

To the Graduate Council:

I am submitting herewith a thesis written by Chris S. Payne entitled "Evaluation of Six Commercial Field Corn Hybrids for Resistance to Ostrinia nubilalis (Hubner)." I have examined the final copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Entomology and Plant Pathology.


Charles D. Pless, Major Professor

We have read this thesis and
recommend its acceptance:




Accepted for the Council:


Vice Chancellor
Graduate Studies and Research

EVALUATION OF SIX COMMERCIAL FIELD CORN HYBRIDS
FOR RESISTANCE TO OSTRINIA NUBILALIS (HUBNER)

A Thesis

Presented for the

Master of Science

Degree

The University of Tennessee, Knoxville

Chris S. Payne

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ABSTRACT

Six commercially available field corn hybrids were evaluated for resistance to first-generation European corn borer at five Tennessee locations. Pioneer 519 and Funk G28278 were significantly more resistant than a susceptible standard, based on whorl feeding damage ratings and mean severity indexes. Under natural corn borer population pressures, the resistant hybrids showed no yield advantage over susceptible hybrids.

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CHAPTER I

INTRODUCTION AND LITERATURE REVIEW

The European corn borer, Ostrinia nubilalis (Hubner) (Lepidoptera: Pyralidae), is one of the most important limiting factors for maximum production of corn, Zea mays L., in the U.S. (Brindley et al. 1975a,b). Losses to U.S. corn crops from 1968 to 1974, due to the corn borer, have been estimated at \$210 million annually; in 1949, alone, it caused \$350 million in damage (Luginbill 1969). The yield loss/borer/plant is generally estimated at 3% (Patch 1941). Although corn is its primary host, the corn borer does feed on over two hundred species of herbaceous plants (Burkhardt 1978).

O. nubilalis was first detected in the U.S. in Massachusetts by Vinal (1917). In 1919, Felt reported the presence of the borer around Lake Erie and western New York. Both of these infestations are believed to have originated from the importation of broom corn from central Europe (Caffery and Worthley 1927). Although the corn borer is most abundant today in Iowa, Nebraska, Minnesota, and Missouri, it is also present in the states stretching from the Canada border to north Florida and from the Atlantic coast to the eastern parts of Colorado, Montana, Texas, and Wyoming (USDA 1977).

Chiang et al. (1960) and others have reviewed the life history of the European corn borer. The insect overwinters in corn stalks as full grown larvae. In the spring, the larvae pupate, and the moths emerge in

the late spring and early summer. Soon after emergence, eggs are laid on the underside of the corn leaves. The first and second instar larvae feed on the leaves that are still in the whorl stage. Later, the third and fourth instars feed on the sheaths, midrib, and around the collar before burrowing into the stalks. The proportion of fifth instar larvae that pupate relative to those that enter diapause and overwinter varies from North to South. Only one generation is normally found in the northern states; however, warm temperatures may allow three generations as far north as central Iowa (Showers and Reed 1971). Three generations per year are consistently found in Alabama (Eden 1959), Missouri (Jones et al. 1939), and Virginia (Peters et al. 1961). Four generations occur in many of the southeastern states such as South Carolina (DuRant 1969) and Georgia (Sparks and Showers 1975).

The second generation of moths lays eggs on corn plants which are at or near maximum height. Second generation larvae begin feeding on plant material around the leaf axil where pollen grains accumulate and also between the husks. These larvae also bore into the stalk, but at an earlier age than do the first generation larvae. Those larvae feeding between the ear husks may enter the cob and shank of the ear causing ears to drop. An increased incidence of lodging results from the tunneled stalks.

The corn borer may be controlled by recommended chemical and cultural control measures (Anon. 1967). Good chemical control has been accomplished using soil systemic insecticides applied at planting (Pless 1969); however, the quantity and timing of rainfall may influence the

amount of control obtained (Pless 1981. Personal Communication). Also, foliar applied spray treatments have proven to be effective when properly timed (Berry 1974). Both soil systemic and foliar applied insecticides require a substantial monetary investment by the grower (Anon. 1967). Other problems of chemical use include insect resistance to specific insecticides and environmental pollution. Cultural control practices include early planting dates and deep fall plowing (Anon. 1967), but these methods do not insure good control from year to year (Sparks et al. 1967). Although many studies have been conducted using parasites, predators, and diseases to control borer populations, the success of these biocontrol programs has been very limited (Bridley et al. 1975a).

Ideally, control of the corn borer should be accomplished by incorporation of two or more methods of control rather than relying on a single method. Another cultural control measure which might complement an integrated control program is the use of corn hybrids which are resistant to attack by O. nubilalis (Hubner). This method of control does not require additional cost to the grower, and it does not contaminate the environment. There is a considerable number of hybrids presently in use which are resistant to the first-generation European corn borer (Guthrie 1974). The majority of these hybrids are being grown primarily in states such as Iowa, Nebraska, Illinois, and Missouri (Corn Belt states) and are not suited to be grown under the photoperiod in Tennessee. It is the purpose of this thesis to evaluate and compare the relative amount of resistance to first generation European corn

borer of six corn hybrids that are now available commercially in Tennessee. The term "resistance," as used in this thesis, refers to qualities that inhibit the borer's establishment and survival in or on the corn plant (Luginbill 1969).

Selection for corn hybrids resistant to the European corn borer has taken place in the U.S. since the late 1920's (Roubaud 1928) and (Hase 1929). Because corn borer resistance has become an important part of corn breeding programs in many states and some private seed companies, an enormous amount of literature has been published on this subject. It would not be practical to cite in this thesis all the papers which have contributed in this area.

Brinkley and Dicke (1963) present a review of significant developments concerning corn borer resistance through 1961. Guthrie (1974) published a review including techniques, accomplishments and future potential of breeding for resistance to European corn borer in corn. The chemical basis of resistance to first-generation borers was reviewed by Gallun, Starks, and Guthrie (1975). Brindley et al. (1975a,b) wrote a bibliography and a review including recent research advances on the borer.

Many researchers have detected significant differences among open-pollinated varieties, inbreds, and hybrids concerning their resistance to attack by the corn borer (Patch 1937; Guthrie et al. 1960; Lynch 1980; Lynch and Guthrie 1980; etc.). The biological relationship between the insect and the corn plant is not the same for the different generations of corn borers. Guthrie (1960) noted that since young

larvae feed primarily on the leaves in the whorl stage, resistance to first generation borers is actually "leaf-feeding" resistance. Because young second-generation larvae feed mostly on pollen accumulation at the axils of the leaves and on sheath and collar tissue, Guthrie termed resistance to second-generation borers "collar- and sheath-feeding" resistance. Resistance to first generation corn borers has been relatively easy to find (Guthrie 1971) as compared with resistance to second generation borers (Guthrie et al. 1972). This thesis deals with resistance to leaf feeding by the first generation borers only.

CHAPTER II

MATERIALS AND METHODS

Five University of Tennessee Experiment Station locations were utilized for this study: (1) the Tobacco Experiment Station, Greeneville, (2) the Knoxville Plant Science Farm, (3) the Plateau Experiment Station, Crossville, (4) the Middle Tennessee Experiment Station, Spring Hill, and (5) the Highland Rim Experiment Station, Springfield.

To accommodate artificial infestation at Knoxville and Greeneville, the field plot design was different from the randomized complete block design used at the other three locations. A split-block design arranged in a randomized complete block was utilized at those two locations. There were four replications with three main plots planted end to end and randomized within each replication. Each main plot consisted of six subplots. The subplots consisted of six field corn hybrids: (1) Funk-G4606, (2) Funk-G28278, (3) Pioneer 3535, (4) FFR 744C, (5) Pioneer 3184, and (6) Pioneer 519. All the hybrids, except FFR 744C, were chosen because of evidence of resistance in earlier work by Pless and Shamiyeh (unpublished, 1980). The FFR hybrid was chosen as a standard susceptible hybrid. Rows were 2.74 meters long with .61 meter alleys between replications. Twenty seeds were planted in each row, and seedlings were thinned to fourteen per row. Two rows of field corn were planted in outside borders.

A European corn borer rearing program was initiated in August, 1980. The colony was maintained at a rearing facility located at the Knoxville Plant Science Farm. Rearing procedures as described by Guthrie, 1971 were followed. A photoperiodic cycle of 16hL:8hD was used. Relative humidity was regulated at about 85°. Temperature was maintained at $27^{\circ} \pm 1^{\circ}\text{C}$ except for six hours during the dark period when the temperature was reduced to $17^{\circ} \pm 2^{\circ}\text{C}$. This lower temperature was used to promote mating (Guthrie 1971). The larvae were reared on Bioserve Southwestern Corn Borer Diet (Table I).

Because of a severe predacious mite infestation in March, 1981, rearing was transferred to a lab located on the University of Tennessee Agricultural campus. In May, 1981, a new colony was started from pupae obtained from the Corn Insects Research Lab, Ankeny, Iowa. Beginning June 5, eggs in the black-head stage from the new colony were used to infest corn plots at the Knoxville Plant Science Farm. The eggs were maintained at $18.5\text{--}20^{\circ}$ until just before infestation, and larvae were hatching as they were being placed into the whorls. Two egg masses (approximately 50 eggs) were placed deep into each corn plant whorl. The corn was 79-102 centimeters extended leaf height at the time of infestation. A sufficient number of egg masses was available for three replications, and these were infested over a seven day period (June 5-12).

In each replication, two main plots were artificially infested. One was used for resistance data and one for yield information. The third main plot was left uninfested and used as a comparison for yield.

TABLE I
COMPOSITION OF CUSTOM SOUTHWESTERN CORN BORER DIET

	gm/L
Agar	17.2
Wheat Germ	21.1
Casein, Vitamin Free	25.0
Sucrose	25.0
Salt Mixture Wesson	7.0
Linseed Oil	0.2
Cholesterol	0.1
Corn Cob Grits	37.0
Methyl Para-hydroxybenzoate	1.5
Sorbic Acid	0.5
Vanderzant Vitamin Mixture	5.3
Ascorbic Acid	2.1

Twelve days after the first replicate was infested, plants were evaluated for corn borer leaf feeding damage according to a 9-class rating scale developed by Guthrie (1960). Hybrids with ratings of 1-3 were considered resistant; those with ratings of 4-6 were considered intermediate in resistance, and those hybrids with ratings of 7-9 were considered highly susceptible. The size, shape, and extensiveness of the leaf injuries were the major rating criteria. The three replicates were rated from June 19 to June 21.

During the time that the ratings were made, ten whorls from artificially infested plants of each hybrid in each replicate were examined to determine percentage of larval survival. From August 26 to August 28, twenty artificially infested plants of each hybrid in each replicate were split to evaluate stalk tunneling.

At the Tobacco Experiment Station, the plants were rated for feeding damage on June 25 and stalks were split on August 19. Because of a lack of sufficient numbers of laboratory reared borers, plants were not infested artificially.

At the Plateau Experiment Station, the Middle Tennessee Experiment Station, and the Highland Rim Experiment Station, only natural populations of corn borers were evaluated. A randomized complete block design was used. There were four replications, each consisting of two main plots planted adjacent rather than end to end. Each main plot contained the same six randomized corn hybrids used in the previous two tests. The first main plot in each replicate was used for resistance data; yield data were taken from the second main plot.

Twenty seeds per row were planted at the Plateau Experiment Station. The plants were thinned to fourteen per row. Row length was 2.74 meters with .61 meter alleys between replications. At the Highland Rim Experiment Station, the same field plot design was used except row length was 7.62 meters with thirty-one plants per row. Row length at the Middle Tennessee Experiment Station was 6.10 meters with twenty plants per row. Conventional fertilizer and herbicide treatments were used at all locations.

Whorl feeding damage ratings were made at the Plateau Experiment Station on June 14 and again on July 1. Stalks were split and evaluated for tunneling on August 18. At the Highland Rim Experiment Station, ratings were made on July 23 and stalks were split on July 23 and August 13. Ratings were made at the Middle Tennessee Experiment Station on June 24 and stalks were split on August 13. The number of plants showing feeding damage was counted at all locations.

CHAPTER III

RESULTS AND DISCUSSION

At the Knoxville Plant Science Farm, where plants were artificially infested with European corn borer eggs, Pioneer 519 had significantly fewer damaged whorls than did the other five hybrids (Figure 1). Pioneer 519 had a lower feeding damage rating (Figure 2) than the standard hybrid (FFR 744C). By using a mean severity index (the product of the percentage of damaged whorls and the damage rating), the hybrids can be compared for both of these factors simultaneously. At the Knoxville location, Pioneer 519, Pioneer 3184, and Funk G28278 had a lower index than the other hybrids (Figure 3).

Laboratory reared eggs hatched just before or soon after being placed into the whorls. Three days following infestation, pin hole feeding damage was observed on most of the infested plants. Because of a high population of natural predators, the corn borer population was entirely destroyed within one week after the last egg masses were applied. The primary predator was Hippodamia convergens. Coleomegilla maculata and Orisus insidiosus were also frequently found. The use of a carbofuran spray could be considered in future experiments to control these predators (Edward et al. 1980). The natural population of corn borers was very low at this location.

The number of tunneled internodes in the stalks was not significantly different among hybrids (Figure 4). Differences in yield

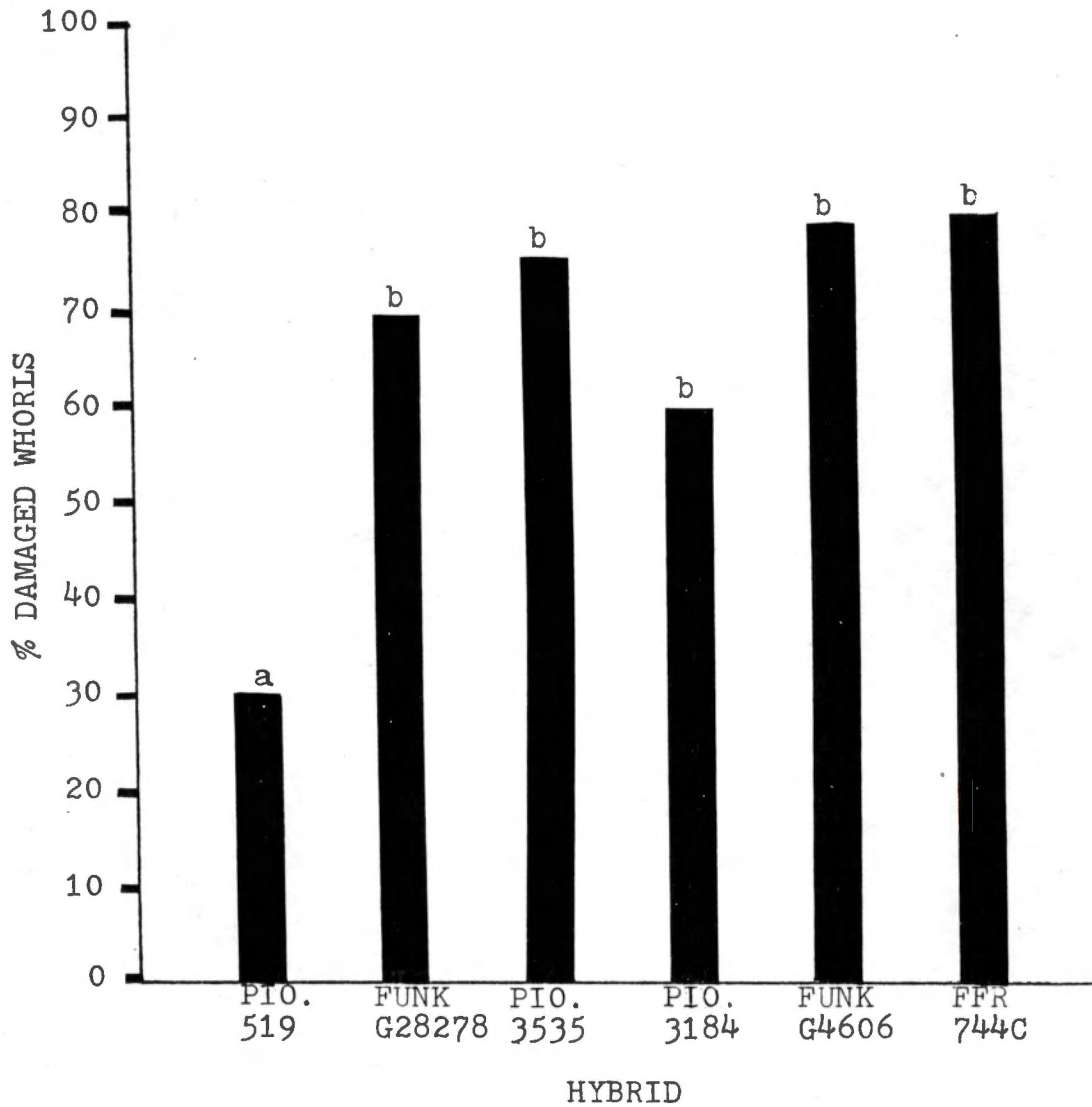


Figure 1. Whorl feeding damage one week after artificial infestation with European corn borer egg masses, Knoxville, 1981.

Any two means with the same letter are not significantly different ($P \leq 0.05$, Duncan's New Multiple Range Test).

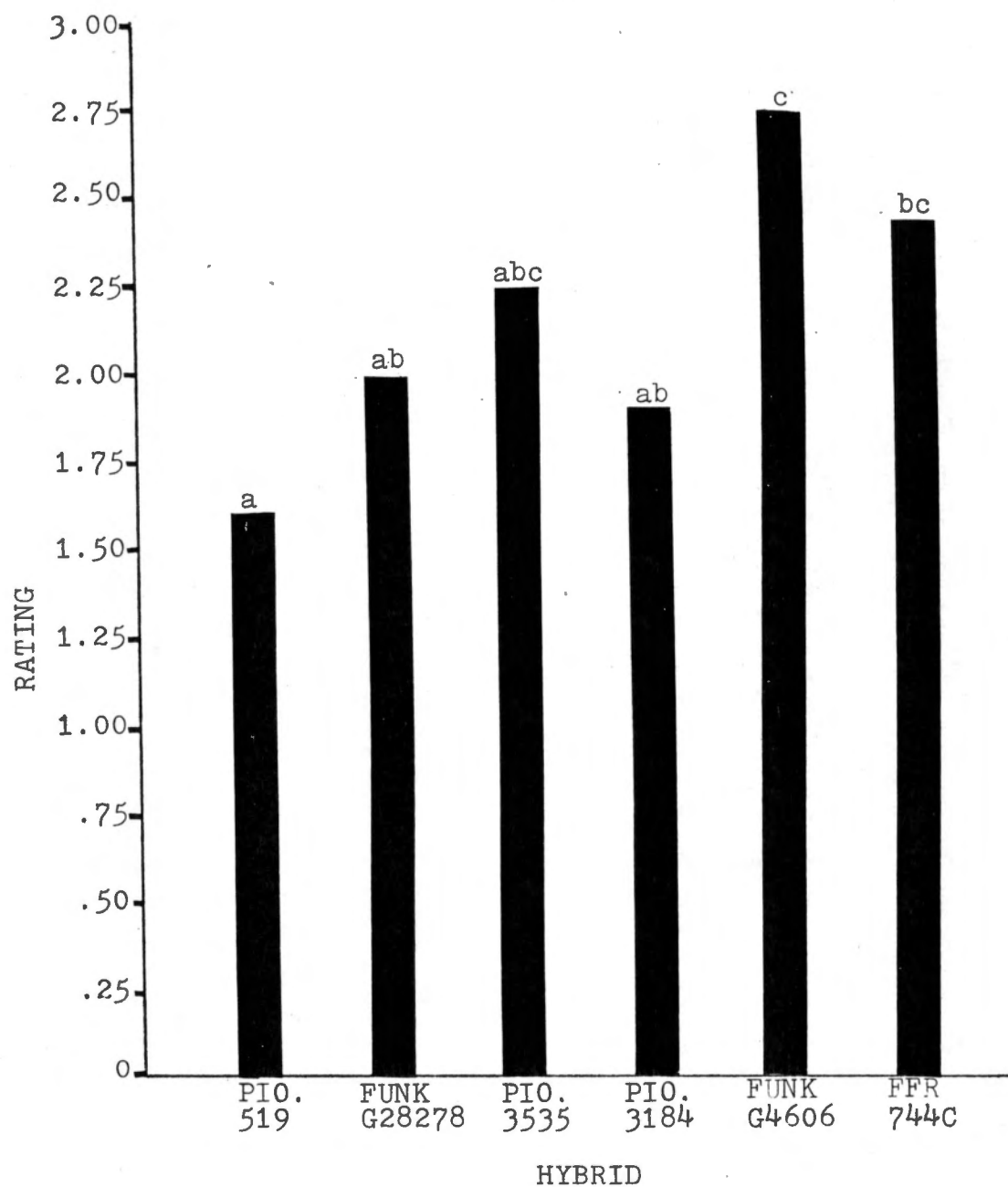


Figure 2. Whorl feeding damage (1 = No Damage, 9 = Extensive Damage) on six field corn hybrids caused by European corn borer, Knoxville, 1981.

Any two means with the same letter are not significantly different ($P \leq 0.05$, Duncan's New Multiple Range Test).

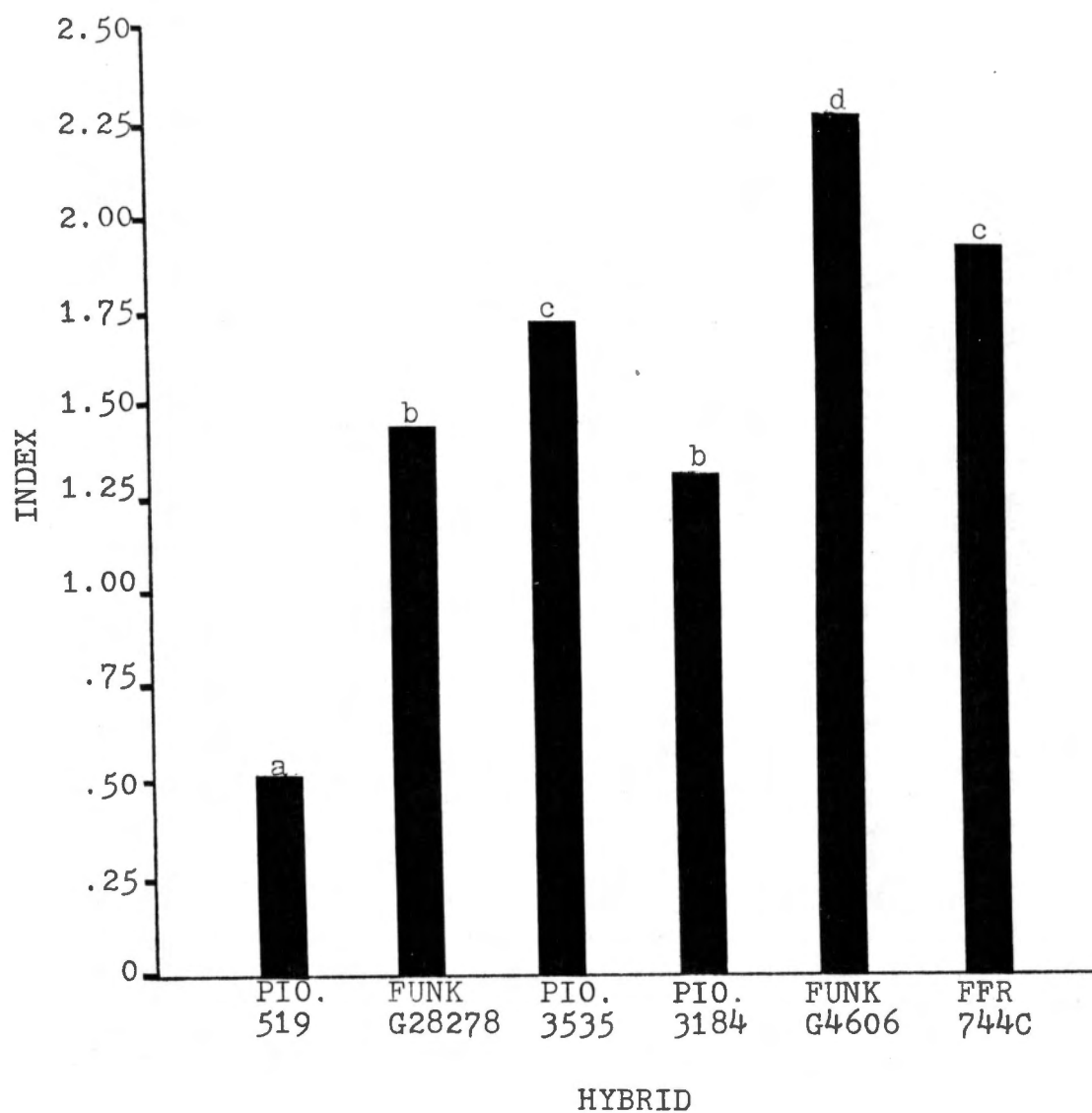


Figure 3. Mean severity index (product of plants with damaged whorls and whorl feeding damage rating), Knoxville, 1981.

Any two means with the same letter are not significantly different ($P \leq 0.05$, Duncan's New Multiple Range Test).

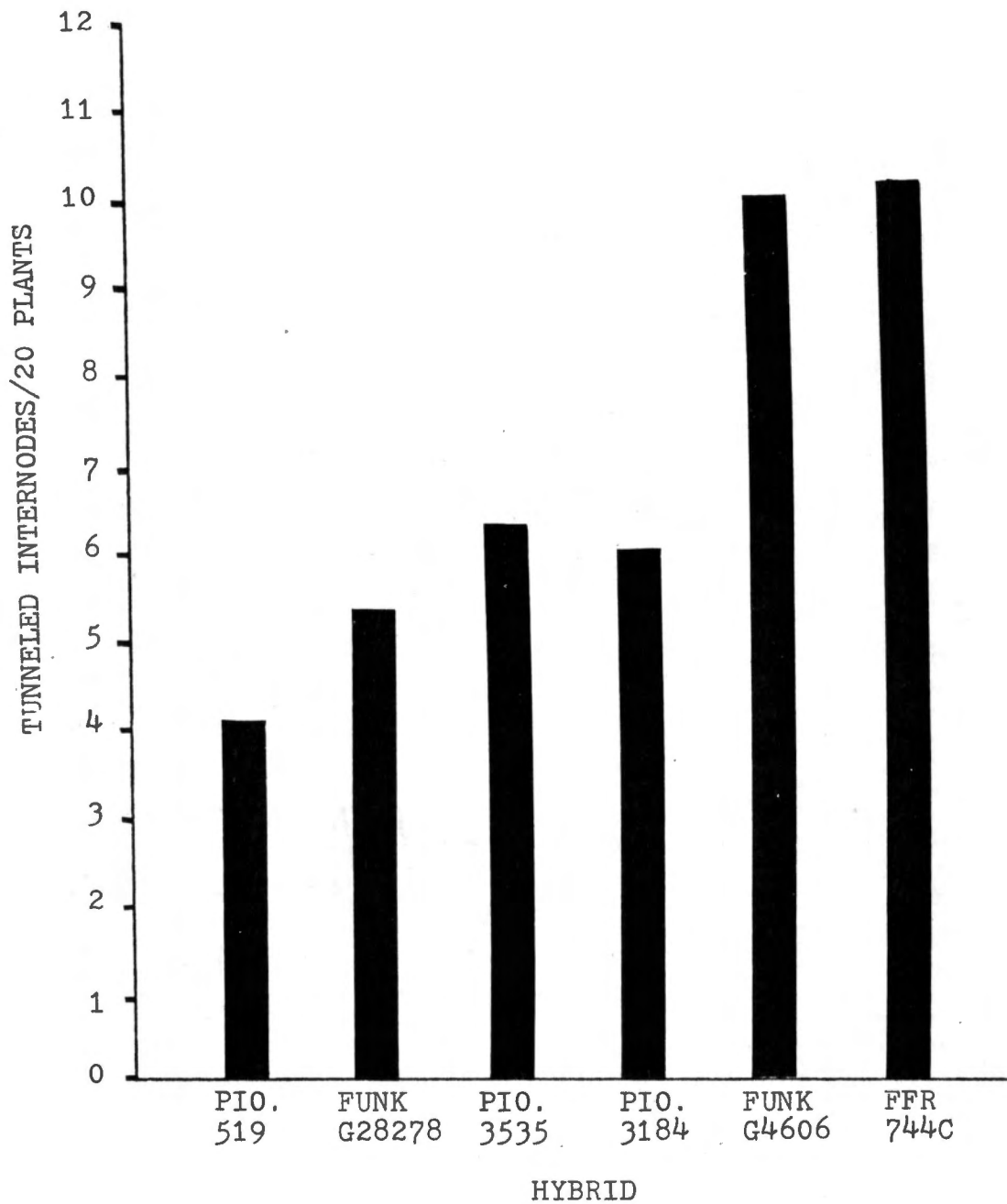


Figure 4. Stalk tunneling by the European corn borer, Knoxville, 1981.

were found among hybrids (Figure 5). Yield of the most resistant hybrid, Pioneer 519, was not greater than that of the standard.

At the Tobacco Experiment Station, no differences were found among hybrids with respect to the percentage of damaged whorls (Figure 6), feeding damage ratings (Figure 7), mean severity index (Figure 8), or tunneled internodes (Figure 9). The lack of significant differences was attributed to the low natural corn borer population. Two hybrids had higher yields than Pioneer 519 (Figure 10).

The percentage of damaged whorls was not significantly different among hybrids at the Plateau Experiment Station (Figure 11). Funk G28278 and Pioneer 3535 had lower feeding damage ratings than the standard (Figure 12). The standard had a higher mean severity index than all of the other hybrids (Figure 13). No differences were found in number of tunneled internodes (Figure 14) or yield (Figure 15).

At the Middle Tennessee Experiment Station, Pioneer 519 and Funk G28278 both had fewer damaged whorls than the standard (Figure 16). Pioneer 519 had the lowest damage rating of all six hybrids (Figure 17). The mean severity indexes of Pioneer 519, Pioneer 3535, and Funk G28278 were all lower than that of the standard hybrid (Figure 18). No differences were found in number of tunneled internodes (Figure 19) or yield (Figure 20).

The highest natural corn borer population occurred at the Highland Rim Experiment Station. At that location, Pioneer 519 and Funk G28278 had fewer damaged whorls than the standard (Figure 21). These two hybrids also had lower damage ratings (Figure 22) and mean severity

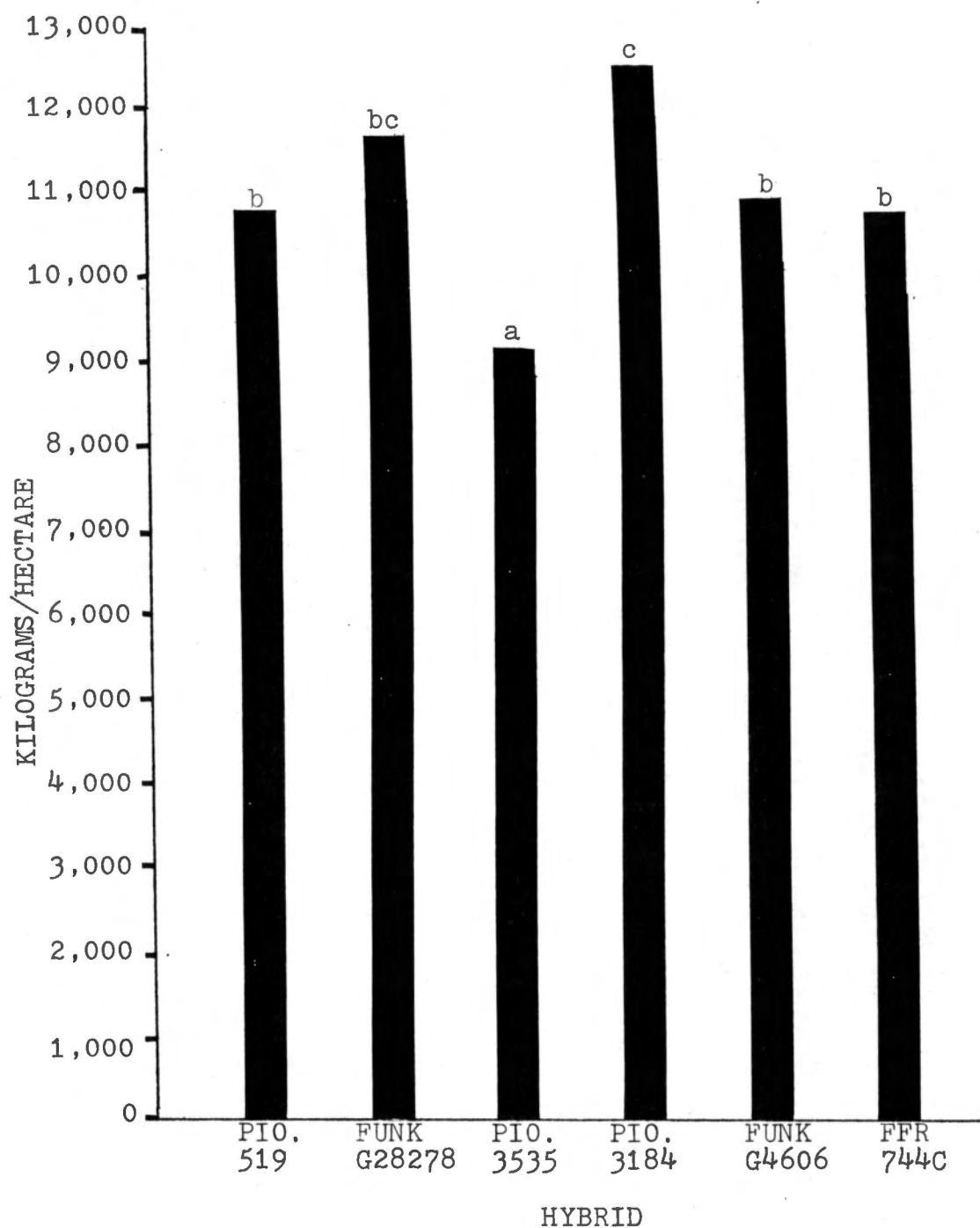


Figure 5. Yield of six field corn hybrids, Knoxville, 1981.

Any two means with the same letter are not significantly different ($P \leq 0.05$, Duncan's New Multiple Range Test).

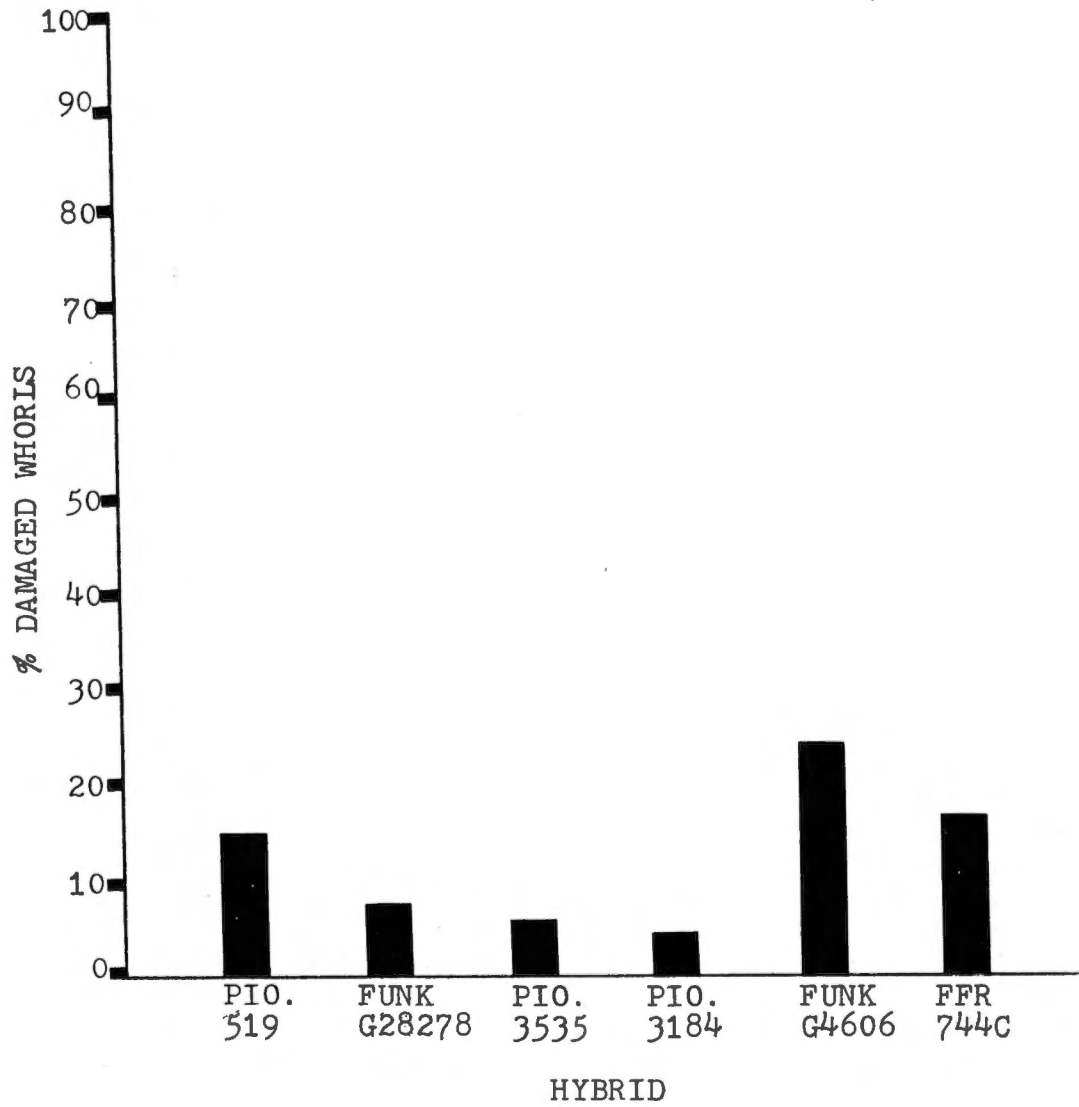


Figure 6. Whorl feeding damage on six field corn hybrids caused by European corn borer, Greeneville, 1981.

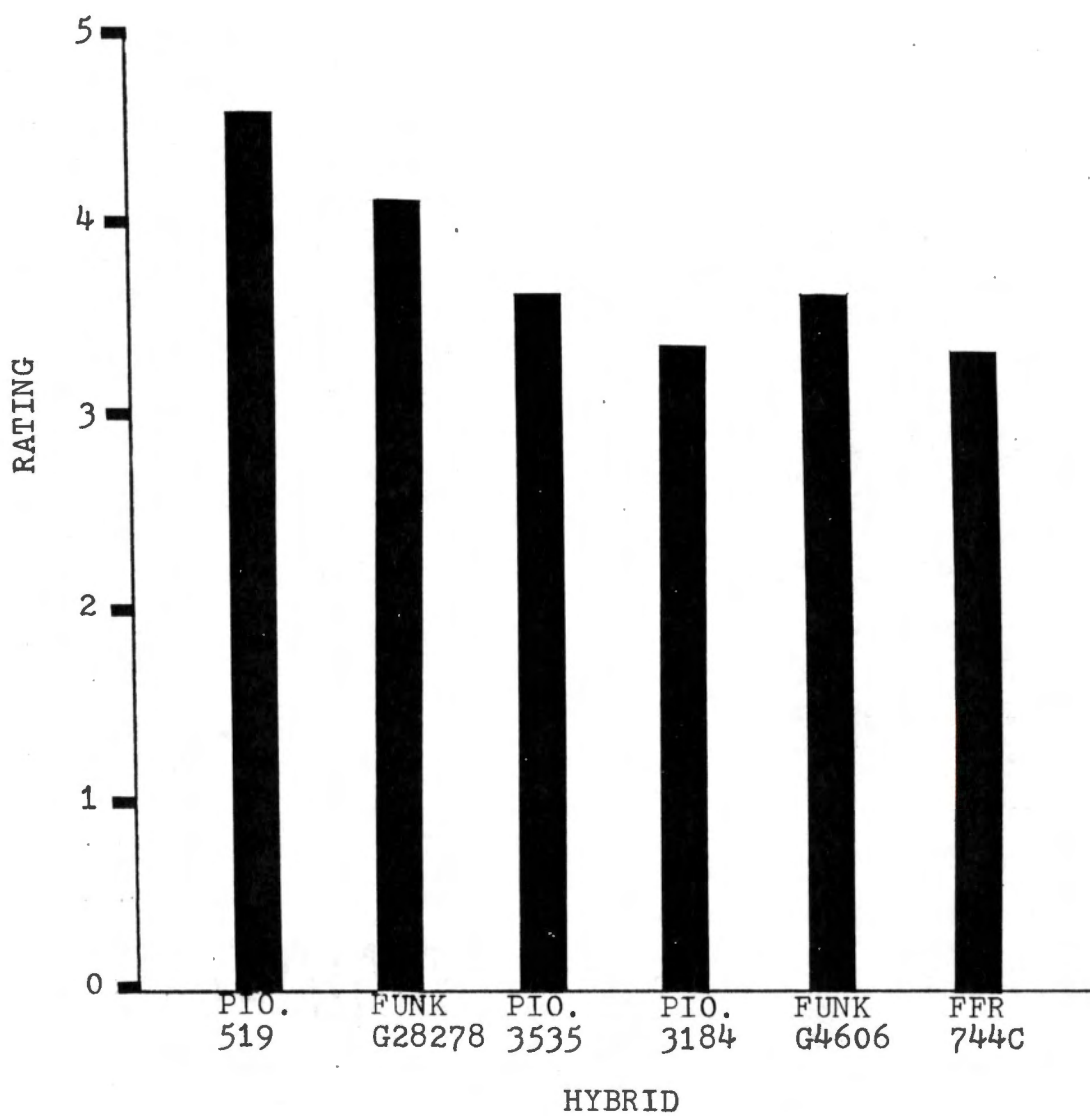


Figure 7. Whorl feeding damage (1 = No Damage, 9 = Extensive Damage) on six field corn hybrids caused by European corn borer, Greeneville, 1981.

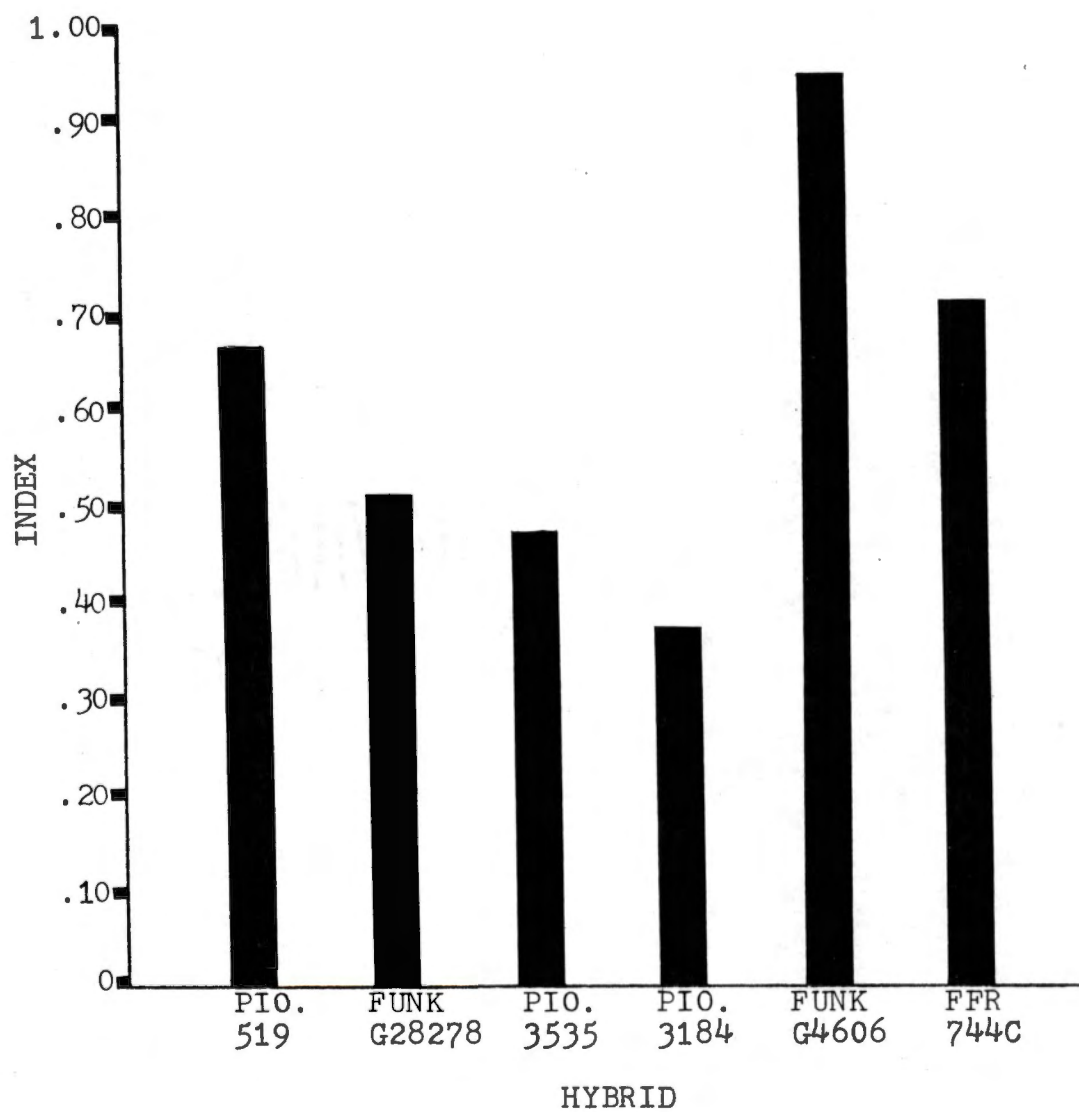


Figure 8. Mean severity index (product of plants with damaged whorls and whorl feeding damage rating), Greeneville, 1981.

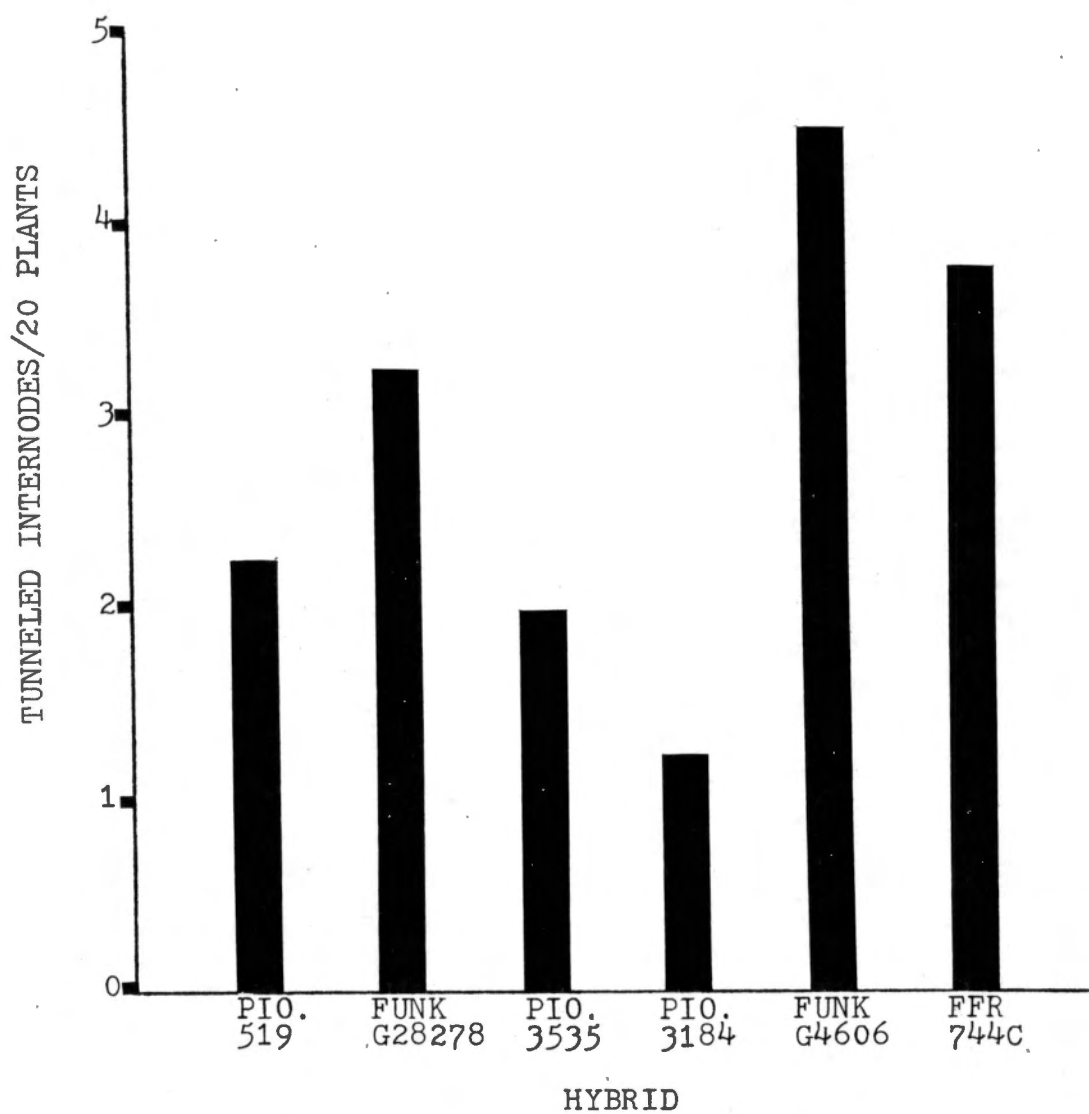


Figure 9. Stalk tunneling by the European corn borer, Greeneville, 1981.

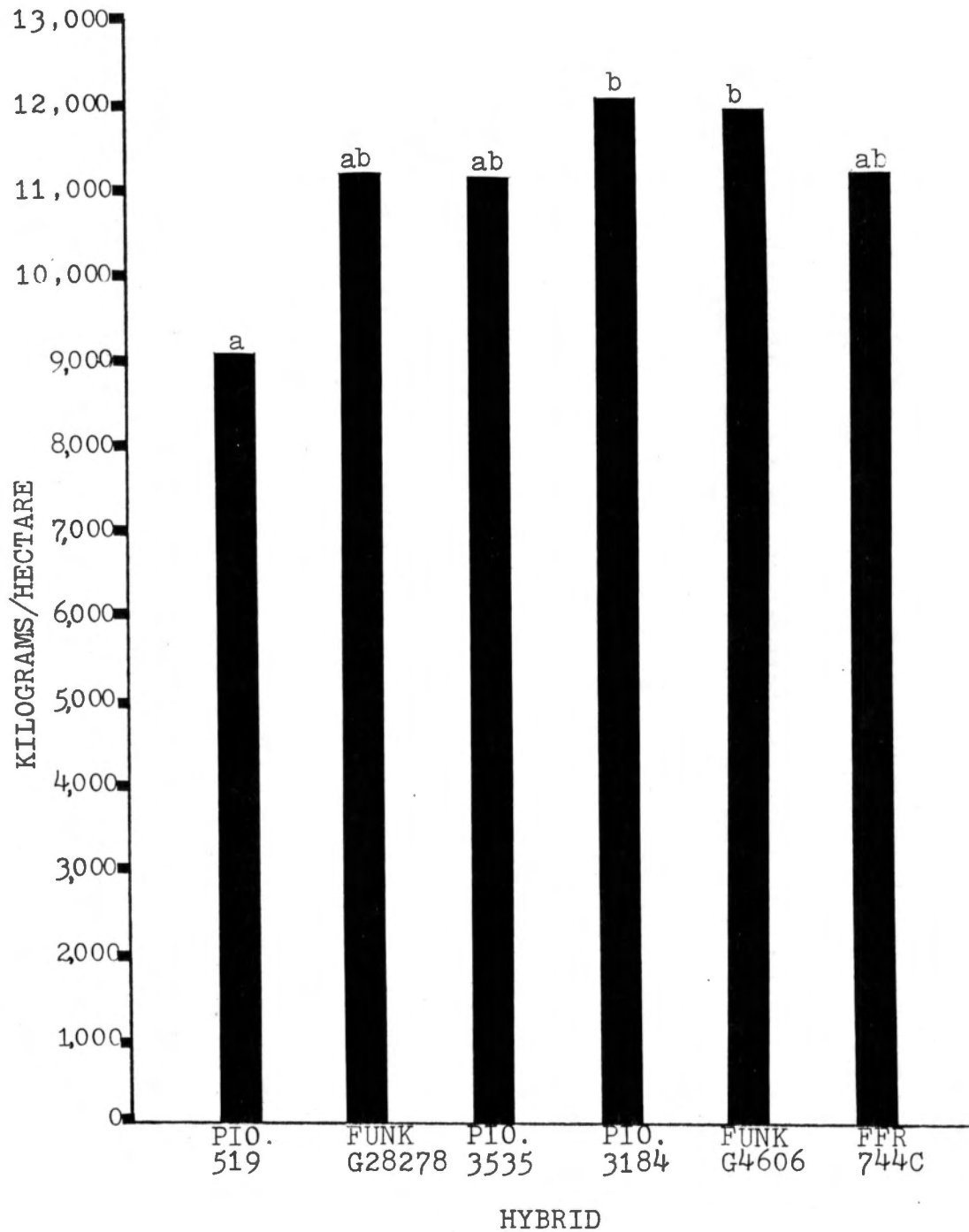


Figure 10. Yield of six field corn hybrids, Greeneville, 1981.

Any two means with the same letter are not significantly different ($P \leq 0.05$, Duncan's New Multiple Range Test).

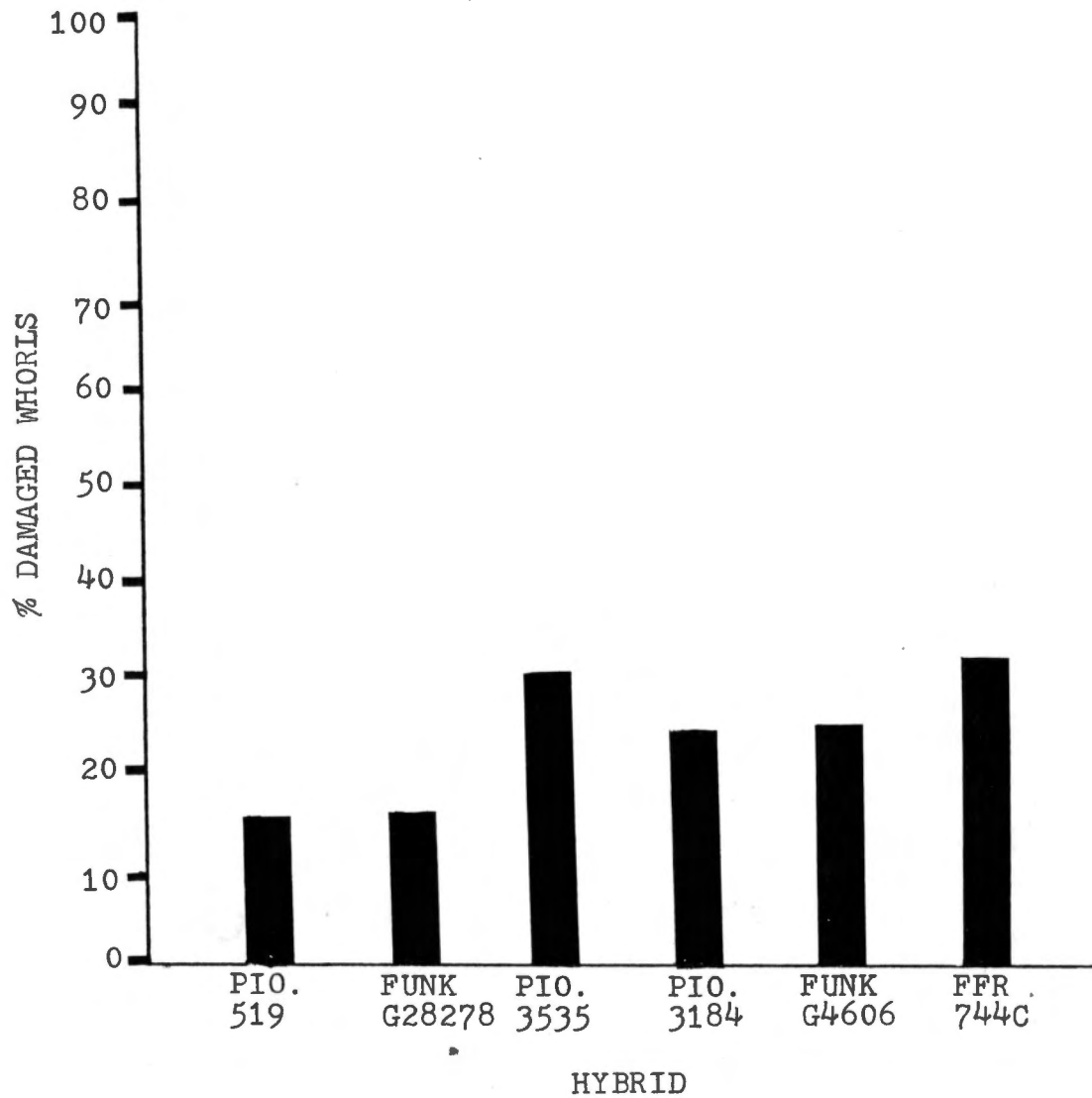


Figure 11. Whorl feeding damage on six field corn hybrids caused by European corn borer, Crossville, 1981.

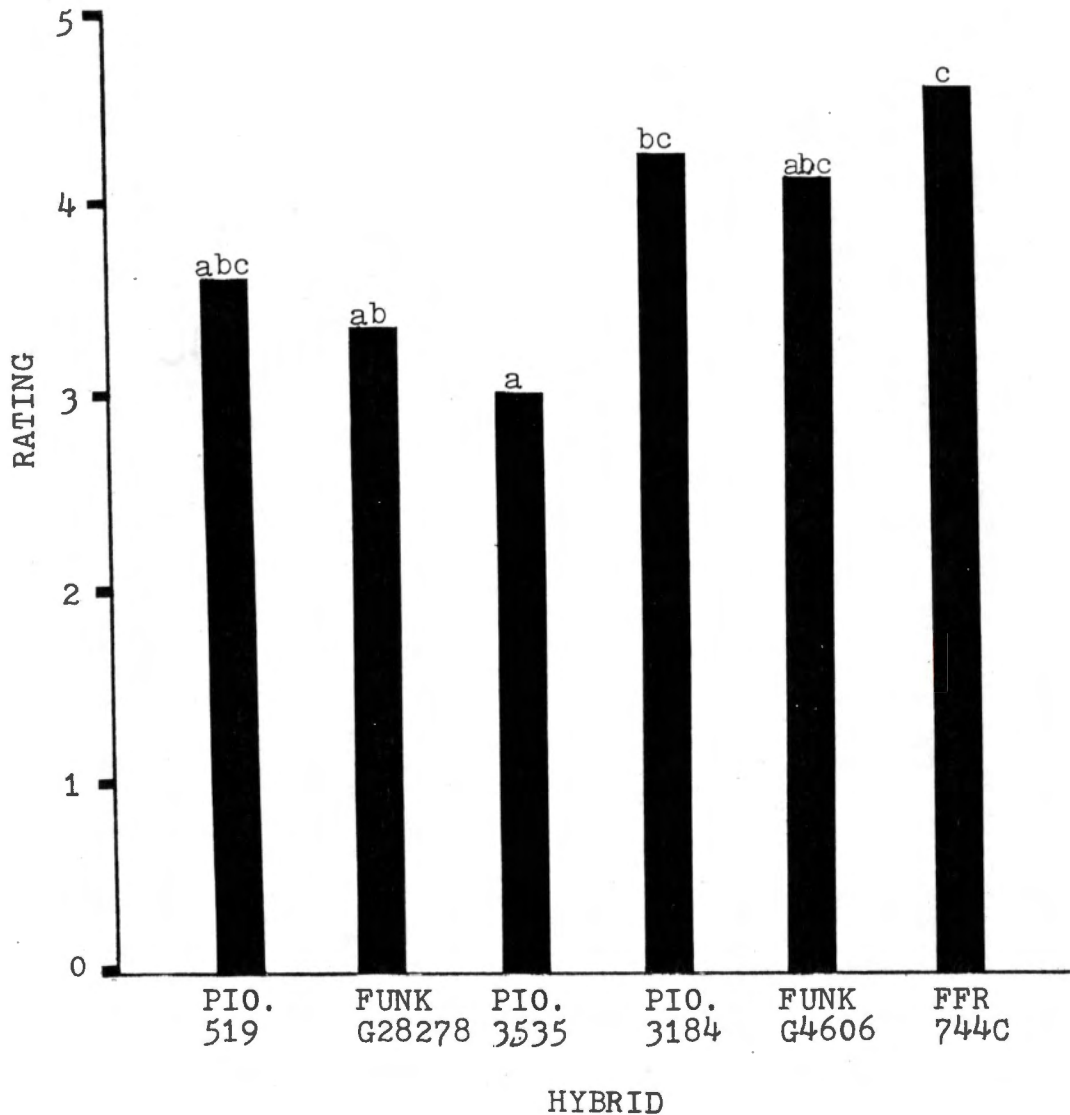


Figure 12. Whorl feeding damage (1 = No Damage, 9 = Extensive Damage) on six field corn hybrids caused by European corn borer, Crossville, 1981.

Any two means with the same letter are not significantly different ($P \leq 0.05$, Duncan's New Multiple Range Test).

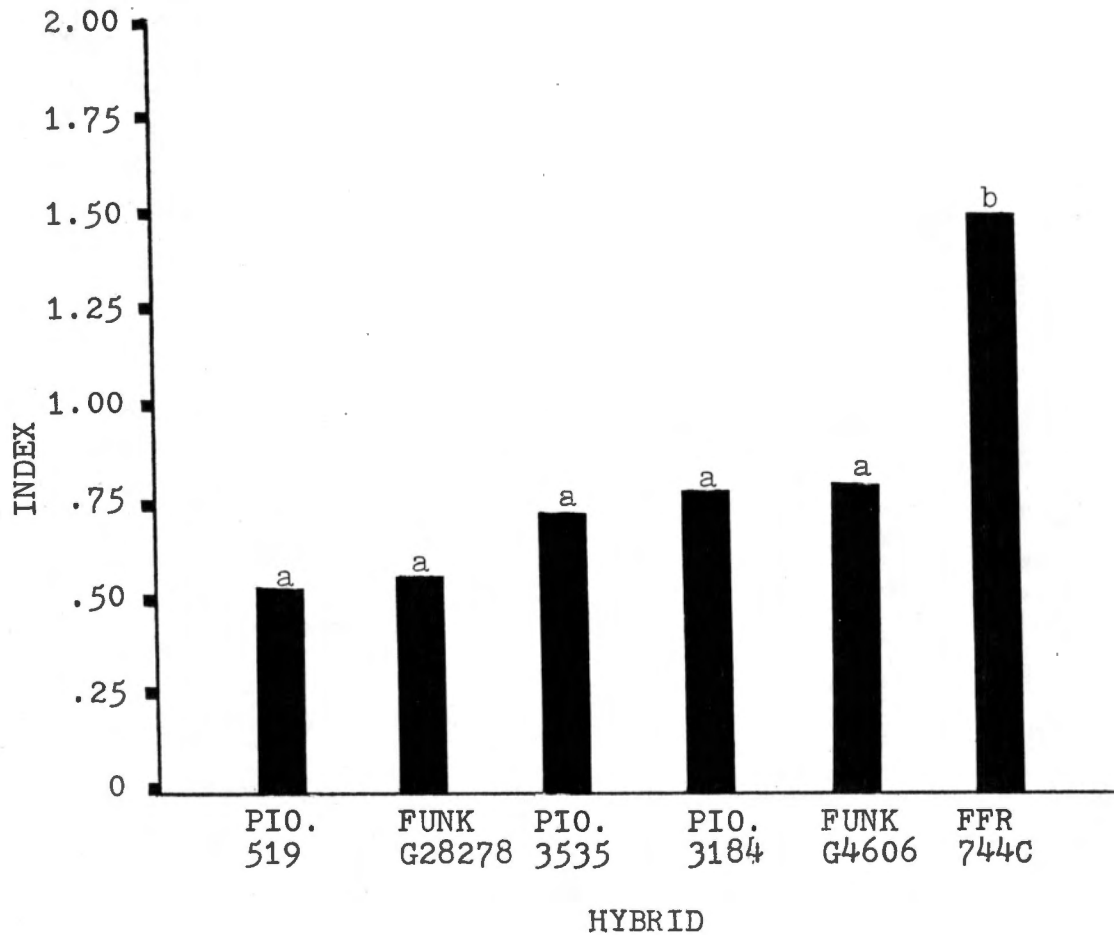


Figure 13. Mean severity index (product of plants with damaged whorls and whorl feeding damage rating), Crossville, 1981.

Any two means with the same letter are not significantly different ($P \leq 0.05$, Duncan's New Multiple Range Test).

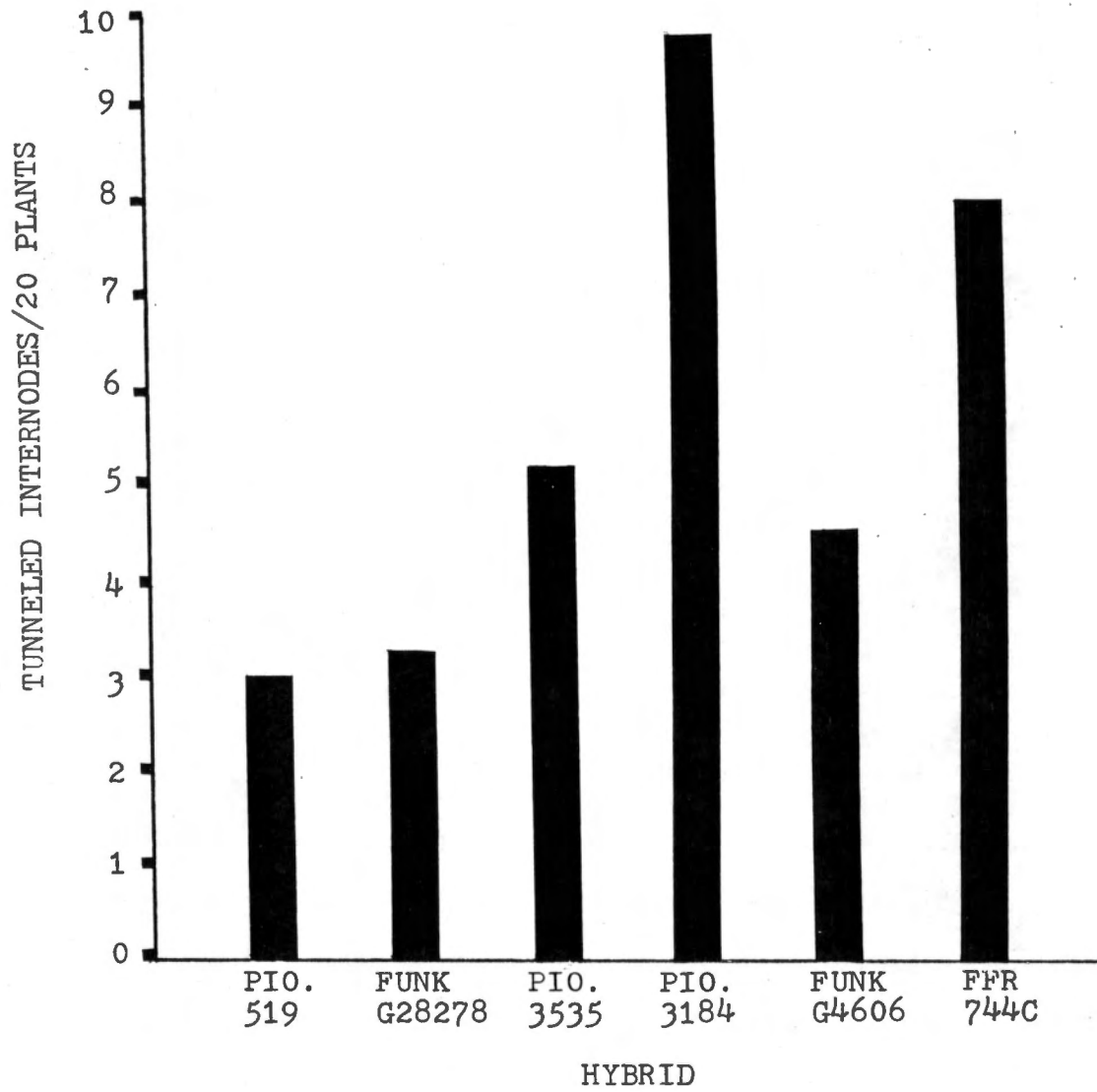


Figure 14. Stalk tunneling by the European corn borer, Crossville, 1981.

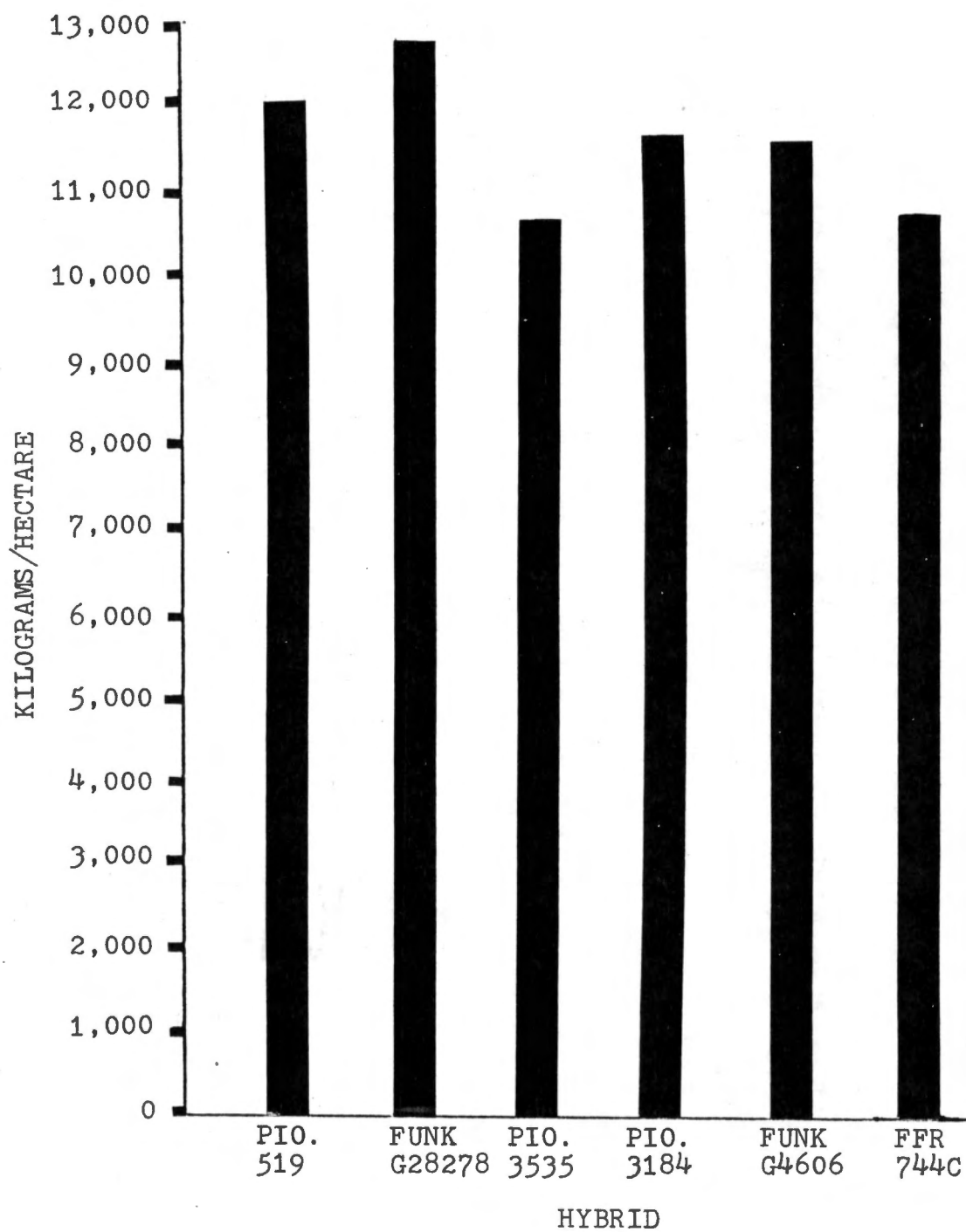


Figure 15. Yield of six field corn hybrids, Crossville, 1981.

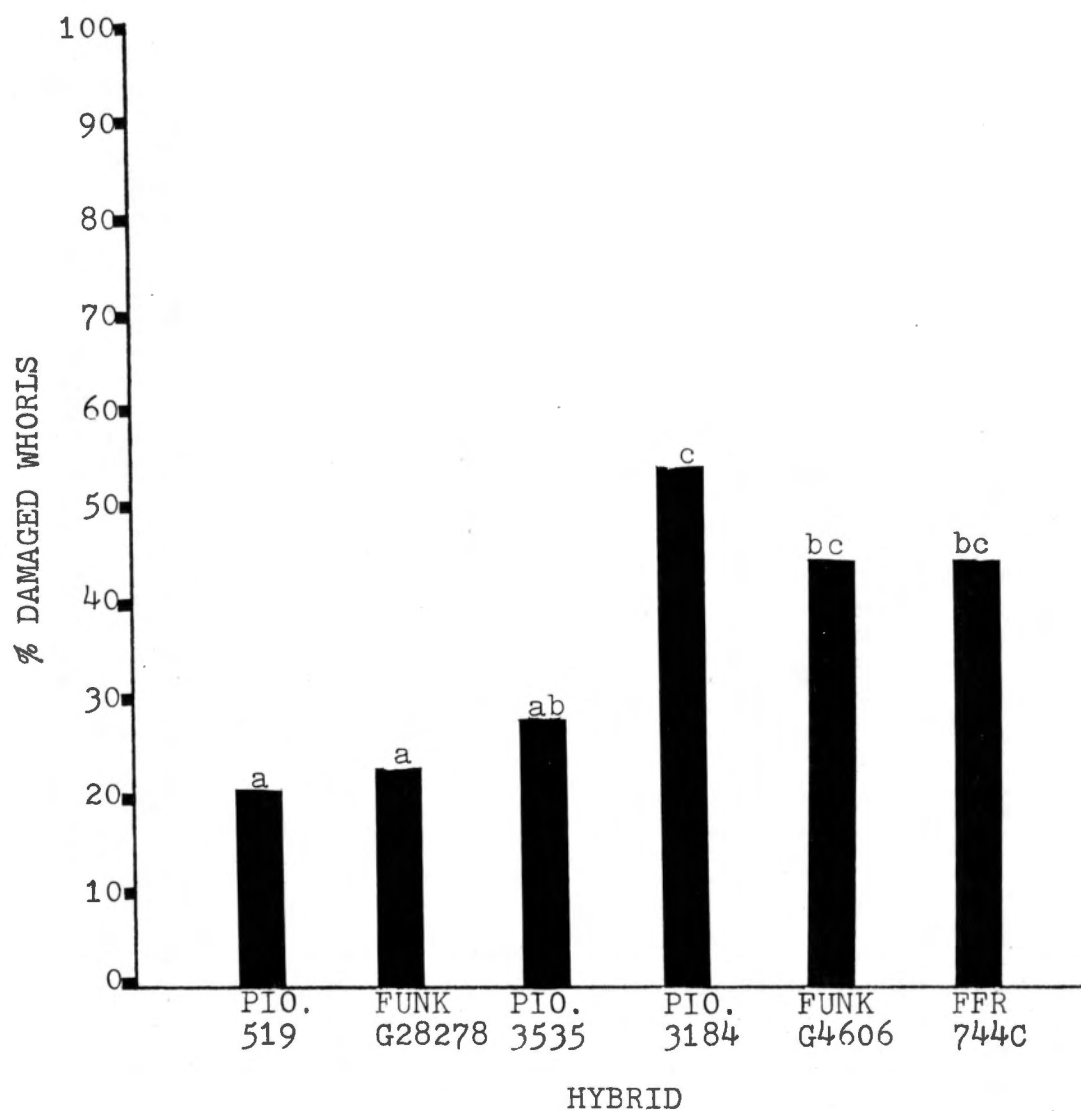


Figure 16. Whorl feeding damage on six field corn hybrids caused by European corn borer, Spring Hill, 1981.

Any two means with the same letter are not significantly different ($P \leq 0.05$, Duncan's New Multiple Range Test).

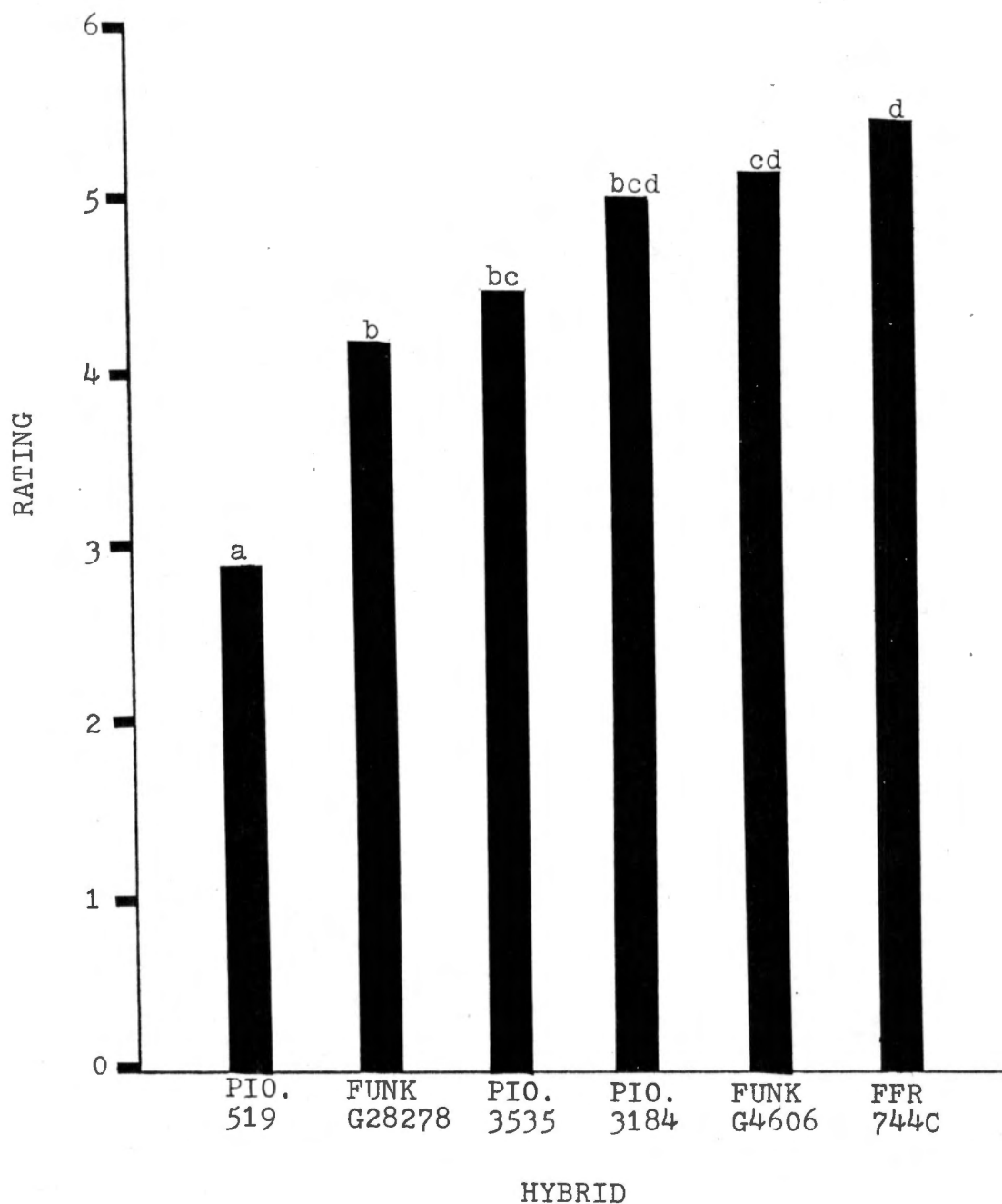


Figure 17. Whorl feeding damage (1 = No Damage, 9 = Extensive Damage) on six field corn hybrids caused by European corn borer, Spring Hill, 1981.

Any two means with the same letter are not significantly different ($P \leq 0.05$, Duncan's New Multiple Range Test).

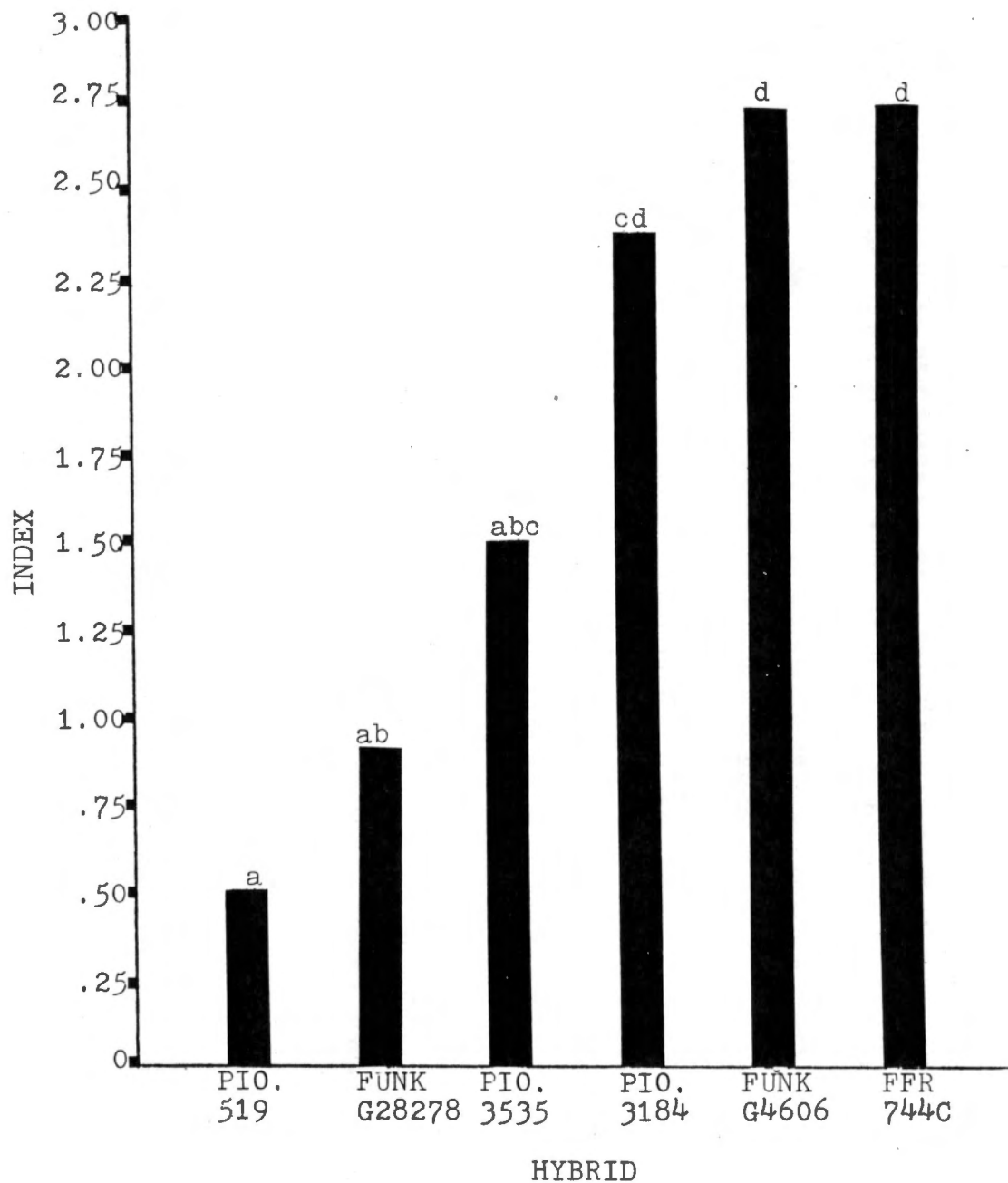


Figure 18. Mean severity index (product of plants with damaged whorls and whorl feeding damage rating), Spring Hill, 1981.

Any two means with the same letter are not significantly different ($P \leq 0.05$, Duncan's New Multiple Range Test).

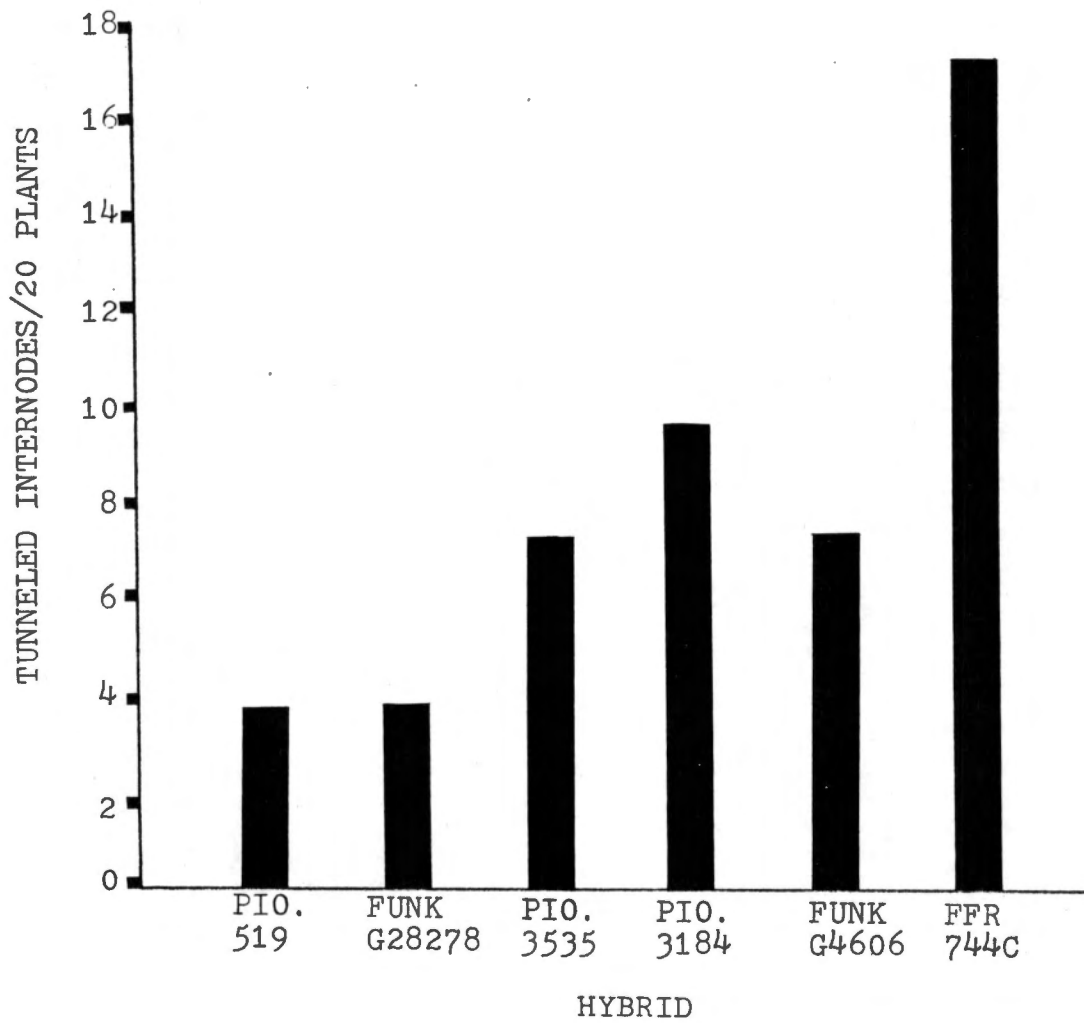


Figure 19. Stalk tunneling by the European corn borer, Spring Hill, 1981.

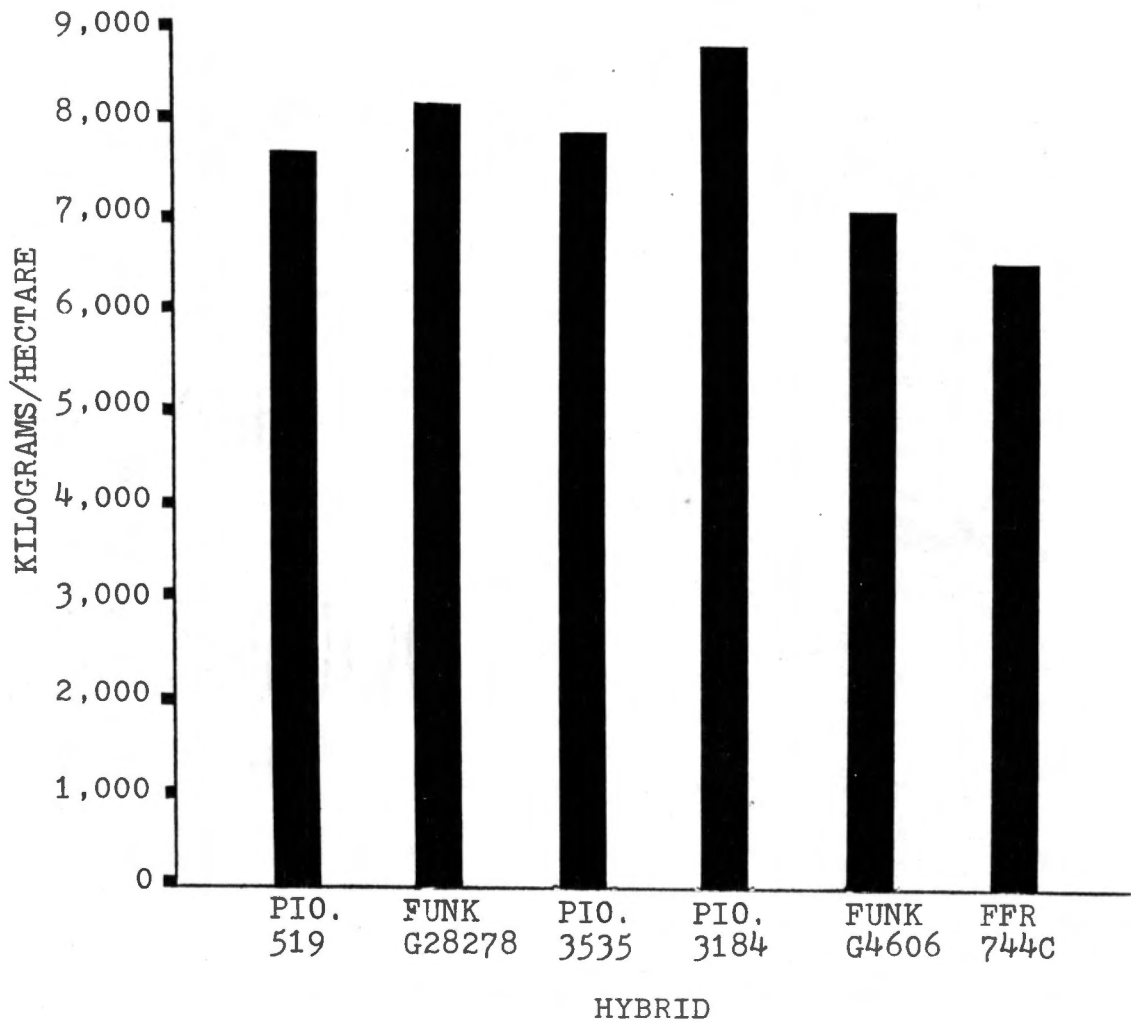


Figure 20. Yield of six field corn hybrids, Spring Hill, 1981.

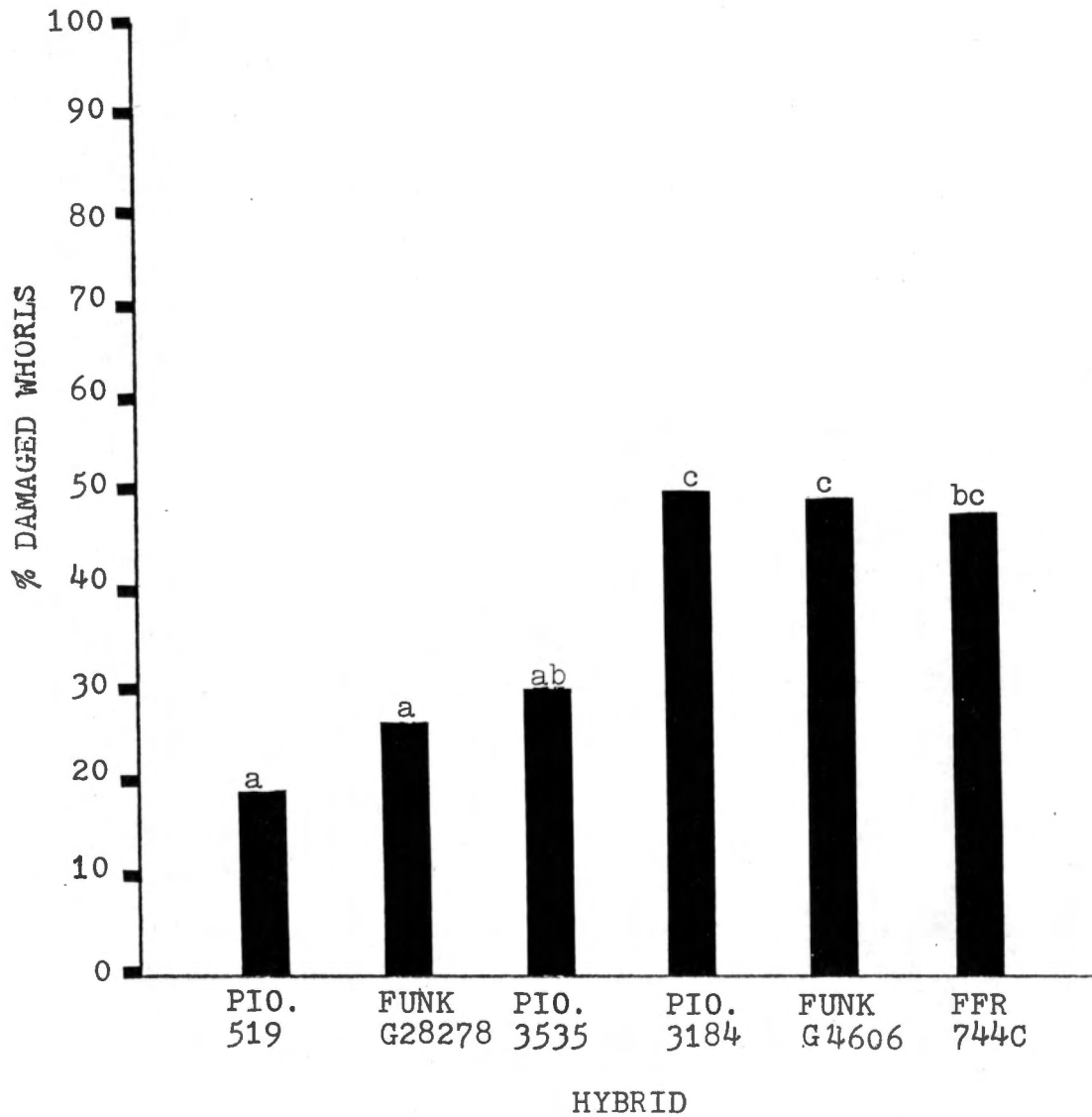


Figure 21. Whorl feeding damage on six field corn hybrids caused by European corn borer, Springfield, 1981.

Any two means with the same letter are not significantly different ($P \leq 0.05$, Duncan's New Multiple Range Test).

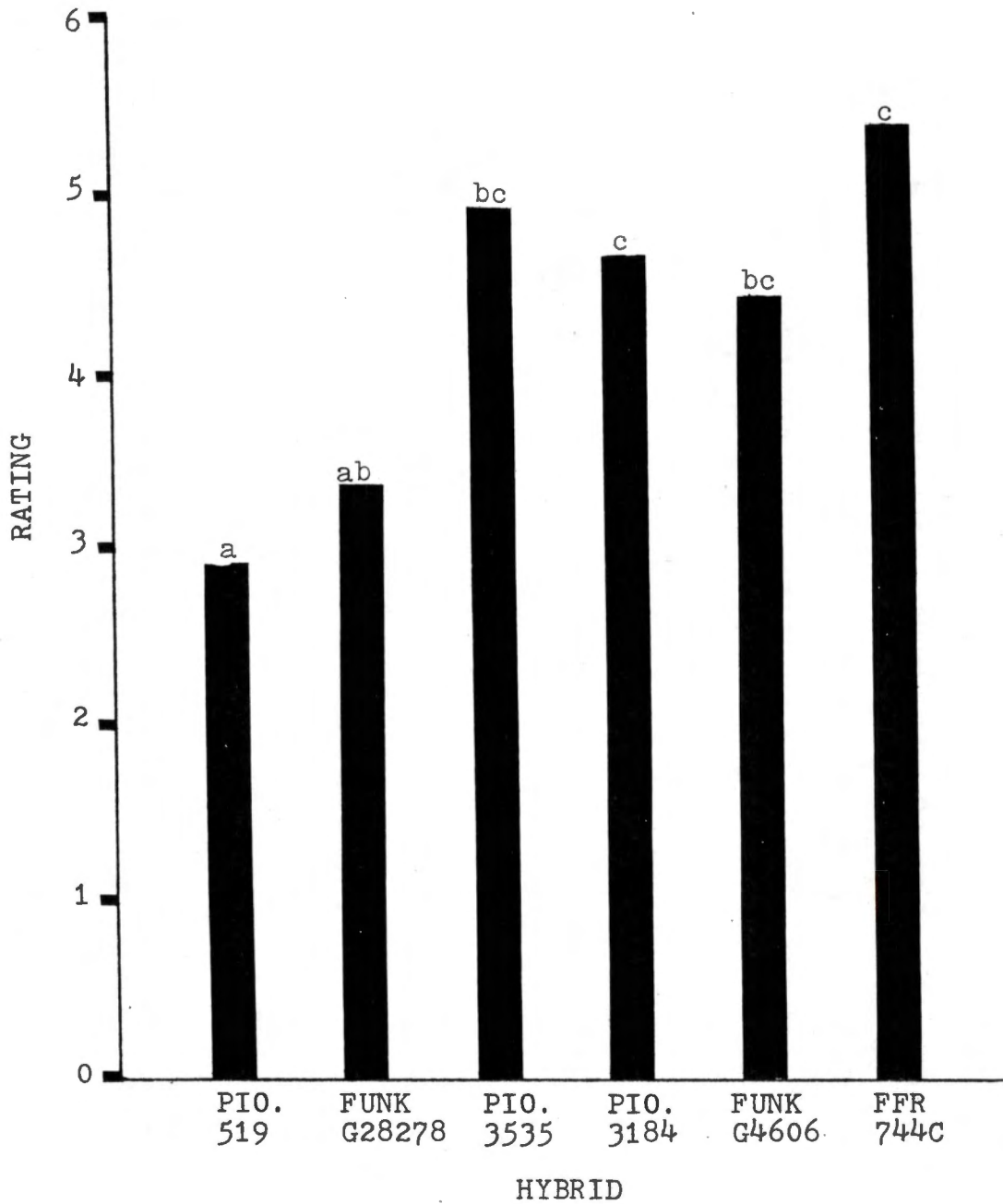


Figure 22. Whorl feeding damage (1 = No Damage, 9 = Extensive Damage) on six field corn hybrids caused by European corn borer, Springfield, 1981.

Any two means with the same letter are not significantly different ($P \leq 0.05$, Duncan's New Multiple Range Test).

indexes (Figure 23) than the standard. This was the only location where significant differences were found in number of tunneled internodes (Figure 24). Pioneer 519 and Funk G28278 both had fewer tunneled internodes than the standard. No yield differences were found among hybrids (Figure 25).

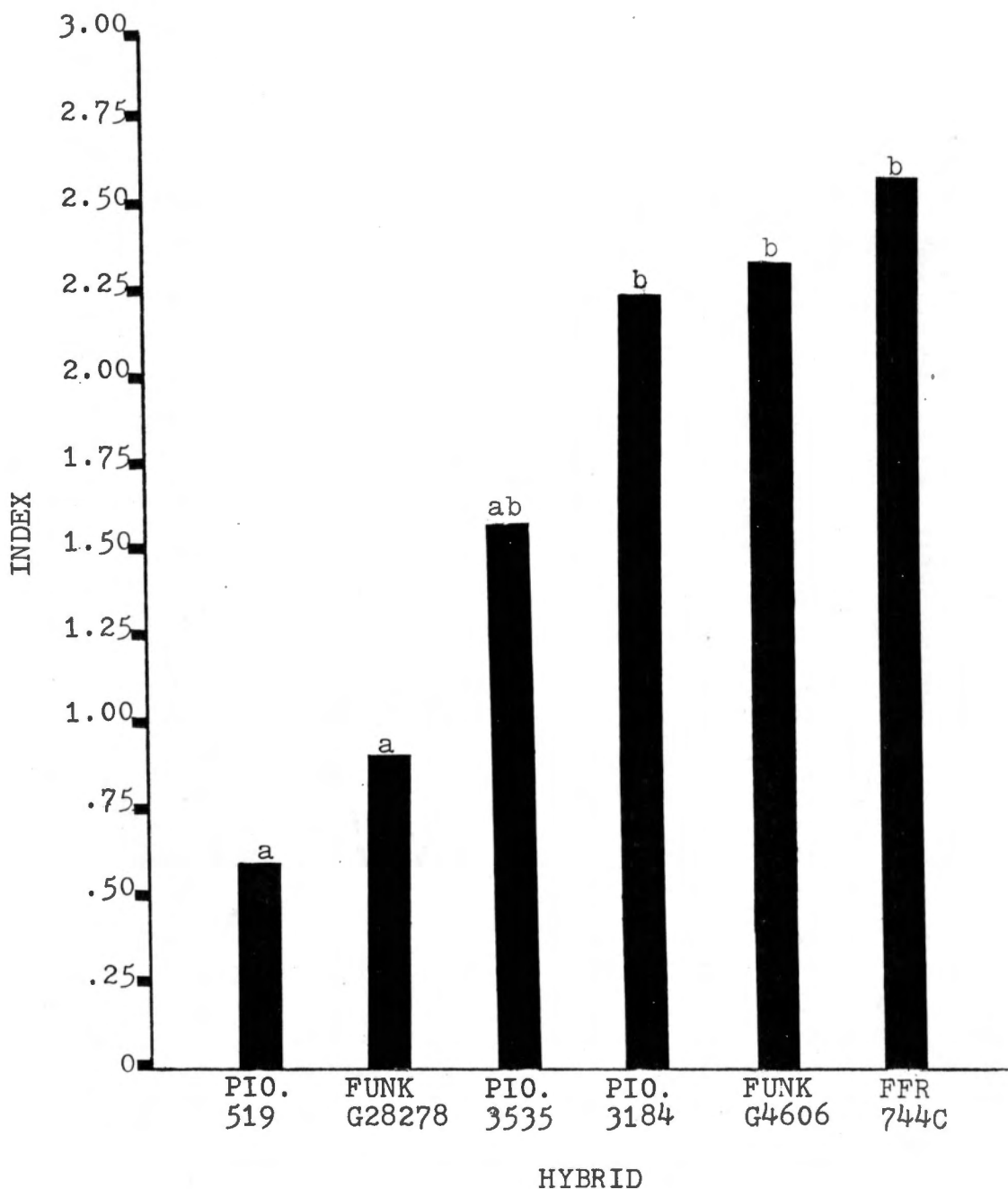


Figure 23. Mean severity index (product of plants with damaged whorls and whorl feeding damage rating), Springfield, 1981.

Any two means with the same letter are not significantly different ($P \leq 0.05$, Duncan's New Multiple Range Test).

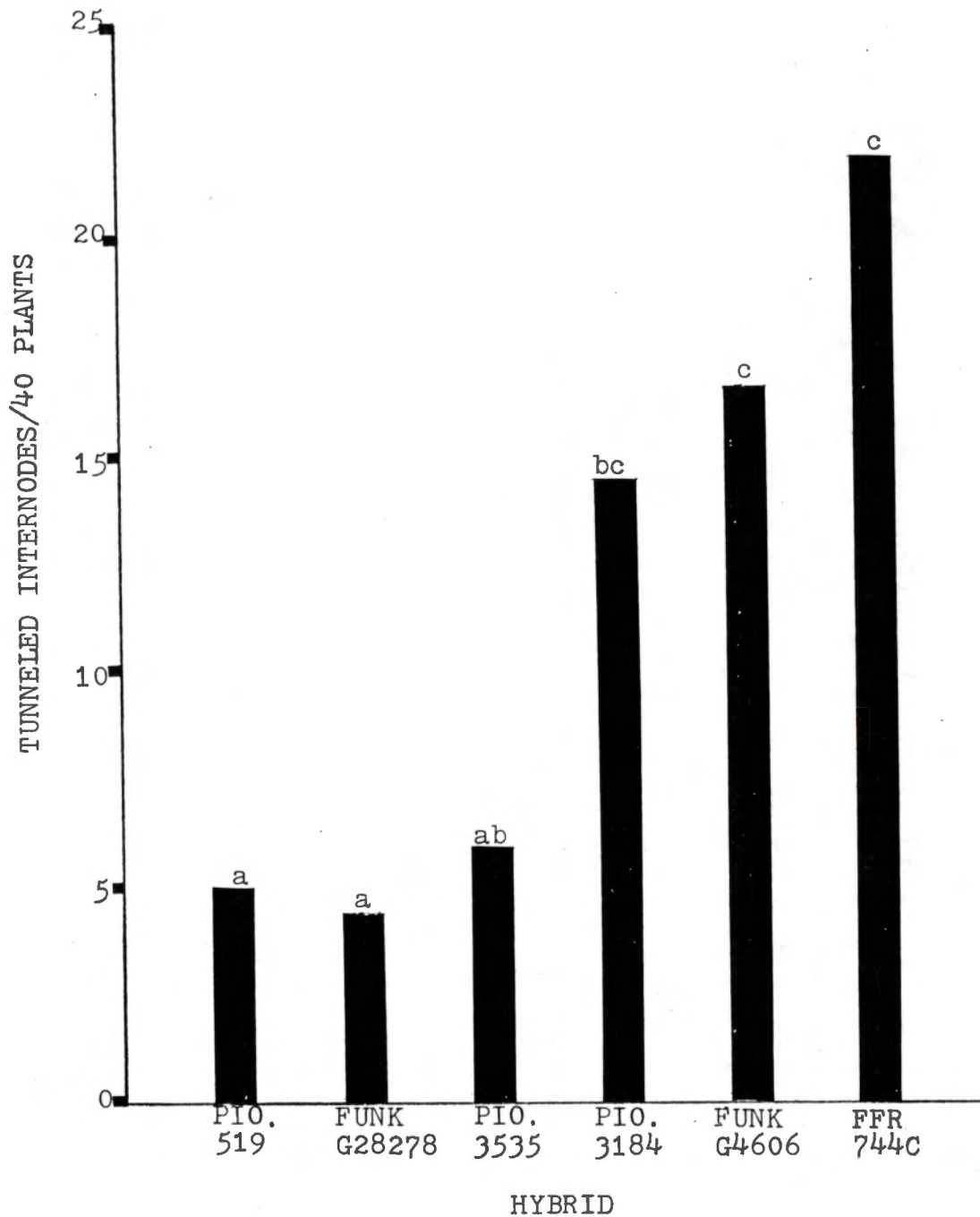


Figure 24. Stalk tunneling by the European corn borer, Springfield, 1981.

Any two means with the same letter are not significantly different ($P \leq 0.05$, Duncan's New Multiple Range Test).

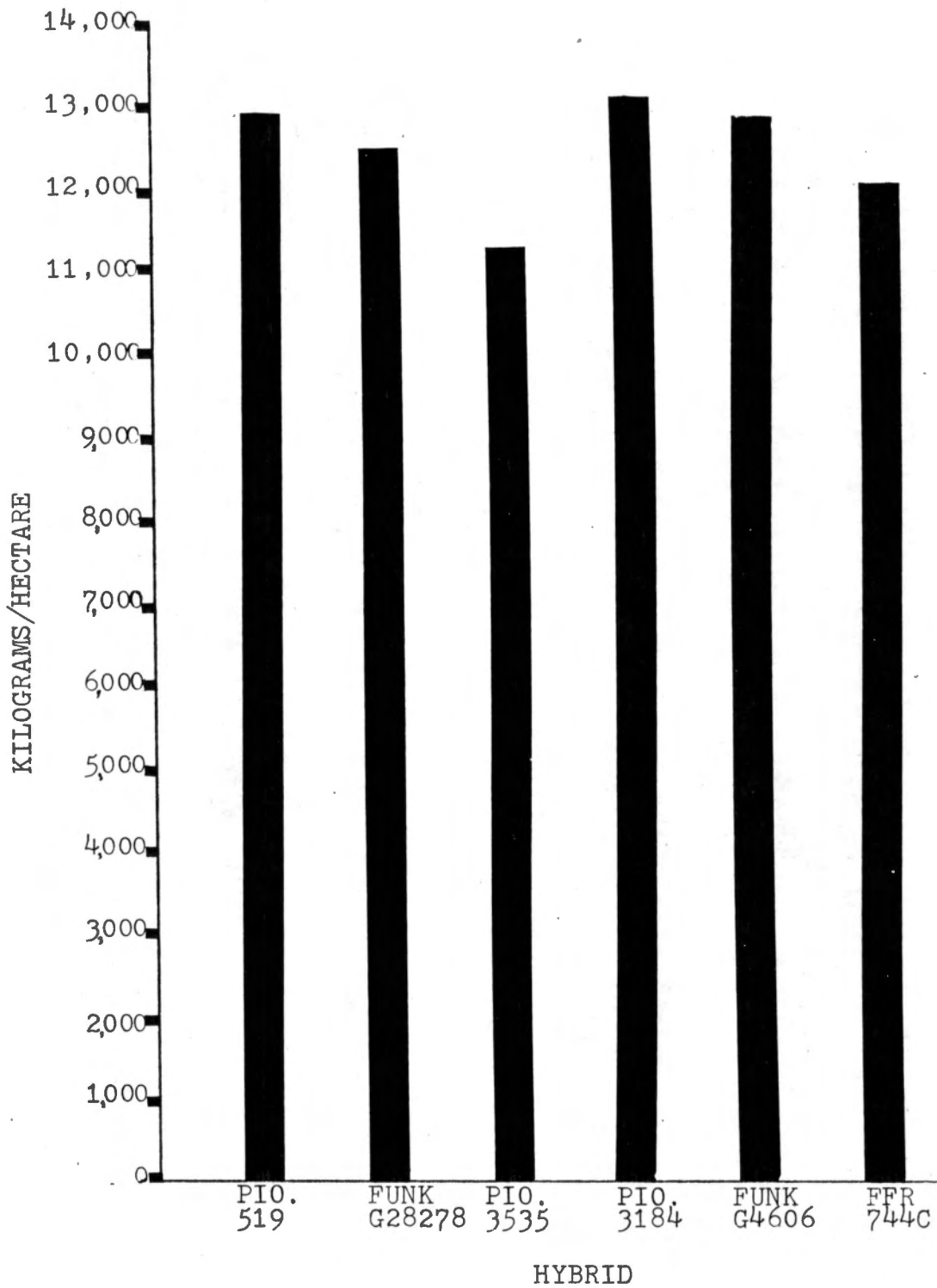


Figure 25. Yield of six field corn hybrids, Springfield, 1981.

CHAPTER IV

SUMMARY AND CONCLUSIONS

Six commercially available field corn hybrids were evaluated for resistance to first-generation European corn borer at five University of Tennessee Experiment Station locations during 1981. Hybrids evaluated were: (1) Pioneer 519, (2) Funk G28278, (3) Pioneer 3535, (4) Pioneer 3184, (5) Funk G4606, and (6) FFR 744C. Resistance was determined by whorl feeding damage and tunneled internodes. Grain yield was taken at each location.

Differences were found among hybrids with respect to at least two measurements of resistance at all locations except one. The hybrids Pioneer 519 and Funk G28278 had a lower damage rating than the standard (FFR 744C) at three locations and a lower mean severity index at four locations. Pioneer 519 and Funk G28278 also had fewer damaged whorls than the standard at three and two locations respectively.

It was concluded that the "resistant" hybrids evaluated in this study are not equal in resistance to the European corn borer. Pioneer 519 and Funk G28278 were most resistant to leaf feeding by first-generation corn borers. These hybrids showed no significant yield advantage over susceptible hybrids. For this reason, under natural corn borer population pressure normally experienced in Tennessee, it is not economically feasible to plant these two hybrids rather than a consistently higher yielding hybrid. The potential of these hybrids should be recognized however, since the average yield for each hybrid

over five locations in Tennessee in 1981 (Pioneer 519, 10,509.37 kg/ha; and Funk G28278, 11,289.39 kg/ha) compares favorably with the 1981 Tennessee state average of 6,764.04 kg/ha (Anon. 1982).

A natural population of first-generation corn borers might be suppressed by planting either Pioneer 519 or Funk G28278. A reduction in first-generation population numbers can prevent a buildup of the destructive second-generation (Guthrie et al. 1974). Therefore, the two hybrids have the potential of being used to suppress both first and, indirectly, second-generation corn borers.

The value of resistant hybrids lies in their ability to produce relatively high yields under both low and high corn borer pressure. For this reason, both yield and resistance should be important considerations in future corn breeding programs. The potential for use of resistant hybrids with high yielding properties is promising for Tennessee.

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APPENDIX

TABLE II

NUMBER OF PLANTS WITH WHORL FEEDING AT FIVE LOCATIONS,* 1981

Hybrid	Location				
	Springfield	Spring Hill	Crossville	Knoxville	Greeneville
Pioneer 519	12.00 a**	15.50 a	5.75	6.33 a	4.00
Funk G-28278	16.25 a	17.50 a	3.75	14.00 b	3.50
Pioneer 3535	18.75 ab	21.25 ab	8.75	15.33 b	3.00
Pioneer 3184	33.00 c	40.50 c	9.50	12.00 b	2.50
Funk G-4606	32.00	33.00 bc	6.25	15.67 b	6.50
FFR 744C	30.00 bc	33.00 bc	11.00	16.00 b	4.75

*Number of plants examined/subplot: Springfield - 62, Spring Hill - 75, Crossville - 56, Knoxville - 20, Greeneville - 28.

**Any two means followed by the same letter are not significantly different ($P \leq 0.05$, Duncan's New Multiple Range Test).

TABLE III

WHORL FEEDING DAMAGE RATINGS AT FIVE LOCATIONS,* 1981

Hybrid	Location				
	Springfield	Spring Hill	Crossville	Knoxville	Greeneville
Pioneer 519	2.92 a**	2.89 a	3.66 abc	1.63 a	4.67
Funk G-28278	3.44 ab	4.21 b	3.36 ab	2.03 ab	4.17
Pioneer 3535	4.98 c	4.49 bc	3.12 a	2.25 abc	3.65
Pioneer 3184	4.70 bc	5.07 bcd	4.30 bc	1.88 ab	3.44
Funk G-4606	4.40 bc	5.17 cd	4.16 abc	2.75 c	3.64
FFR 744C	5.36 c	5.44 d	4.60 c	2.42 bc	3.38

*Number of plants examined/subplot: Springfield - 62, Spring Hill - 75, Crossville - 56, Knoxville - 20, Greeneville - 28.

**Any two means followed by the same letter are not significantly different ($P \leq 0.05$, Duncan's New Multiple Range Test).

TABLE IV

MEAN SEVERITY INDEX AT FIVE LOCATIONS,* 1981

Hybrid	Location				
	Springfield	Spring Hill	Crossville	Knoxville	Greeneville
Pioneer 519	.61 a**	.55 a	.57 a	.53 a	.68
Funk G-28278	.89 a	.93 ab	.55 a	1.46 b	.52
Pioneer 3535	1.59 ab	1.53 abc	.98 a	1.73 c	.47
Pioneer 3184	2.24 b	2.36 cd	1.05 a	1.33 b	.37
Funk G-4606	2.30 b	2.70 d	1.06 a	2.28 d	.95
FFR 744C	2.57 b	2.75 d	1.50 b	1.94 d	.72

*Number of plants examined/subplot: Springfield - 62, Spring Hill - 75, Crossville - 56, Knoxville - 20, Greeneville - 28.

**Any two means followed by the same letter are not significantly different ($P \leq 0.05$, Duncan's New Multiple Range Test).

TABLE V
NUMBER OF TUNNELED INTERNODES AT FIVE LOCATIONS,* 1981

Hybrid	Location				
	Springfield	Spring Hill	Crossville	Knoxville	Greeneville
Pioneer 519	5.00 a*	3.75	3.50	4.00	2.25
Funk G-28278	4.75 a	3.75	3.75	5.25	3.25
Pioneer 3535	6.00 ab	7.25	5.25	6.25	2.00
Pioneer 3184	14.25 bc	9.75	9.75	6.00	1.25
Funk G-4606	16.25 c	7.25	4.50	10.00	4.50
FFR 744C	22.25 c	17.25	8.00	10.25	3.75

*Number of plants split/subplot: Springfield - 40, all other locations 20.

**Any two means followed by the same letter are not significantly different (P ≤ 0.05, Duncan's New Multiple Range Test).

TABLE VI
YIELD (kg/ha) AT FIVE LOCATIONS,* 1981

Hybrid	Location			
	Springfield	Spring Hill	Crossville	Greeneville
Pioneer 519	12,836.74	7,731.46	12,044.72	10,756.07 b** 9,177.87 a
Funk G-28278	12,515.84	8,245.06	12,734.49	11,671.34 bc 11,280.22 ab
Pioneer 3535	11,299.89	7,824.27	10,680.11	9,105.91 a 11,203.15 ab
Pioneer 3184	13,041.24	8,808.99	11,607.42	12,493.07 c 12,142.25 b
Funk G-4606	12,802.13	7,013.37	11,585.39	10,976.53 b 12,014.04 b
FFR 744C	12,098.99	6,583.92	10,746.97	10,822.88 b 11,351.80 ab

*Number of plants examined/subplot: Springfield - 62, Spring Hill - 75, Crossville - 56, Knoxville - 20, Greeneville - 28.

**Any two means followed by the same letter are not significantly different (P ≤ 0.05, Duncan's New Multiple Range Test).

VITA

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