OVIPOSITION OF THE STALK BORER *PAPAIPEMA NEBRIS* (LEPIDOPTERA: NOCTUIDAE) AMONG VARIOUS PLANTS, AND PLANT CHARACTERISTICS FOR OVIPOSITIONAL PREFERENCE

H. Brett Highland[1] and James E. Roberts, Sr.
Department of Entomology
Virginia Polytechnic Institute and State University
Blacksburg, VA 24061
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ABSTRACT

In ovipositional plant preference tests in greenhouse cages, the stalk borer (SB) *Papaipema nebris* Guenée, preferred narrow leaved perennial grasses over wider leaved annual grasses or broad - leaf plants. Fescue, *Fescuta arundinacea* Schreb., and orchardgrass, *Dactylis glomerata* L., were the most preferred plants for oviposition, while annual rye stubble, *Secale cereale* L., and smooth pigweed, *Amaranthus hybridis* L., were among the least preferred. Significantly higher numbers of eggs were laid on plants standing upright in ovipositional cages, compared with numbers of eggs laid on cut plants lying on cage floors. The SB preferred to oviposit on desiccating plant material, regardless of the plant species used in our tests. The SB did not lay eggs on any broadleaf plants used in choice tests, and retained eggs until death. Results of SB ovipositional preferences were reviewed. Possible cultural control techniques, and their importance in regard to the SB infestation syndrome in no - till field corn are discussed.

Key Words: *Papaipema nebris*, stalk borer, oviposition preference.

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INTRODUCTION

OVIPOSITIONAL PREFERENCE by phytophagous insects is a form of behavior which can serve as a temporal link between overwintering eggs and host plants, or a spatial link for migrating and dispersing insects and host plants. Chemical cues have been shown to be the most important criteria for host plant selection by ovipositing Lepidoptera, (Renwick & Radke 1983 Gupta & Thorsteinson 1960), but height and denseness of vegetation, flowering of host plants, plant age, color, moisture level, and tactile characteristics have all been factors proposed to explain observed ovipositional preferences. The black cutworm, *Agrotis ipsilon* (Hufnagel), was shown to prefer curled dock, *Rumex crispus* L., and yellow rocket, *Barbarea vulgaris* R. Br. for oviposition over 14 crop and weep species, including corn and soybean (Bushing & Turpin 1976). Attractiveness was thought to be associated with low growth form. The cabbage looper, *Trichoplusia ni* (Hubner) was found to prefer 21 week old broccoli and cauliflower plants for oviposition to younger, 15 week old plants (Boling & Petrie 1971). *Heliothis* spp. laid 60% fewer eggs on soybean varieties with glabrous compared with hirsute leaves (Lukefahr et al. 1965), whereas *Plathypena scabra* (Fabricius) laid 20 times more eggs on pubescent soybean leaves than on glabrous one (Pedigo 1971).

[1] Address of author: Texas Agricultural Experiment Station, P. O. Box 785, Pearsall, TX 78061

The stalk borer (SB), *Papaipema nebris* Guenée, is a pest in no - till field corn, and has been found feeding on 176 host plants in 44 families (Decker 1931). Increases in the pest status of this insect have been associated with changing weed populations, which act as alternate hosts associated with reduced tillage systems (Bailey et al. 1985; Stinner et al. 1984). Perennial and annual grasses have been identified as plants whose development and reproduction are favored in no - till crops (Elliot 1974; Donaghy & Stabbe 1972; Williams & Ross 1970). Annual and perennial grasses, such as orchardgrass, *Dactylis glomerata* L., wheat, *Triticum aestivum* L., and quackgrass, *Agropyron repens* L., have been identified as preferred species for oviposition by SB, and may account for the increased pest status of this insect in areas where no - till is practiced (Levine 1985; Stinner et al. 1984). This insect has also been reported to delay oviposition until a suitable plant substrate is provided, contributing to the hypothesis that the SB is relatively selective when ovipositing (Decker 1931). This insect has one generation a year, and overwinters in the egg stage (Decker 1931). Manipulation of grass densities near infested fields has been recommended to reduce SB oviposition (Stinner et al. 1984). The objectives of our study were to determine what species of plants common to Virginia no - till corn fields would be preferred for oviposition by the SB, to identify common characteristics of preferred plants, such as plant orientation, moisture and height, and to suggest the implications of these ovipositional preferences by the SB in regard to its pest status in no - till corn.

MATERIALS AND METHODS

Stalk borer larvae were reared in the laboratory on a meridic pinto bean based diet (Levine 1983). Individuals were collected from a Southwestern Virginia corn field, and were one generation removed from a wild population in 1984, and two generations removed in 1985. In order to conduct oviposition experiments, sex of pupae was determined, and pupae were held until adult emergence which was monitored by visually observing the colony three times weekly. All adults were immediately placed in ovipositional cages, making adults between 1 - 48 h old at test initiation.

All tests were conducted in organdy and glass cages (60 by 56 by 70 cm) with wooden floors. Cages were placed in a well ventilated greenhouse during tests, where temperatures fluctuated (22 - 34 C), and photoperiods of 11 : 13 (L : D) to 13.11 (L:D) were observed. All tests took place between 15 August and 1 October in 1984 and 1985. Plants in all tests were carefully inspected for SB eggs at test termination by physically separating leaves and stems. Individual eggs were counted in 1984 and 1985, and egg masses were also counted in 1985.

Ovipositional Preference Varying Species and Plant Orientation, 1984

Plants used in tests were selected on the basis of their relative prevalence in and bordering no - till corn fields in Southwestern Virginia. Giant foxtail, *Setaria faberii* Herrm., tall fescue, *Festuca arundinacea* Schreb., orchardgrass, *Dactylis glomerata* L., smooth pigweed, *Amaranthus hybridus* L., and rye (stubble), *Secale cereale* L., from the previous years cover crop were transplanted from a no - till corn field near Blacksburg, Virginia. Plants were collected between 15 August and 15 September, which is within the normal oviposition period of the SB in Southwestern Virginia. When plants were collected from the field, measurements were taken of leaf length and width. Percent moisture of representative plants of each species was determined by cutting plants at the soil line, then weighing, drying, and reweighing. Corn was grown in the greenhouse, and was at the 6 - 8 true leaf stage at the time of test initiation. All plants were inspected for SB egg masses, then transfered to 0.5 liter plastic pots with potting soil.

Plants in test 1 were cut and presented to SB adults lying on cage floors. Plants in test 2 were presented to SB adults upright in pots in ovipositional cages. In tests 1 and 2, one upright plant or cut plant bunch respectively was presented to SB adults for each plant species per replication. In tests 3-5, one upright plant and one cut plant of a particular species were presented to SB adults for each replication. Position of plants was randomized for each replication. In test 14 (results not given in a table), single pots of common broadleaf weeds, including common milkweed, *Asclepias syriaca* L., pigweed, *Amaranthus* spp., black nightshade, *Solanum nigrum* L., and horsenettle, *Solanum carolinense* L., were collected from no - till corn fields and placed in ovipositional cages.

Eight pairs (8 males, 8 females) of adults within 48 hrs of emergence were released per cage for tests 1 and 2. Four pairs of adults within 48 hours of emergence were released per cage in tests 3, 4, 5, and 14. All cages were supplied with an open dish with 10% sugar water. Eight replications were performed in tests 1 and 2, and four replications were performed in tests 3, 4, 5, and 14. Replications were continued for either 21 days, or until the death of all moths, whichever came first.

Ovipositional Preference Varying Plant Height and Moisture Level, 1985

Giant foxtail, tall fescue, orchardgrass, and fall panicum, *Panicum dichotomiflorum* Michaux., were collected between 15 August and 17 September 1985 from the border of a no - till corn field in Montgomery County, Va. Each plant was closely inspected for SB eggs prior to test initiation. Corn was grown in the greenhouse, and was tested at the 6 - 8 true leaf stage. All plants were dug and transplanted to plastic pots (0.5 liter) with potting soil.

In tests 6, 7, 8, and 9, two plants of a given species at two different heights were placed in ovipositional cages. Plants were clipped to either 20 or 40 cm in height. In tests 10, 11, 12, and 13, two plants of a given species under two different watering regimes were placed in ovipositional cages. Plants in these tests were either not watered, or were watered three times weekly for the duration of the test. Samples of each plant species under each water regime were weighed before and after each test to measure percent moisture at test conclusion.

Four pairs of SB adults were released per cage in tests 6 - 13. All cages were supplied with 10% sugar water. Four replications were performed for tests 6 - 13, and tests were continued for 21 days, or until death of all moths.

Statistical Analysis

Separate statistical analyses were performed for each test. Data on ovipositional preference was analyzed by analysis of variance in a randomized complete block design, with blocks being individual cages in the greenhouse. Data on leaf moisture, leaf length, and leaf width were analyzed by analysis of variance in a completely randomized design for each plant characteristic. Differences between means were determined by students t - test (tests 3 - 13), or by Duncan's multiple range test (Table 2, and tests 1, 2, and 14). Data in tests 1 -14 were transformed using an arcsine transformation (Duncan 1951; Little & Hills 1978; SAS Institute 1982). All tests were analyzed at the $P = 0.05$ level of significance.

RESULTS

Ovipositional Preferences Varying Species, and Plant Orientation 1984

In experiments testing the attractiveness among plants presented horizontally to ovipositing SB, the greatest number of eggs were found deposited on foxtail, orchardgrass, corn or fescue (Table 1, Test 1). No eggs were laid on pigweed, or on the rye stubble. When different plants were presented upright in pots, fescue was the most highly preferred plant for oviposition by the SB. Pigweed was the least desirable plant for oviposition (Table 1, Test 2). These results are in agreement with Levine (1985), who found that grasses such and orchardgrass, wheat, and sudax were preferred for oviposition over broadleaf weeds such as ragweed, red clover, and alfalfa. Stinner et al. (1984) also reported ovipositional preference of the SB for grasses, such as orchardgrass, fall panicum, quackgrass, and timothy over broadleaf weeds, such as giant ragweed and pigweed.

Using orchardgrass, fescue or foxtail, and presenting plants either cut or standing, moths preferred to lay eggs on standing, uncut plants in all tests (Table 1, Tests 3, 4, and 5). Our results differ from Levine (1985), who found no difference in numbers of eggs laid on cut or standing foxtail. No eggs were laid on cut orchardgrass in four replications (Table 1, Test 3) even though we show that the SB will readily lay eggs on horizontal, cut orchardgrass if a choice of upright plants is not provided (test 1). The species most preferred for oviposition by the stalk borer in test 2 was fescue, which was also the plant with narrowest leaves (Table 2). Plants with relatively wide leaves, and high plant moisture, (corn and pigweed), were not among the plants most preferred by the SB for oviposition.

Ovipositional Preference Varying Plant Height and Moisture Level, 1985

Although the SB laid more eggs on taller plants, fescue was the only plant tested in which there were significantly higher numbers of eggs and masses laid on the taller plants (Table 3, Test 6). This is in agreement with Levine (1985), who found that taller plants such as sudax (86 cm) and giant foxtail (104 cm), were not among the plants preferred by the SB for oviposition when compared to shorter plants such as orchardgrass (29 cm), or wheat (47 cm).

When individual plants of one plant species were presented to stalk borers either watered three times weekly or not watered and allowed to desiccate, more eggs were laid on desiccating plants, regardless of the species used (Table 3, Test 10, 11, 12, and 13). The number of egg masses laid on desiccating plants was significantly higher using fescue, foxtail and orchardgrass, whereas the number of eggs laid on desiccating plants was significantly higher for corn, fescue, foxtail, and orchardgrass.

No eggs were recovered from any replication using only broadleaf weeds as ovipositional material (test 14). This is in general agreement with Levine (1985), Stinner et al. (1984), and Decker (1931), who found little or no oviposition by the SB on broadleaf weeds or broadleaf crop plants.

DISCUSSION

Previous studies have shown that grasses, especially perennial cool season grasses, are preferred by the SB for oviposition (Stinner et al. 1984; Levine 1985). Perennial cool season grasses are very common plants in and around no - till corn in Virginia. Many fields have a history of continuous corn cultivation, and these

Table 1. Ovipositional preference of the SB for various plants, situated either upright or horizontal in cages, 1984.

Plant	Mean no. eggs ± SD	Percent	Range
Test 1 - Plants cut and presented to the SB lying horizontal on cage floors.*			
Foxtail	69 ± 93 a†	40	0 - 272
Orchardgrass	47 ± 98 ab	27	0 - 279
Corn	34 ± 61 ab	20	0 - 170
Fescue	22 ± 29 ab	13	0 - 78
Pigweed	0 b	0	-
Rye (stubble)	0 b	0	-
Test 2 - Plants presented to the SB upright in pots.			
Fescue	974 ± 544 a†	50	204 - 1512
Orchardgrass	622 ± 777 b	32	12 - 2068
Foxtail	234 ± 414 bc	12	0 - 7158
Corn	116 ± 157 bc	6	0 - 440
Pigweed	0 c	0	-
Test 3 - Orchardgrass plants are presented to the SB both horizontal on cage floors, and upright in pots.			
Orchardgrass (upright)	490 ± 467 a‡	100	26 - 1168
Orchardgrass (horizontal)	0 b	0	-
Test 4 - Fescue plants are presented to the SB both horizontal on cage floors, and upright in pots.			
Fescue (upright)	332 ± 204 a‡	90	212 - 638
Fescue (horizontal)	37 ± 36 b	10	0 - 76
Test 5 - Foxtail plants are presented to the SB both horizontal on cage floors, and upright in pots.			
Foxtail (upright)	275 ± 375 a‡	92	4 - 820
Foxtail (horizontal)	24 ± 36 b	8	0 - 78

* Eight replications in tests 1 and 2, four replications in test 3, 4, and 5.

†Means followed by the same letter are not significantly different using Duncan's multiple range test (Duncan 1951), means transformed to arcsine square root (Percentage of total number of eggs laid in test/100) (Little & Hills 1978, SAS 1982).

‡Means followed by the same letter are not significantly different at the .05 level using the students t-test, df = 3, means transformed to arcsine square root (Percent of total number of eggs laid in test/100) (Little & Hills 1978, SAS 1982).

Table 2. Percent moisture, length and width of leaves from representative plants used in ovipositional tests, 1984.

Plant	Percent eggs laid (test 2)	Mean percent moisture	Mean leaf length (cm)	Mean leaf width (cm)
Corn	6 bc*	76.5 a	57.8 a	4.3 a
Pigweed	0 c	51.6 a	5.3 d	3.6 b
Orchardgrass	32 b	35.0 ab	53.0 a	.7 d
Foxtail	12 bc	30.6 ab	32.5 c	1.7 c
Fescue	50 a	32.0 bc	40.0 b	.4 d

* Means in variable grouping followed by the same letter are not significantly different at the 0.05 level using ANOVA and Duncan's multiple range test for mean separation (Duncan 1951, SAS 1982).

grasses are used on field borders and in waterways. Replacement of these plants would be difficult, and the elimination of these plants is not a viable control alternative. Conversely, grass clumps and associated SB within fields can be targeted for control using herbicides mixed with insecticides prior to corn planting. This close relationship of the SB with perennial cool season grasses contributes to the cycle of the damage syndrome of the SB in no - till corn. Increased SB infestations in certain fields, and in weedy areas in fields, has been observed from season to season, and could be explained by ovipositional preferences of the SB for existing weeds. Perennial cool season grasses are the predominant growing plants in early and mid spring during SB egg hatch. Preference for oviposition by the SB for these grasses will increase the survival of newly emerged SB larvae by ensuring eclosion near available food resources. Movement of SB females is believed to be limited (Bailey et al. 1985), and could also contribute to the clumped distribution of many perennial infestations.

The fact that significantly more eggs were laid on upright grasses could be an important behavioral factor to consider in manipulative SB cultural control practices. Grasses in borders of infested fields could be cut before moth emergence, thus possibly moving ovipositing SB away from corn fields in search of more highly preferred oviposition sites, such as areas with standing grasses.

Reasons for ovipositional preference for desiccating, brown wilted, and upright plants are unknown. One factor which could account for this behavior is the habit of the SB of using narrow leaves which fold at the midrib for oviposition. We would estimate that 90% of eggs in our tests in 1984 and 1985 were laid on the midrib of folding leaves. This is in agreement with Levine (1985), who found that moths prefer to lay eggs on curled leaves. This natural folding of the leaves is accentuated when desiccation occurs. Females laying eggs in the leaf crease often used a glue like material to fold the leaf together, forming a protective packet surrounding egg masses. This could serve to increase protection from adverse environmental factors during winter months, such as low temperature or moisture loss, and to protect eggs form parasites and predators.

Table 3. Ovipostional preference of the SB for plants varying plant height and moisture level, 1985.

Test 6 - 9 Plants cut to varying heights and presented to SB for oviposition.*

Plant	Ht. (cm)	Mean no. of masses ± SD†	Percent	Range	Mean no. of eggs ± SD†	Percent	Range
Test 6							
Fescue	20	2.5 ± 3.3 b	17	0 - 7	108 ± 182 b	17	0 - 380
	40	12.5 ± 8.1 a	83	1 - 19	543 ± 406 a	83	20 - 898
Test 7							
Foxtail	20	2.2 ± 1.3 a	26	1 - 4	118 ± 76 a	39	60 - 226
	40	6.25 ± 5.1 a	74	1 - 12	182 ± 155 a	61	10 - 368
Test 8							
Fall panicum	20	1.5 ± 2.3 a	26	0 - 5	64 ± 110 a	29	0 - 228
	40	4.2 ± 3.4 a	74	0 - 7	160 ± 131 a	71	0 - 286
Test 9							
Orchard - grass	20	2.5 ± 2.4 a	31	0 - 5	103 ± 169 a	31	0 - 356
	40	5.5 ± 5.8 a	69	0 - 13	228 ± 257 a	69	0 - 556

Test 10 - 13 - Plants watered, or not watered and presented to SB for oviposition.

Plant	Water	Mean no. of masses ± SD	Percent	Range	Mean no. of eggs ± SD	Percent	Range
Test 10							
Corn	+	1.25 ± 2.5 a	18	0 - 5	61 ± 123 b	13	0 - 246
	—	5.75 ± 6.0 a	82	0 - 14	412 ± 531 a	87	0-1192
Test 11							
Fescue	+	2.0 ± 2.5 b	32	0 - 5	79 ± 106 b	28	0 - 224
	—	4.25 ± 4.0 a	68	1 - 10	199 ± 201 a	72	4 - 410
Test 12							
Foxtail	+	.75 ± .95 b	14	0 - 2	47 ± 55 b	22	0 - 98
	—	4.60 ± 2.60 a	86	1 - 7	165 ± 135 a	78	18 - 308
Test 13							
Orchard - grass	+	1.0 ± 2.0 b	13	0 - 4	64 ± 129 b	15	0 - 258
	—	6.75 ± 3.1 a	87	4 - 11	359 ± 207 a	85	188-646

* Four replications were performed for each plant factor interaction.

†Means followed by the same letter are not significantly different at the .05 level using students t - test, df = 3, for each plant and plant factor interaction. Data transformed to arcsine square root (Percent of total number of egg masses (or eggs) laid in test/100) (Duncan 1951, Little & Hills 1978, SAS 1982).

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