RESISTANCE IN CORN (ZEA MAYS) TO THE
FALL ARMYWORM SPODOPTERA FRUGIPERDA:
THE IMPACT OF PUBLIC RESEARCH ON
COMMERCIAL SEED COMPANIES

J. L. Overman
DeKalb-Pfizer Genetics, Inc.
Union City, Tennessee 38261

ABSTRACT

The fall armyworm, Spodoptera frugiperda (J. E. Smith), is an economic pest of
late-planted corn, Zea mays L., in the southern United States and it reduces the market
potential for the currently available commercial hybrids. Commercial hybrid seed com-
panies are responsible for developing and marketing the majority of the commercial
corn hybrids. These companies are still dependent on public institutions to identify and
release resistant germplasm, develop insect rearing methods and to design efficient
breeding techniques for developing resistant elite lines. This paper discusses the major
discoveries from the public sector and their impact on commercial seed research.

RESUMEN

El gusano cogollero, Spodoptera frugiperda (J. E. Smith), es una plaga que causa
pérdidas económicas en el maíz, Zea mays L., que es sembrado tarde en el sur de los
Estados Unidos y que reduce el mercado potencial de los híbridos hoy día disponibles.
Compañías comerciales de semillas híbridas son responsables del desarrollo y mercado
de la mayoría del maíz híbrido comercial. Estas compañías todavía dependen de in-
stituciones públicas para identificar y hacer disponible germplasmas resistentes, desar-
rollar métodos para criar insectos, y para diseñar eficientes técnicas de fitoejercimiento
para desarrollar las mejores selecciones de variedades. Este trabajo discute los descub-
rimientos más importante del sector público y de su impacto en investigaciones comer-
ciales.

Wiseman and Davis (1979) provided a historical review of plant resistance to the fall
armyworm (FAW), Spodoptera frugiperda (J. E. Smith). Davis (1980a) reviewed the
current public plant resistance programs on corn, Zea Mays L., sorghum, Sorghum
bicolor (L.) Moench; peanuts, Arachis hypogaea L.; bermudagrass, Cynodon dactylon
(L.) Pers.; rice, Oryza sativa L.; and millet, Pennisetum glaucum L. Their discussions
included comments on factors limiting advancement in FAW research. Concerns in-
cluded a need for team research involving entomologists and plant breeders, improve-
ments in insect rearing, and better plant-infesting techniques. Equally important is the
need for transfer of research information from the USDA/ARS, universities, and inter-
national institutes to private institutions such as commercial seed companies. This link-
age is essential because commercial U.S. seed companies are the primary employers of
corn breeders. These breeders are currently responsible for developing the majority of
elite inbred lines and testing and deploying new hybrids. The remainder of the paper
reviews the potential impact of public FAW research on corn seed companies.
Insect Rearing

Efficient programs for developing FAW resistant cultivars depend on an adequate supply of the proper larval stage applied at the appropriate plant growth stage. The following techniques, derived from public research, are being used in commercial seed research.

FAW are reared in 28.4-ml plastic cups which are 1/3 filled with southwestern corn borer diet (Davis 1976). The cups are stacked on 11" x 17" cookie sheets. A 10-liter batch of diet is prepared in a 20-liter steam jacketed kettle. The diet is poured using 1000-ml plastic beakers. Three people routinely fill about 1500 cups (1/3 full) in 10 minutes. Alternatively, the diet can be dispensed with the insect-diet dispenser (Davis et al. 1978). Egg masses are surface-sterilized and hatched in 3.8 liter glass jars. After hatching the first-instar larvae are mixed with autoclaved 20-40-mesh corn cob grits (Davis 1980b). The hand operated larval dispenser (bazooka) (Wiseman et al. 1980) is used to infest each cup with 2-3 larvae. The cups are then hand-capped with plain paper cardboard lids. Alternatively, a larval dispenser-capper machine can be used for these two operations (Davis 1980b). Larvae are incubated for about three weeks at 27°C at the end of which time the pupae are removed by hand or with a mechanical pupal harvester (Davis 1982).

Pupae are placed in oviposition cages for adult emergence and egg laying. Adults and eggs are handled according to Davis et al. (1985a). Potential production with this system is about 10 million eggs per day. Production costs are nominal and most of the facilities can also be used for rearing the southwestern corn borer, Diatraea grandiosella Dyar; European corn borer, Ostrinia nubilalis Hubner; sugarcane borer, Diatraea saccharalis F.; and corn earworm, Heliothis zea Boddie.

Field Techniques

Infestation methods were developed by Wiseman and Widstrom (1984) and Davis and Williams (1980). FAW egg masses are hatched in the dark in 3.8 liter glass jars. The first-instar larvae are mixed with 20-40-mesh corn cob grits. The mixture is calibrated for delivering 20 larvae per shot with the bazooka. Plants are infested with two applications in the whorl at the 6-to-10-leaf stage. Ten to 14 days later the plants are rated on a leaf feeding scale as follows: 1-2 highly resistant, 3-4 resistant, 5-6 intermediate, 7-8 susceptible, 9 highly susceptible. In breeder's segregating nurseries, insecticides are applied after evaluation to prevent migration of the larvae from susceptible onto resistant plants. Resistant plants are then tagged for pollination and identification at harvest.

Sources of Resistance

All elite corn belt lines and germplasm tested were rated susceptible for FAW. All resistance currently being used can be traced to coastal tropical flints and Carribean area germplasm. Resistant germplasm available from public research is as follows: Antiqua 2D (Wiseman et al. 1981) from the Tifton, GA, research group; resistant germplasm MpSWCB-4, Mp701, Mp702, Mp703, Mp704, Mp705, Mp706, and Mp707 from the Mississippi State research team (Scott and Davis 1981, Scott et al. 1982, Williams and Davis 1980, 1982, 1984). The Mississippi germplasm has leaf-feeding resistance to FAW and southwestern corn borer. Recently this germplasm was shown to have leaf-feeding resistance to the European corn borer; Asian corn borer, O. furnacalis
Guenee: African maize stem borer, *Chilo partellus* Swinh.; and the sugarcane borer (F. Davis, personal communication). The presence of multiple resistance should make this germplasm a more attractive breeding material for U.S. and foreign commercial breeding programs.

**Mechanisms of Resistance**

Several investigators have examined the mechanisms of resistance in corn to FAW. In laboratory choice and no-choice experiments, Wiseman et al. (1981) determined that nonpreference was the primary cause of resistance in Antigua 2D-118. Resistance in MpSWCR-4 was mainly antibiosis with low levels of larval nonpreference. In field and cage studies Wiseman et al. (1983) showed significantly more larvae crawling off Antigua 2D-118 to surrounding uninsected plants than off the resistant MpSWCR-4 or the susceptible check. These results supported their earlier findings of antibiosis in MpSWCR-4 and nonpreference in Antigua 2D 118.

Ng et al. (1985) further examined the antibiosis effect of resistant vs. susceptible hybrids. The survival, growth, and reproduction for FAW larvae were studied in field and laboratory tests. Larvae reared on resistant vs. susceptible genotypes had higher mortality, longer larval-development time, smaller larvae, and smaller female pupae. Under laboratory conditions the reproductive rates were 34-50% less for FAW reared on resistant genotypes.

In a novel approach, Williams et al. (1985) examined larval growth and behavior of FAW on callus initiated from susceptible and resistant corn hybrids. Mean weights of larvae reared for 1 week on callus of resistant and susceptible genotypes were 29.5 and 50.0 mg, respectively. In choice tests, newly-hatched larvae preferred callus from susceptible genotypes over resistant. Williams et al. (1985) suggest that callus may be used to study the basis of resistance and its chemical nature, and to evaluate genotypes in environments where the whole plant is not adapted.

**Commercial Value**

In the final analysis, the value of FAW resistance must be demonstrated in the farmer's field. As a general rule, resistant hybrids must be competitive with other commercial hybrids in the absence of the pest, and demonstrate a significant yield advantage under infestation. Resistant germplasm is more likely to be used by breeders if resistance is additive or dominant in gene action.

Scott et al. (1977) found single-cross hybrids containing one resistant parent yielded twice as much under FAW infestation as susceptible commercial hybrids. In a corn-following-wheat double-cropping system, Williams and Sanford (1983) showed an estimated profit from FAW and rust-resistant hybrids, but not for commercial hybrids.

Studies by Widstrom et al. (1972) and Williams et al. (1978) showed general combining ability for leaf-feeding resistance to be highly significant. Thus, all resistant inbreds in hybrids tested had significant negative effects on FAW as measured by reduced leaf feeding. Williams et al. (1978) speculate that resistance would be expressed in combination with other susceptible lines.

**Summary**

The FAW is an economic pest of late-planted corn in the South and reduces the market potential for currently available commercial hybrids. Resistant hybrids would
have a significant marketing advantage over the present susceptible hybrids. Commercial seed companies depend on public institutions (USDA/ARS, universities, etc.) to identify and release resistant germplasm, and develop insect-rearing methods and field techniques. In the past, deficiencies in these areas have restricted commercial development of FAW hybrids resistant to FAW. Major innovations and releases in the areas of resistant germplasm, FAW rearing methods, and field and laboratory techniques from USDA/ARS, universities and international research groups should enhance FAW research in commercial companies.

Références Cité

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PLANT RESISTANCE AND NUCLEAR POLYHEDROSIS VIRUS FOR SUPPRESSION OF THE FALL ARMYWORM (LEPIDOPTERA: NOCTUIDAE)

J. J. Hamm and B. R. Wiseman
U.S. Department of Agriculture,
Agricultural Research Service,
Insect Biology and Population Management
Research Laboratory,
P. O. Box 748,
Tifton, Georgia 31793

ABSTRACT

The susceptibility of fall armyworm, Spodoptera frugiperda (J. E. Smith), larvae to nuclear polyhedrosis virus (NPV) was studied in relation to host plant resistance in corn, Zea mays L. In laboratory tests, freeze-dried silks of resistant (Zapalote Chico) and susceptible (Stowell's Evergreen) corn lines were incorporated into artificial diets. Larvae treated with the virus before they were held individually on the test diets showed significantly higher mortality due to NPV on the diet containing resistant silks than on the diet containing susceptible silks. When larvae were fed on test diets for 6 days before they were treated with the virus, the larvae grew larger and were less susceptible to the NPV on the diet containing susceptible silks than on the diet containing resistant silks. In a field test comparing five lines of corn with a spectrum of leaf-feeding resistance to fall armyworm, larvae growing on the most susceptible line had the lowest mortality due to NPV. Thus, the susceptibility of fall armyworm larvac to NPV was inversely related to the growth and vigor of the larvae, which was directly related to the susceptibility of the host plant. Therefore, the fall armyworm NPV should be more effective when used on resistant lines of corn than on susceptible lines.