terials had reduced the number of bollworms and the surviving larvae at that time were predominantly second and third larval instars (see table). Fourteen days after treatment, further reductions in bollworm numbers were recorded only in the virus, the two *B. thuringiensis* and the check plots. The larvae in these treatments were predominantly of the fourth and fifth instars. There was no change in bollworm abundance in the carbaryl treatment, and in the Nia 10242 and Azodrin treatments the number of worms had increased. In the latter three plots, the smaller instars predominated indicating survival of recently hatched worms of the natural population. This survival

AVERAGE NUMBER OF BOLLWORM LARVAE AND THEIR PREDOMINANT LARVAL INSTAR PER 100 PLANTS 7 AND 14 DAYS AFTER TREATMENT WITH INSECTICIDES IN EXPERIMENT 2

Treatment and dosage per acre		Number surviving		Larval instar	
		7 days	14 days	7 days	14 days
Virus	6×10^{12} polyhedra	18	13	3	5
B. thuringiensis	4 gal	25	22	3	4
B. thuringiensis and carbaryl 80 WP	4 gal 1½ lb	20	19	2	4
Carbaryl 80 WP	3 lb	14	14	2	1
Nia 10242	0.5 lb	20	23	3	1
Azodrin	0.5 lb	24	27	3	3
Check	untreated	33	27	3	5

was attributed to the short residual nature of the compounds and to a lack of sufficient natural controls, as these compounds were demonstrated to be generally toxic to beneficial species which aid in controlling bollworms.

Boll damage

Seven days after the initial spray application, all materials had reduced boll damage by about 60% compared with the check. Fourteen days after treatment, as shown in graph 2, substantial reductions in boll damage were still evident in the Nia 10242, virus, carbaryl alone and the *B. thuringiensis*-carbaryl plots, respectively. At harvest, the virus and the two *B. thuringiensis* treatments resulted in fewer damaged bolls, whereas Nia 10242 and Azodrin recorded more damaged bolls than the check, both in the areas where laboratory-reared worms were used and where only a natural infestation of boll-worm had occurred. The values were significantly different at the 1% level as determined by Duncan's Multiple Range Test. These differences were also reflected in the yield data as Nia 10242 and Azodrin produced substantially less seed cotton per acre than did the other treatments, including the check.

A third experiment was conducted following the second spray application in experiment 2. The procedures employed were identical to those used in the previous experiment; but different areas of the plots were infested, and laboratory-reared worms were placed only in the virus, carbaryl and check plots. By the 14th day, the virus demonstrated superior control, reducing the number of live worms by 61% and boll damage by 68%. The carbaryl treatment was less effective, having reduced live worms by 31% and boll damage by 44%.

Results

Based on results of the experiments conducted thus far, the *Heliothis* virus preparation as well as the *B. thuringiensis* preparation appear to offer the most promise of the materials tested for effective and selective control of early instar bollworms on cotton. Of the two insect pathogens, the virus preparation demonstrated more rapid immediate control, and more effective long-term control. *B. thuringiensis* did not appear to give immediate control but was effective over the longer period, apparently because it inhibited larval feeding activity and disrupted insect development. The addition of carbaryl to *B. thuringiensis* did not appear to enhance the effectiveness of either material 14 days after treatment. At harvest, the combination treatment was no more effective than *B. thuringiensis* alone. Of the chemical insecticides tested, only Nia 10242 and carbaryl appeared to give adequate bollworm control over a 14-day period at the concentrations used. The disadvantage of these compounds is their lack of selectivity and their apparent short residual effectiveness which permits reinfestation by bollworm unless repeated applications are made at frequent intervals. Research in 1965 will be largely directed towards determination of the proper timing and dosage of *Heliothis* virus and *B. thuringiensis* for effective, economical control of early instar bollworm larvae on cotton.

L. A. Falcon is Assistant Invertebrate Pathologist, Division of Invertebrate Pathology, University of California, Berkeley; T. F. Leigh is Associate Entomologist, Department of Entomology, U. C. Davis; R. van den Bosch is Entomologist, Division of Biological Control, U. C. Berkeley. J. H. Black is Farm Advisor, Agricultural Extension Service, Kern County; and V. E. Burton is Extension Entomologist, U. C. Davis.

Progress report on

RESULTS OBTAINED during 1963, demonstrating that pear decline is caused by a pear psylla-transmitted virus, were confirmed during 1964. Most of the tests were conducted at a new three-acre experimental plot established at Vacaville where 2,230 young trees were planted in 1964. Most of the 1964 virus tests were conducted with Bartlett tops on *Pyrus ussuriensis* rootstocks. Some of the tree symptoms developed approximately two months after the pear psylla had fed on them, and consisted of quick decline collapse or of chlorosis in the youngest foliage. Also, many of the infected trees developed a reddish color in the leaves that was absent in healthy trees.

Psylla and virus

The virus appears to be persistent in the psylla vector for at least three to four weeks. In the tests showing this persistence, the same groups of psylla were transferred serially to as many as seven different healthy pear trees after removal from the slow decline virus source tree. The feeding time on each healthy tree varied from a few hours on the first trees to five to seven days on subsequent trees. Studies conducted at Riverside suggest that adult psylla transmit virus more effectively following long acquisition feeding periods on diseased plants than after relatively short periods of feeding.

It was further demonstrated in 1964 that pear psylla toxin, in the absence of virus, is not the primary cause of pear decline. In 1963, a series of 234 young pear trees, on *Pyrus serotina* rootstock in the greenhouse at Berkeley, had been heavily infested for one to two months with psylla, most of which were apparently virus-free. The infested branches of many of them were killed by the feeding, and the trees showed other evidence of

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psylla shock. These trees, and 245 psylla-free controls, were transplanted to the Vacaville plot in February, 1964. When inspected in August, 1964, most of the psylla-trees had grown as much as the controls.

Graft transmission trials

Final readings (including microscopic analysis of bark samples) were taken from several experiments designed to determine whether pear decline is caused by a graft-transmissible virus. In each of five experiments, the incidence of pear decline was higher among graft-inoculated test trees than among the noninoculated controls. In most instances, the incidence of transmission was low—the highest being 33%. When caged trees were colonized with virus-free pear psylla, they did not develop quick decline unless they had been graft inoculated. The graft transmitted virus was also demonstrated to produce quick decline in the absence of pear psylla. These trials were terminated and several new graft transmission experiments were initiated using inoculum from decline-affected trees near Wenatchee, Washington. The purpose of these studies is to determine whether the cause of pear decline in Washington is different from that in California.

Pathological cytology

It is believed that the pear decline virus multiplies in the commercial varieties of French pear, but that it does not directly cause visible symptoms in the French scion. The virus or some substance formed as a result of infection of the scion by the virus is apparently translocated down the trunk and induces necrosis in the rootstock tissue (Oriental). If the virus does multiply in the French shoots, some cytological changes should occur even though no external symptoms appear. Recently, numerous inclusion bodies, characteristic of virus infection, were found in procambium and phloem parenchyma cells of commercial varieties of pear affected by pear decline. Although these bodies were occasionally seen in apparently healthy pear, they occurred in much greater numbers in diseased trees. Studies are continuing to determine whether these cytological changes are a consistent indication of the presence of pear decline virus.

Biological control

Studies were continued to determine if conditions could be found under which psylla could be controlled by biological means. As exhaustive search for pathogens such as fungi or bacteria, capable of reducing psylla populations has been unsuccessful so far. However, predaceous insects have been found which may prove to be effective in psylla control. In one experimental orchard near San Jose, natural enemies, particularly anthocorid and lacewing predators, provided good control of pear psylla in the absence of insecticides. These untreated trees, however, bore 36% codling moth-infested fruit. In another locality, predators were not effective and psylla reached damaging numbers when left untreated. These results indicate that pear culture without insecticides, although favorable for pear psylla control in some cases, is not practical because of the resulting codling moth injury. Consequently, studies were initiated to find codling moth control methods not harmful to pear psylla predators. To date no effective integrated spray program of this nature has been achieved.

Propagation of rootstocks

During 1964, 38 healthy Bartlett trees on *P. communis* stock were located in decline-ridden orchards in four counties: Eldorado, San Joaquin, Placer and Yolo. Suckers arising from the roots of healthy trees in Eldorado, Placer and Yolo counties have been propagated and will be multiplied by mound-layering. A few of the more promising rootstock selections should be ready for field trials in the 1965 to 1966 season.

Rootstock identification

Methods for identification of rootstock species were further perfected. Paper chromatography of polyphenolic compounds extracted from sucker leaves allows accurate identification of any of the five *Pyrus* species most frequently present as rootstocks. Hybrids are often distinguishable as such. In commercial orchards, samples were obtained for rootstock identification concomitantly with bud union samples taken for decline diagnoses. Results showed a high incidence of decline with rootstocks identified as *P. communis*. Some hybrids between *P. communis* and *P. serotina* (Oriental) were found among rootstocks planted as "domestic French."

Pear decline project research workers involved in the preparation of the report from which this condensation was obtained include: J. Blair Bailey, D. D. Jensen and John L. Nickel, Department of Entomology and Acarology, and Y. Tanada, Department of Invertebrate Pathology, University of California, Berkeley; Peter B. Catlin, W. H. Griggs, and Kay Ryugo, Department of Pomology; and T. A. Shalla, Department of Plant Pathology, U. C., Davis; R. C. Dickson, Department of Entomology; Henry Schneider, Pamela Tsao and T. S. Pine (USDA), Plant Pathology; George Kaloostian, Entomology (USDA), U. C., Riverside.