sealed using an adhesive tape. Four of the sealed bags were kept in the sun at ICRISAT, Patancheru (17° N, 72° E) for a week in June 1998 (maximum outside air temperature 42°C) and a similar number was kept in the laboratory at 30–35°C to act as controls. The rise in temperature inside the bag was measured using a mercury thermometer inserted into the bag. The contact point between thermometer and bag was also sealed with adhesive tape so that hot air inside the bag did not escape. After the treatment, both treated and untreated bags were placed in an ordinary cardboard box of $40 \times 30 \times 30$ cm dimensions and kept in the laboratory at about 30–35°C. Samples for germination were drawn immediately after solar heating and up to 41 weeks of storage. Germination was determined in the laboratory at 25°C using Petri dishes lined with filter paper to which 10 ml distilled water were added (results in triplicate). Ten seeds were placed in each Petri dish and germination was recorded after four days.

3. Results and discussion

The temperature in bags kept in sunlight (solarized) varied with time of the day (Fig. 1). The maximum recorded temperature was about 65°C. This rise in temperature is comparable to the rise noted in surface layers of soils covered by transparent polyethylene (Chauhan et al., 1988). Rise in temperature in bags kept in the laboratory (control) was only slight (Fig. 1). The difference in temperature between the two treatments was large from noon onward and remained so until the evening.

Bruchids in all the solar-heated bags died without laying eggs. It can be expected that a temperature up to 65°C was lethal on the first day. Data for a wide range of insect pests (Fields, 1992) indicate that they die within a few minutes at temperatures above 55°C. Determination of minimum length of solar heating required to completely kill bruchids was not investigated in the present study, but a day's exposures could be enough to heat all the grain in the bags to >55°C and thus eliminate all bruchids. Considerable bruchid egg laying had taken place when the control treatment was examined five weeks after the treatment. Adult bruchids were also seen alive in two of the four control bags along with dead bruchids which had completed their life cycle. The bruchid damage (apparent visually by the presence of a hole in the seed coat) continued to increase with time, and while there was no bruchid damage in the solar-heated bags even after 41 weeks of storage, damage in the control bags had increased to 90% by this time (Fig. 2). This indicated that seed solar heating was effective in completely eliminating bruchids and then protecting seeds from bruchid damage. We have tested the effects of solar heating on bruchids in small bags and the extent to which effects are modified in larger bags needs to be verified. With time, bruchid population increased appreciably in the control bags and a large number of them escaped after making holes. However, they did not gain entry into the solar-heated bags even though the bags were kept in the same box in the laboratory at 30–35°C. This suggests that seeds kept in polyethylene bags are

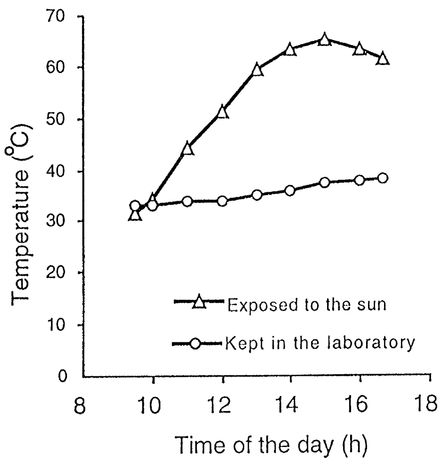

Fig. 1. The effect of solar heating on temperature build-up at different times of a typical sunny day in June in Patancheru, India.

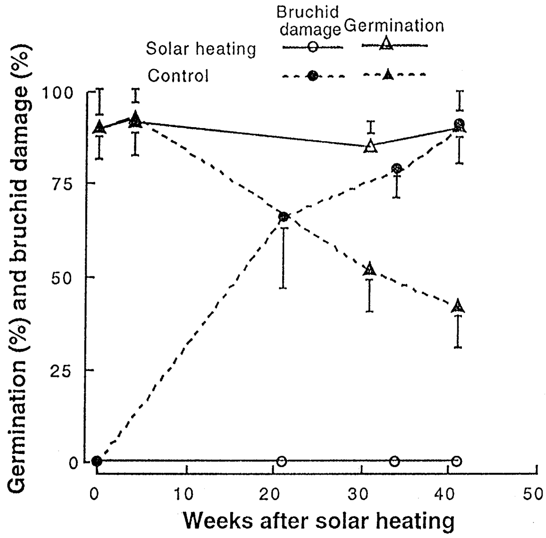

Fig. 2. The effect of solar heating on germination (%) and bruchid damage (%) as compared to the control. Vertical bars are standard errors of means in the solar heated (above the response line) and the control treatment (below the response lines).

protected from post-treatment invasion, which could be a major problem with some other treatments.

There was no adverse effect of the high temperatures on germination of seeds in the solar-heated bags (Fig. 2). For example, germination of seed was 90% before treatment and immediately after week-long solar heating, germination was 92%, and remained at this level until 41 weeks of storage when the experiment was terminated. In contrast, seed germination in the controls which was equally as high as in the solar-heated bags for the initial few weeks, continued to decline thereafter and was only about 42% after 41 weeks of storage. The decline was clearly due to damage caused by bruchids. Such seeds when sown in the field result in a poor plant stand and yield.

Even though pigeonpea was used in the present study as the test material, it is suggested that the results for bruchid infestation may be equally applicable to other grain legume crops such as cowpea [*Vigna unguiculata* (L.) Walp.], mung bean [*V. radiata* (L.) Wilczek] and black gram [*V. mungo* (L.) Hepper]. However, the adverse effect of high temperature on seed germination needs to be determined for individual crops as sensitivity may differ. Thus, considering the potential advantages, the positive aspects of this low cost method need to be widely researched and popularized among farmers in the semi-arid tropics.

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