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Observations on the effect of regular releases of *Trichogramma* spp. in controlling *Heliothis* spp. and other insects in cotton

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Summary

Regular releases of the egg parasite *Trichogramma* spp. were made at the rate of 50 000 adults per hectare from November 1975 to March 1976 on 8 ha of cotton in south-east Queensland. Whole plant sampling indicated the presence of adult parasites in the crop and the observed mean egg parasitism rate of 49.4% (range 11.7 to 100.0%) was insufficient to provide adequate control of *Heliothis*. Some control of *Heliothis* larvae was provided by populations of predatory species which built up in the trial site.

A single application of *Bacillus thuringiensis* Berliner and chlorphenamidine (350 g ha^{-1}) provided adequate control of a larval population of *Anomis flava* (Fabricius) which built up in the unsprayed crop. This treatment did not affect the emergence of adult parasites from the host eggs (*Sitotroga cerealella* (Oliver)). Eggs of *A. flava* were not parasitized by the *Trichogramma*.

1. INTRODUCTION

Conflicting data have been reported in the literature of the success of the use of egg parasites to control *Heliothis* spp. throughout the world.

Stinner, Ridgeway, Cappedge, Morrison and Dickerson (1974) indicated that even after releases of between 45 000 and 950 000 adults per hectare of *Trichogramma pretiosum* Riley, the reduction of *Heliothis* populations in cotton was of the order of 33 to 81%. However, these data were hampered by apparent drift of ULV methyl parathion from up to 1.5 km upwind of the trial site, causing up to 75% mortality of the adult parasite. In South Africa it has been reported (Anon. 1975) that the release of *T. pretiosum* into cotton areas increased the parasitism of *Heliothis* eggs by only 3.4% in unsprayed and by 2.4% in sprayed plots. A similar situation has been reported by Parsons and Ulyett (1936) in South Africa using *T. lutea* Girault where releases of the species failed to increase egg parasitism above natural parasitism levels.

Conversely, there are reports indicating a high success rate from the use of *Trichogramma* spp. in the control of *Trichoplusia ni* (Hübner) (Oatman, Platner and Greany 1968), *Heliothis zea* (Boddie) (Ashley, Allen and Gonzalez 1974) and *H. armiger* (Hübner) (Bournier and Peyrelongue 1973). De Bach (1974) has also reported on the successful use of *Trichogramma* spp. for the control of cotton pests in some areas of the USSR, particularly in conjunction with the use of *Bacillus thuringiensis* Berliner.

Twine (unpublished data) showed that, with preliminary weekly releases of 80 000 *T. pretiosum* per hectare in cotton in the St. George area of south-east Queensland during 1973–74, parasitism of *Heliothis* spp. eggs was of the order 90 to 96%. In view of the apparent success of this work, the usefulness of *Trichogramma* spp. for the potential control of *Heliothis* spp. was considered to warrant further investigation.

2. MATERIALS AND METHODS

Sources of parasites

Grimm and Lawrence (1975) developed a technique for the production and collection of Angoumois grain moth (*Sitotroga cerealella* (Oliver)) for mass rearing of *T. pretiosum*. Using this method, host eggs parasitized in Perth, Western Australia, were air freighted to Toowoomba and stored at 4°C until required for release. The species released is considered to belong to the *T. pretiosum-T. minutum* Riley complex and has been tentatively identified as *Trichogramma* nr. *pretiosum* Riley (Viggiani, personal communication).

Table 1. Release programme of *T. pretiosum* on cotton. Mywybilla. 1975–76

	Nov	Dec	Jan	Feb	Mar	Apr
Number of weekly releases	2	2	4	4	4	1
Adults per hectare per release	25 000	50 000	50 000	50 000	50 000	50 000

Release rate

Since very few data are available on the searching efficiency of *Trichogramma* spp. the release rates (Table 1) were set at a level higher than those used in many overseas areas. The same numbers of *S. cerealella* eggs were used for each release but, because of the variability of the parasitism of these eggs (50 to 80%), the number released was not identical for each release. For all releases, however, the data presented in Table 1 represent an approximation of the minimum number of parasites released.

Method of release

Cards of parasitized host eggs were held under refrigeration in Toowoomba for a short period (always less than 7 days) and taken to the release site 60 km west of Toowoomba as needed. Stakes were placed in the test area 70 m apart along a row and 40 m between rows across the field. Cards were attached to the stakes by rubber bands 75 cm above ground level and grease was applied around the stakes below the cards to prevent predation by ants.

Agronomy

Eight hectares of the variety Deltapine 16 were planted on 11 November 1975 with 350 units of nitrogen per hectare and a banded treatment of a herbicide, prometryne, 1.4 kg ha^{-1}. The crop was furrow irrigated on three occasions, including a pre-plant watering as in normal commercial practice.

The crop was planted in an area as remote from other cotton crops as practicable and away from other crops likely to be sprayed with insecticides. The nearest insecticide applications were made to a commercial cotton crop 4 km from the trial site.

Meteorological data from the area are presented in Table 2.

Sampling methods

The following samples were taken weekly from mid November until late May to monitor insect activity and the incidence of parasitism: 20 samples of 0.5 m of row were examined for *Heliothis* spp. eggs and larvae, cotton looper (*Anomis flava* (Fabricius)) larvae and cotton tipworm (*Crocidosema plebejana* Zeller) larvae; insect activity (damaged terminals and fruiting forms); and squares, flowers and bolls present. These samples were taken *in situ*.

Table 2. Meteorological data for the trial site. Mywybilla. 1975–76

	Temperature				Humidity	Precipitation			
	Maximum		Minimum			Rainfall (mm)		Number of wet days	
	1975–76*	Mean*	1975–76*	Mean*	Mean*	1975–76	Mean*	1975–76	Mean*
Nov ...	27.2	28.4	14.1	14.4	52	68	70	5	7
Dec ...	28.0	29.1	17.6	16.3	60	98	94	3	9
Jan....	27.6	29.8	17.3	17.5	65	22	97	2	9
Feb....	27.1	29.4	17.4	17.4	66	109	74	4	8
Mar ...	27.7	28.3	17.7	15.6	64	25	66	4	8
Apr ...	24.6	25.7	10.6	12.4	63	6	38	1	5
May...	21.4	21.4	9.1	8.6	63	69	36	2	5
Jun....	18.9	18.5	4.3	6.4	72	18	44	2	6
Jul.....	18.3	17.6	3.3	4.8	66	31	42	3	6

*Data supplied by Bureau of Meteorology for readings taken at Pittsworth, 31 km south-east of trial site.

To monitor insect activity further, 10 plants were cut at ground level, placed singly into plastic bags and returned to the laboratory for examination. Each plant was thoroughly washed with water while still in the plastic bag. The wash was poured into a 2 L separating funnel containing 200 mL of kerosene. The two liquids were shaken together, and all insects were found at the water:kerosene interface. The insects were separated out and counted.

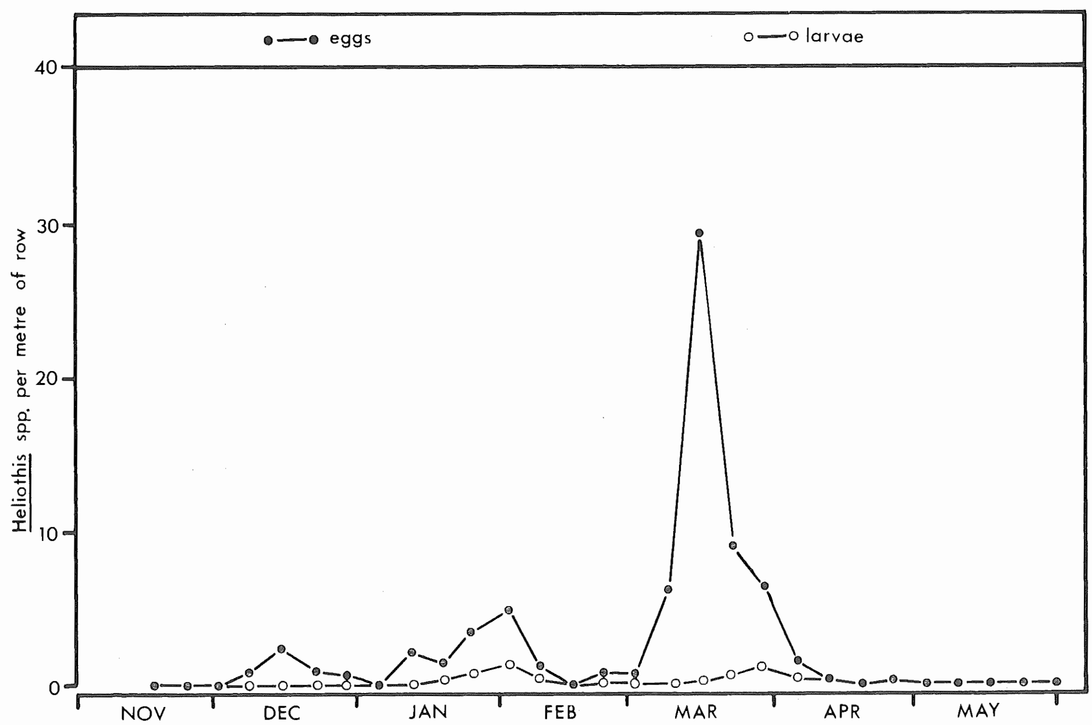

Figure 1. Activity of *Heliothis* spp. in cotton. Mywybilla. 1975–76.

Fifty *Heliothis* spp. eggs, and eggs of *Anomis flava* (Fabricius) (when present), were collected using a technique similar to that described by Hoffman, Ertle, Brown and Lawson (1970). These eggs were incubated at 25°C and parasite emergence and identity recorded.

3. RESULTS AND DISCUSSION

Insect activity

The results of sampling for the key pests (*Heliothis* spp., *A. flava* and *C. plebejana*), *Trichogramma* spp. and spider species are set out in Figures 1 to 4.

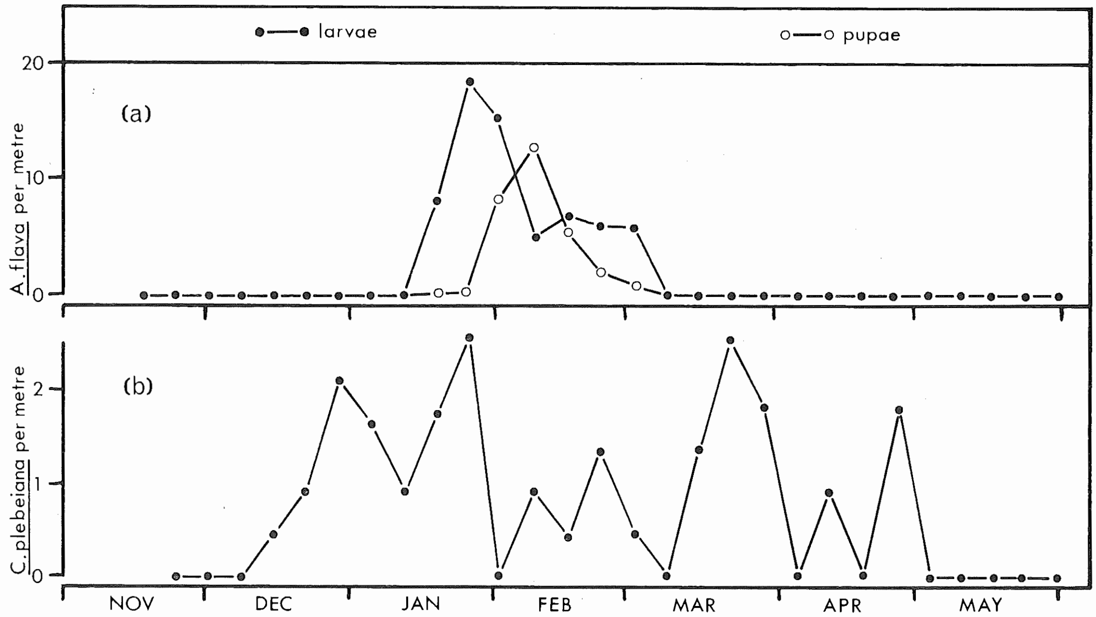

Figure 2. Activity of two insect pests of cotton. Mywybilla. 1975–76. (a) Cotton looper, *A. flava*. (b) Cotton tipworm, *C. plebejana*.

Heliothis *spp.*

The numbers of *Heliothis* spp. eggs and larvae are shown in Figure 1. There were two periods of minor *Heliothis* spp. activity during December and January, and a major peak in March. This peak coincided with a peak in square counts (Figure 5). For all three periods the survival of eggs to larvae was very low.

The severity of the infestation during late January, while causing considerable damage to terminals and squares (Figure 6), was less than that observed on other commercial plantings in the general area at that time. This difference is attributable to the lateness of the experimental crop, which resulted partly from late planting and partly from the retarding effect of 2,4-D damage sustained by the crop during December. Earlier planted crops were supporting a heavier square load in late January, and were more attractive to *Heliothis*.

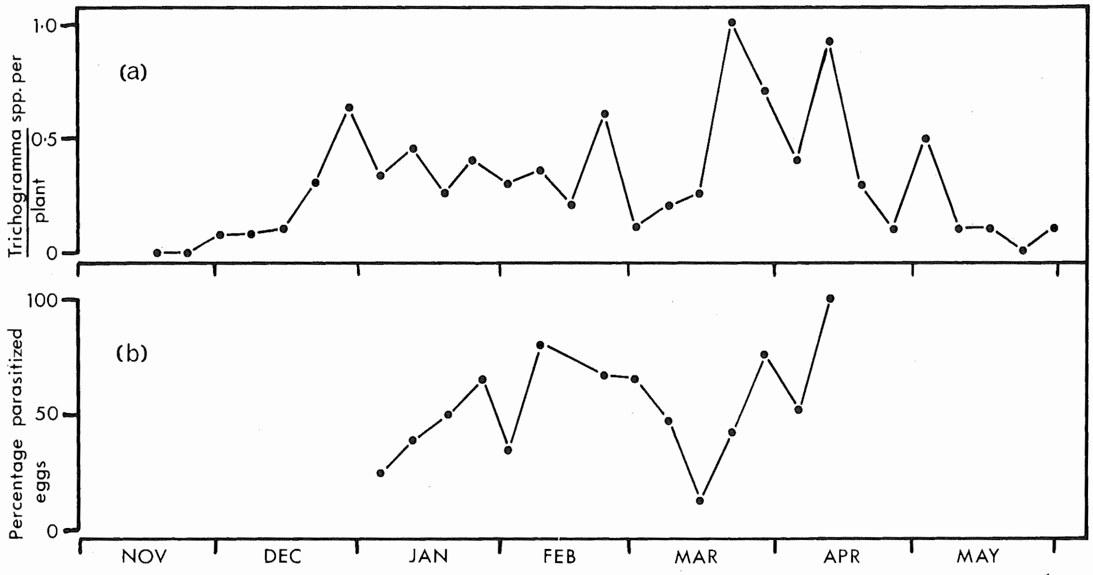

Figure 3. Activity of *Trichogramma* spp. in cotton. Mywybilla. 1975–76. (a) Numbers of adults per plant. (b) Percentage parasitized eggs.

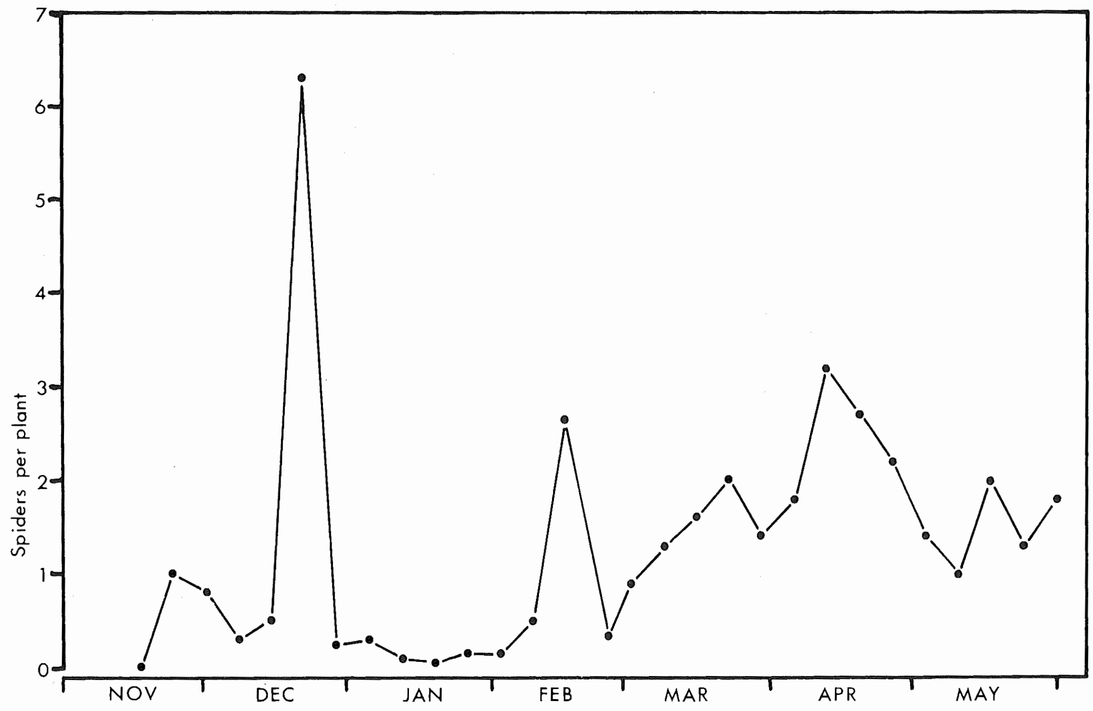

Figure 4. Activity of various spider species in cotton. Mywybilla. 1975–76.

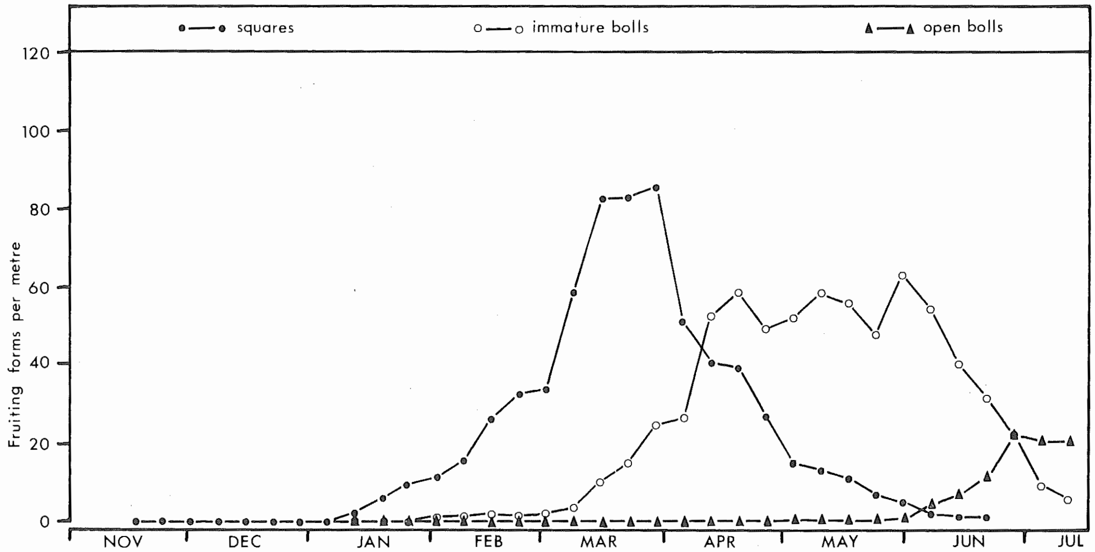

Figure 5. Fruiting pattern of cotton. Mywybilla. 1975–76.

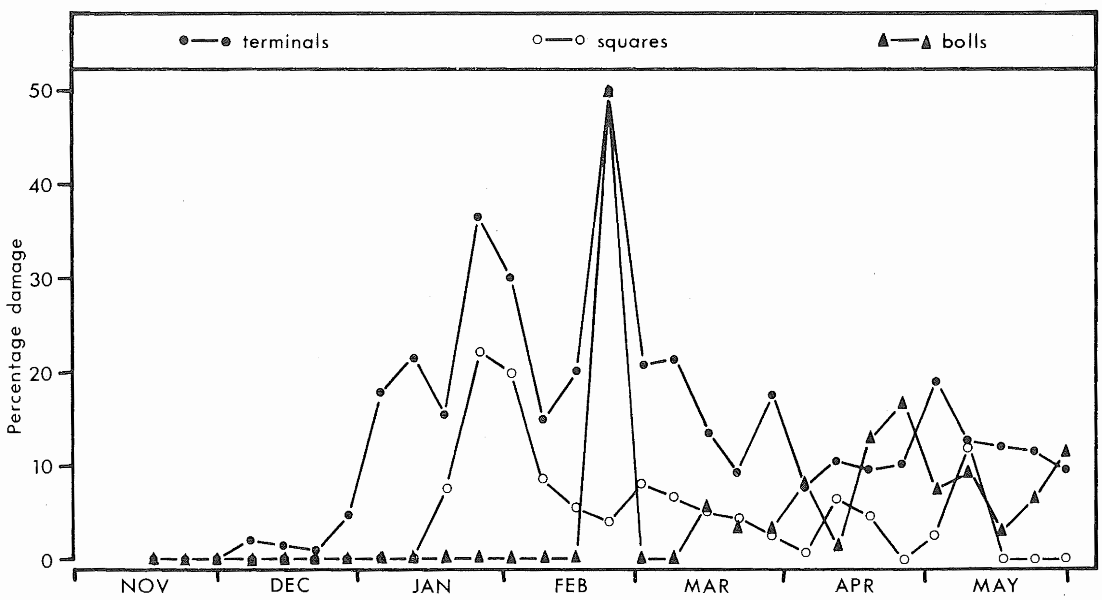

Figure 6. Percentage fruiting forms damaged by *Heliothis* spp. Mywybilla. 1975–76.

Non-target lepidopterous pests

A severe build-up of *A. flava* began during early January (Figure 2a). Severe damage to tissue was recorded and, in some instances, damage to the developing squares and bracts occurred. Of the few eggs of *A. flava* collected, none was found to be parasitized by *Trichogramma* spp. This result contrasts with high levels of parasitism of *A. flava* by *Trichogramma* spp. reported by Woods (private communication) in the Ord River area of Western Australia following mass releases of this egg parasite.

On 20 February 1976 *B. thuringiensis* and chlorphenamidine were applied over half the trial site at the rate of 350 g a.c. ha^{-1}. The effect of this application on the emergence and activity of subsequent *Trichogramma* releases is discussed in section 3.

C. plebejana was active throughout the season (Figure 2b) and, together with some 2,4-D damage, was considered to be the main factor associated with a large number of secondary branches formed on the plants. Terminal damage (Figure 6) and the resulting branching caused a delay in the maturity of the crop. This, together with the cold weather experienced during June and July, contributed to the poor yield and quality of the crop.

Trichogramma *spp.*

Despite the bag sampling procedure for sampling whole plants, a large number of *Trichogramma* spp. were collected throughout the season (Figure 3). The release rate of 50 000 adult parasites per hectare represents approximately 0.5 adults per plant (at a plant density of 10 plants per metre-row). The data illustrated in Figure 3a indicate a high recovery of the release rate and, in view of the crude method of sampling for the small wasps, suggest the build-up of parasites on host eggs within the release area. Despite the apparently plentiful supply of parasites, the parasitism of *Heliothis* spp. eggs (Figure 3b) was low. When considered in relation to the *Heliothis* spp. activity (Figure 1) the inadequacy of a constant release rate in a mass release programme is highlighted. During March, when *Heliothis* spp. activity was greatest, the parasitism rate declined, probably as a result of the parasite numbers being insufficient to cope with the increase in available hosts.

Predators

The most noticeable feature of the trial was the increase in numbers of many predatory species in the absence of pesticides when compared with the low populations observed in other commercial plantings. Spiders (particularly *Chiracanthium diversum* Koch) were active throughout the season (Figure 4) and these, together with the populations of other predatory species which also built up, appeared to be responsible for the high mortality of *Heliothis* spp. larvae during March following the heavy egg lay at that time.

Numbers of the predatory green carab, *Calosoma schayeri* Erichson, also built up during February, seemingly as a response to the increase in *A. flava*. However, the sampling techniques employed in this trial were inadequate to monitor the species.

Crop growth

The pattern of squaring set out in Figure 5 indicates that peak square production did not occur until late March at which time normal environmental conditions are unsuitable to mature developing squares before harvest. Boll numbers (Figure 5) also verify this late setting of the crop. Peak boll counts were not recorded until late April, at which stage low temperatures (Table 1) were lengthening maturity time of the developing fibre.

The damage to squares and bolls (Figure 6) reflects the activity of *Heliothis* spp. larvae during the main period of crop growth. The high levels of damage sustained during January and February account for the major loss in yield to the crop.

The weight of seed cotton harvested from the trial site was 4410 kg, giving 6 bales of raw cotton (0.75 bales ha^{-1}) totalling 1365 kg of cotton (ginning percentage 30.9%). Grades for this cotton averaged 1 1/32 inch staple length and a micronaire of 3.0 to 3.2. This compares with a crop on the same farm, receiving normal insecticide applications, yielding 2.9 bales ha^{-1}. An area of 32 ha of late cotton, also receiving some 2,4-D damage but being treated with a normal insecticide programme, yielded 0.86 bales ha^{-1}. However, comparison of these yields, while reflecting the low control provided by the *Trichogramma* spp. releases, is compounded by a number of agronomic and environmental factors which normally result in lower yields.

The degree of control of *Heliothis* provided by *Trichogramma* releases should be gauged not only by the extent of the parasitism of *Heliothis* eggs (in terms of the density of eggs present) during the release period but also by the ability of the parasites to maintain an 'adequate' parasitism rate through a period of increasing oviposition.

During this trial the parasitism rate fluctuated considerably from 11 to 100% with an average of 49.4%. This rate alone does not reflect a satisfactory level of control for commercial situations and the suitability of the parasites is further decreased by the fact that these levels were achieved under light *Heliothis* infestations. The decline in parasitism during the period of increased oviposition in March further identifies the inadequate control offered by the parasites at the release rates employed in the trial.

Effect of *B. thuringiensis*:chlorphenamidine on *Trichogramma* spp.

Cards of parasitized *S. cerealella* eggs used for the release of *Trichogramma* spp. were placed throughout the trial site before the application of *B. thuringiensis* and chlorphenamidine at the rate of 350 g ha^{-1}. The spray was applied using a boom spray at 410 kPa pressure. Seven cards were dispersed throughout the area to be sprayed and three were used in the unsprayed areas. Twenty four hours after treatment the cards were returned to the laboratory and emerging parasites counted. There was a mean of 1174 (s.e. ± 262) adult parasites recovered per 4 cm^2 of card from the sprayed area and 1178 (s.e. ± 384) adults per 4 cm^2 of card from the unsprayed areas. These data suggest that parasite emergence from the host eggs is unaffected by the treatment.

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