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Resistance to a Spotted Stem Borer[1] in Sorghum and Maize[2,3]

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ABSTRACT

A useful level of resistance to *Chilo zonellus* (Swinhoe) exists in both maize (corn) and sorghum breeding material used in East Africa. Ratings for leaf feeding proved useful in separating resistant and susceptible maize inbreds but not maize hybrids or sorghum varieties. For these, larval counts and exit holes per plant might be used, but yield also would be an important criterion. Thus, a technique of applying recurrent selection to composite populations by infesting every plant with 1–3 egg masses in the leaf whorl and of basing the final selection on yield is likely to prove an effective method of developing types of maize and sorghum possessing enhanced resistance to *C. zonellus*.

Development of plant resistance, which has played an important part in reducing injury by the European corn borer, *Ostrinia nubilalis* (Hübner), to maize (corn) in North America, required the following preliminary work: (1) Study of the biology of the insect and its relationship to the host plant. (2) Development of techniques for obtaining uniformly high levels of infestation; these involved infesting plants with egg-masses from insects reared in the laboratory or, more recently, on synthetic diets. (3) Obtaining reliable criteria for measuring resistance, which must be simple and rapid to use and suitable for statistical analysis. (4) Identification of suitable sources of resistance (Brindley and Dicke 1963).

A spotted stalk borer, *Chilo zonelles* (Swinhoe) (= *C. partellus*), was chosen for resistance studies to be made part of the East African major cereals project because of its wide distribution and importance as a major pest of sorghum and maize in both eastern Africa and India. The European corn borer and this stalk borer belong to the same family and have certain features in common, though many differences exist in behavior and life history. The European corn borer prefers maize, and *C. zonellus* prefers sorghum, but both will accept readily either host as an oviposition site and as larval food. Also, the early larval stages of both feed on leaves and midribs before entering the stalks and can survive unfavorable periods in the host's life cycle by remaining within the stems as torpid larvae. The unfavorable period for the European corn borer is winter; with the onset of warmer weather, the larvae pupate, and the adults emerge

[1] Lepidoptera: Pyralidae.

[2] Contribution from the East African Agriculture and Forestry Research Organization, East African Community, with the U.S. Agency for International Development, the Entomology Research Division, USDA, and the Agriculture Research Council, British Overseas Development Ministry, cooperating. Received for publication Feb. 19, 1970.

[3] Mention of a pesticide does not constitute a recommendation by the USDA.

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shortly afterward. With *C. zonellus*, onset of the rains after the dry season stimulates the torpid larvae to pupate in the stems, and the adults emerge soon afterward when young host plants are likely to be available (Gupta 1940, Ingram 1958, Nye 1960).

METHODS AND MATERIALS.—All tests were made at the Serere Research Station, Uganda, in 1967–68 during either the 1st or 2nd rains, the growing seasons. Seeds of sorghum varieties were obtained from the Serere collection, and those of maize were obtained from the Kitale Maize Breeding Program in Kenya which includes material developed in Eastern and Central Africa. The larvae of *C. zonellus* and the egg masses were obtained from a laboratory-reared culture maintained on either sorghum stalk sections or on artificial diets adapted from those used by Guthrie et al. (1965) for the European corn borer. The diet developed by Keaster and Harrendorf (1965) and recommended by Chatterji et al. (1966[8]) for *C. zonellus* was not used because wheat germ, an essential ingredient, was not obtained in time; however, this diet has the advantage of not requiring leaf material, a source of contaminating microorganisms which were sometimes troublesome in our cultures.

The moths oviposited readily on waxed paper, which was then cut into pieces, usually with 1 egg mass on each. Egg masses were fixed to the plant 1–2 days before the eggs were due to hatch by passing a pin through the waxed paper. If masses were placed on the plants earlier, they were likely to be destroyed by predators (ants were among the worst). The larvae used to infest the plants were obtained by allowing them to emerge in small vials and then transferring these to the plants within a few hours with a small artist's brush.

Three tests were made with sorghum and 2 with maize to study the relationship between borer activity and plant damage. The following measurements were made:

(1) Leaf-feeding ratings. These ratings were based on the system used by Guthrie et al. (1960) to measure resistance to the European corn borer. Plants were scored for leaf damage on a scale of 1–9, 1 = little feeding and 9 = severe feeding. Then plants were grouped as resistant (rating of 1–3), intermediate (rating of 4–6), and susceptible (rating of 7–9), and for making genetic studies. However, in rating the damage in test 5 (2nd test with sorghum) the scale was reversed and magnified 10 times (10 = severe damage; 90 = little damage) to make it comparable to the ratings for damage by the sorghum shoot fly, *Atherigona varia* (Meigen), and the overall rating was based on the accumulated scores from ratings for 3 expressions of borer damage. These were leaf feeding (10 = severe; 30 = slight), occurrence of borer holes in the stalk (10 = numerous; 30 = few) and seedless panicle branches or broken stalks (10 = severe; 30 = slight).

(2) Larvae per stalk, recorded at the time of harvest; also occasional pupae from late stalk dissections were included in larval counts.

(3) Number of exit holes per stalk.

(4) Length of tunneling per stalk at harvest.

(5) Plant stand at harvest.

(6) Number of ears or heads per plot.

(7) Number of seedless heads per plot.

(8) Plant height measured from ground level to the basal branches of the tassel (or head) in sorghum.

(9) Yield of threshed grains at a moisture level of ca. 15%.

Since results of the 1st test showed that interference by the natural population of borers could introduce a substantial error, all plots in subsequent tests were sprayed with malathion or endosulfan about once a week except for 10-day periods before and after the artificial infestations.

RESULTS AND DISCUSSION.—*Test 1.*—The test was planted to 'Combine Kafir 60' (CK-60) sorghum and 5 treatments (10 plants/plot; 4 replicates) were used: (1) no artificial infestation; (2) infestation with 3 egg masses in the whorl at 1 time; (3) infestation with 3 egg masses in the whorl, each at 2-day intervals; (4) an egg mass in the whorl once a week for 3 weeks; and (5) 3 egg masses pinned about halfway out on the leaf midveins at 2-day intervals. The plants were about 20 days old when the infestation was started, and data were collected 40–42 days later.

Table 1 shows the results. Damage measurements varied in ease of recording. Leaf feeding was by far the quickest obtained, but this measurement was also the most subjective. Moreover, it indicated little difference among treatments and had a high coefficient of variability. Plant height, though easy to measure, could be used only within a given plant entry, that is, the heights of infested and uninfested plants of the same variety could be compared. Measurement of the length of tunneling and counts of larvae required the destruction of the plant so these measurements could be taken only at harvest if the seeds were required for further tests. Also, in test 1 the length of tunneling had a large coefficient of variability and seemed to be influenced more by the length of time the egg masses were on the plant than by the number of larvae per plant. Survival of larvae was significantly less when the egg masses were pinned out on the leaves. The suggestion from the data shown in Table 1 that egg masses placed out on the leaves result in shorter plants was not borne out by the subsequent tests. Borers did not significantly influence plant stands in this or other tests reported here, since the time of infestation was apparently too late to cause extensive "deadhearts" and consequently plant deaths.

Tests 2 and 3.—Test 2 (sorghum) and test 3 (maize) were similar in design and in data recorded. Both were split-split plot design with 4 replications. The major split was 3 times of infesting: 20, 30, and 40 days after 50% plant emergence. Then, within each time of infesting, we included an entry susceptible to *C. zonellus* a resistant entry, and the cross between the two selected after prior screening [sorghum varieties CK 60 (resistant) and SB 65 (susceptible), and maize inbreds A (resistant) and F (susceptible)]. Also, in test 3, each maize entry was subjected to 4 methods of infesting as follows: (1) 1 egg mass/plant; (2) 1 egg mass + 1 additional mass 2 days later; (3) 6 first instars; and (4) 6 larvae + 6 additional larvae 2 days later. Method 3 and 4 were considered too laborious for tests involving a large number of plants and were omitted from test 2 (sorghum). Ten plants were infested in each plot of sorghum and 3 plants in each plot of maize.

[8] S. M. Chatterji, K. H. Siddiqui, V. P. S. Panwar, G. C. Sharama, and W. R. Young. Rearing of the maize stem borer, *Chilo zonellus* Swinhoe on artificial diet. Paper read at 3rd Inter-Asian Maize Improvement Conf., New Dehli, India. Oct. 1966.

Table 1.—Mean ratings of borer damage on CK 60 sorghum infested with 3 egg masses of *C. zonellus*/plant (4 replicates).

Infestation method	Rating leaf feeding[a]	No. larvae/stalk	Tunnel length (in.)	Plant height (in.)
No artificial infestation	2.2	0.4	1.3	27.3
Once in whorl	5.0	3.0	7.0	27.3
2 days apart in whorl	5.0	2.7	5.9	26.4
Weekly in whorl	5.3	2.9	3.6	27.4
2 days apart on leaves	5.7	1.8	6.5	29.3
LSD ($P = 0.05$)	2.5	.6	2.6	2.9
CV (%)	28.2	17.8	36.1	7.5

[a] Rating from 1–9 with 1 = little feeding and 9 = severe feeding.

Table 2 shows the results of test 2. The method of infestation did not affect any character of the plants except yield: the use of 2 egg masses resulted in a slightly lower yield than 1 egg mass (7230 vs. 7750 lb/acre), a difference that was just significant at $P = 0.05$. The interaction between time and method of infestation for larvae per plant just reached significance at the 5% level and was the only interaction to do so. Data in Table 2 are averages of the 2 methods of infestation.

Some measurements showed fairly large differences among sorghum entries, but the leaf-feeding rating was a poor indicator of expected grain yield. The hybrid, the highest yielder, consistently had the highest leaf feeding rating, but the rating for CK 60 did not differ from that of SB 65 for any time of infestation. Infestations at 20, 30, and 40 days after 50% plant emergence differed significantly from one another in leaf-feeding ratings, but the infestation at 30 days did not differ significantly from the infestation at 40 days in yield and percentage of seedless heads. Also, adjusting yield for leaf-feeding rating had no effect on the varietal differences, that is, the values did not change in the "F" test. The higher leaf-feeding ratings shown for CK 60 in test 1 compared with that in test 2 were the result of a lack of standardization between the systems of rating leaf damage used in the 2 tests.

Measurements of tunnel lengths, stalk exit holes, and the number of larvae per stalk were highly variable, although the hybrid had the highest values. If these measurements are used for rating resistance, they probably should be taken before the grain is ready to be harvested. The large number of larvae recorded and the slightly lower amounts of tunneling in test 1 (Table 1) compared with test 2 (Table 2) could have occurred because the plants in test 1 were about 10 days earlier than those in test 2 counting from the time when the infestations began.

The counts of heads per plot indicated that the hybrid had more heads than the other varieties and that this changed little for different times or methods of infestation. However, there was a significantly lower percentage of grainless heads when the infestation was begun earlier.

The yields of sorghum grain in test 2 appeared unusually high, because no border plants were placed at the ends of the rows; therefore, the harvested plants (without plant competition) gave an inflated yield. However, yields were influenced significantly by the time of infestation: infestation at 20 days depressed yields more than infestation at 30 or 40 days, especially when 2 egg masses were used. Yields indicated that CK 60 was more resistant (or tolerant) than SB 65, since SB 65 had a much higher reduction in yield after the infestation at 20 days than did CK 60, which relatively was slightly affected. The cross of the 2 varieties should have a yield somewhere in between the two if the genetic effects were additive, but such was not the case. CK was rated more resistant to borers than SB 65, but the hybrid was inferior to both in borer activity ratings. However, the hybrid gave a much better yield than either parent and showed less suppression of yield in the presence of the borers.

	% yield increase over infestation at 20 days	
	30 days	40 days
SB 65	50	57
CK 60	23	29
Hybrid (CK 60 × SB 65)	16	15

Thus, perhaps heterosis plays some role in limiting the effects of borer damage.

Table 2.—Comparison of mean measurements of susceptible (to *C. zonellus*), resistant, and susceptible × resistant entries of sorghum artificially infested (4 replicates).

Comparison	Rating[a] of leaf feeding	No. larvae/stalk	No. exit holes/stalk	Tunnel length (in.)	No. heads/plot	% seedless heads	Stalk height (in.)	Grain yield (lb/acre)
Varieties								
CK 60	2.88	1.73	2.17	6.4	12.9	2.94	31.1	5540
SB 65	3.04	1.63	2.30	7.8	14.2	3.12	27.2	5860
CK 60 × SB 65	3.47	2.07	3.04	9.2	17.5	3.04	45.0	11,080
LSD ($P = 0.05$)	0.30	n.s.	0.56	1.4	1.9	n.s.	1.8	790
CV (%)	15.9	52.3	37.2	29.7	20.7	14.5	8.4	17.5
Time of infestations[b]								
20 days	3.92					2.47		5830
30 days	3.27					3.28		8190
40 days	2.22					3.35		8460
LSD ($P = 0.05$)	.41					0.45		920
CV (%)	18.5					21.0		17.4

[a] Rating from 1–9 with 1 = little feeding and 9 = severe feeding.
[b] After 50% plant emergence.

Table 3 gives the results of the maize test. None of the interactions reached significance at the 5% level. A shortage of egg masses during the test restricted infestation to 3 plants/plot, but the number proved adequate for evaluating the measurements recorded. We intended to measure plant height and yield, but vandalism prevented. Of those measurements obtained, either leaf-feeding ratings or counts of borers per plant proved adequate to separate resistant inbred A from susceptible inbred F if about 20 plants were used in each of 4 replications. Measuring the length of tunneling was not so accurate as the other 2 criteria.

By the measurement of borer activity, inbred F proved slightly more susceptible than inbred A, and the hybrid was more susceptible than either parent. This result parallels those obtained with sorghum (Table 2), so it is most unfortunate that no figures on yield could be obtained to assess the borer tolerance of the hybrid.

Methods 3 and 4 of infesting were consistently inferior to the other 2 methods and certainly did not justify the required extra labor. Furthermore, application of the additional egg masses in Method 2 did not seem to add consistently to the level of infestation obtained by Method 1. Infestation at 40 days gave less feeding but more tunneling compared with the other 2 times of infestation, as with sorghum (Table 2). However, highest larval recovery occurred with infestation at 30 days compared with recovery in sorghum in which infestation at 30 days averaged the lowest larval recovery.

Test 4.—This test was designed to determine whether measurable differences in resistance to damage by *C. zonellus* existed within the eastern African maize breeding materials and, if such differences did exist, whether they could be differentiated by using agronomic measurements. A preliminary test indicated that feeding ratings were difficult to make in segregating lines. Therefore, plots infested with 1 egg mass/plant were compared with plots treated with an insecticide for each maize entry. Also, since planting dates seemed to influence yields of maize in Uganda, especially during the 2nd rains, plantings were made Aug. 22 and Sept. 6. On each date, 14 maize entries were planted in both infested and sprayed plots and the infestation with egg masses was done 20–26 days after plant emergence. Spraying with endosulfan was done weekly. The plots were 2 rows with a maximum of 13 plants/row; the test was replicated 3 times.

Table 4 gives entries and results. Yields, adjusted for moisture content, showed highly significant differences among varieties. Also, the interaction between planting dates and varieties in yield gave highly significant differences. The difference between the infested plots and sprayed plots was significant at only the 5% level, and rather large differences in yield were required to achieve significance when the yield of any one variety with and without borers was compared. Only 'Kitale Composite B' showed an appreciable lower yield when it was infested with borers. Moreover, several varieties showed no apparent reduction in yield when they were infested, among them the single cross hybrid 'SR 52,' which yields consistently well in Rhodesia, where it was developed, through Zambia and throughout East Africa.

Differences in ears per plant were highly significant among varieties, between infested and sprayed plots, and within the interaction of planting dates and varieties; however, this measurement, like yield, showed a fairly high coefficient of variability (17.3 and 18.6%, respectively). Plant height showed differences only among varieties, which would be expected.

Table 3.—Comparison of mean measurements of susceptible (to *C. zonellus*), resistant, and susceptible × resistant entries of maize artificially infested (4 replicates).

Comparison	Leaf feeding[a]	No. larvae/stalk	Tunnel length (in.)
Varieties			
A	2.51	4.22	13.8
F	2.91	4.82	14.6
A × F	3.25	5.73	17.2
LSD (P = 0.05)	0.36	0.57	1.7
CV (%)	49.7	46.7	44.4
Time of infestation[b]			
20 days	3.23	3.70	8.5
30 days	3.40	6.06	18.2
40 days	2.04	5.01	18.9
LSD (P = 0.05)	0.25	0.85	3.3
CV (%)	30.2	59.8	75.1
Method of infesting			
1. 1 egg mass/plant	3.35	6.16	16.5
2. 1 egg mass/plant twice 2 days apart	3.47	6.52	19.7
3. 6 1st-instars	2.19	3.00	10.9
4. 6 1st-instars twice 2 days apart	2.55	4.01	13.9
LSD (P = 0.05)	0.40	0.88	2.7
CV (%)	50.7	65.7	64.9

[a] Rating from 1–9 with 1 = little feeding and 9 = severe feeding.
[b] After 50% plant emergence.

Table 4.—Comparisons of agronomic measurements for determining differences among maize entries by using borer infested and uninfested (sprayed) plots (averages from 2 dates of planting, 3 replicates).

Variety	Yield (lb/acre)		Number of plots	
	Infested plots	Sprayed plots	Infested plots	Sprayed plots
EC 573	1480	1580	50	54
'Embu 12'	2010	2410	57	74
'Embu II'	2590	2960	60	68
'Kitale Comp. C'	2620	3000	67	74
'White Star'	2690	3130	72	84
'Embu I'	3250	3460	71	76
Embu II	3530	3420	88	73
'Uganda Comp. A'	3370	3800	70	82
'Kitale II'	3920	3620	78	73
Kitale Comp. B	3270	4430	60	78
'Zambia Comp. A'	3860	3850	70	76
'Honga B'	4380	4270	99	97
SR-52	4770	4840	85	83
F × G	4920	5380	91	98
Mean	3340	3580	73	78

LSD (borer/sprayed) mean yields: 138
SE yield for any 1 variety or variety yields in the same column: 368

Table 5.—Comparisons among sorghum varieties infested with *C. zonellus* and *A. varia*.

Entry	Borer rating	Shoot fly recovery rating	Combined rating	Heads/100 plants	Yield (lb/acre)
5DX 36/1/2	81	50	131	132	1900
Namatare	81	73	154	190	1630
5DX 142/4	77	56	133	159	2690
5DX 162/1	76	63	139	175	2600
CK 60	74	25	99	51	700
Dobbs	72	58	130	188	2300
H x 60/7/2	67	48	115	149	2230
Serena	62	75	137	78	2280
5DX 61/2/1	62	59	121	145	2280
SUK-1	62	29	91	97	1040
3DX 57/1	61	63	124	183	2410
SB 79	60	58	118	147	2320
4DX 34/1/4	58	52	110	134	2000
L 28	57	58	115	148	2210
5DX 50/4/1	55	50	105	124	1700
5DX 61/6/2	55	49	104	113	1500
5DX 142/9	52	50	102	121	1500
5DX 18/2	51	63	114	141	2120
'Redlan'	47	41	88	78	1100
SB 77	41	44	85	88	1210
SB 65	38	48	86	88	1360
Combine Type 2	36	43	79	68	970
'Coprock'	35	16	51	37	460
LSD ($P = 0.05$)	9.1	9.5		27.9	460
CV (%)	18.8	23.1		26.7	32.1

Thus, none of the measurements seemed very satisfactory for rating borer damage since there was no significant interaction of varieties and the borer-spray treatments.

Test 5.—Test 5 was made with 23 sorghum varieties that were selected for yield in the Serere breeding program. Each plot was a single row with 10 plants infested with 1 egg mass/plant, and there were 12 replications. The test was designed to rate both resistance to *C. zonellus* and recovery resistance to the sorghum shoot fly, an insect which is equally damaging to sorghum. The shoot fly resistance and the list of varietal pedigrees have been reported in a separate paper (Doggett et al. 1970); however, the shoot fly ratings are presented in Table 5, as they are a part of the combined ratings for the varieties.

Plant stands at harvest were uniform, yet the variation in the number of heads was highly significant among varieties. However, these differences seemed more closely related to genetic variation and to shoot fly damage than to borer attack. Differences in grain yields were also highly significant, that is, the regression of yield on borer rating and on percent recovered plants were both significant. However, the values for the partial regression coefficients were $b_{Y\ SF.B} = 0.2410 \pm 0.0086$, and $b_{Y\ B.SF} = 1.9188 \pm 0.2841$, so the shoot fly was of greater importance in reducing yield than the stem borer, as can be seen from the F values:

	F value
Yield	15.02
Yield, adjusted for % recovered plants	7.31
Yield, adjusted for borer rating	12.26
Yield, adjusted for both ratings	6.90

The genetic correlation between yield and borer damage was $r_g = 0.553$. Thus, it should not be difficult to obtain high-yield varieties that are resistant to *C. zonellus* from an effective breeding program with populations combining the factors, and recurrent selection among families (Doggett and Eberhart 1968) should be effective in improving resistance and yield in such populations. From the results of the present tests, each plant should be infested with 1–3 borer masses, and the highest yielding survivors should be selected and recombined to form the improved population for the next breeding cycle.

Of course, resistance to one insect does not necessarily result in resistance to another. Hence CK 60 was resistant to borers but not to shoot flies (Table 5). However, the combined rating against the 2 pests is of interest. Except for 'Namatare,' any entry that yielded more than 2000 lb/acre had a combined rating of 110 or above. In fact, the correlation between yield and the combined rating was $r = 0.708$ (rising to $r = 0.778$ if Namatare is excluded.) These 2 pests thus accounted for about ½ the variation in yield. The indigenous varieties 'Dobbs' and L 28 had combined ratings of 130 and 115, and 'Serena,' which was proved widely successful in East Africa, had a rating of 137, as would be expected in any areas where these 2 pests are endemic. Since Namatare may be ratooned in Buganda season after season with conditions very favorable to both pests, its combined rating of 154 is not unexpected. However, Namatare is a very specialized beer sorghum selected primarily for its brewing characters rather than for yield. Its somewhat lower yield (Table 5) could therefore result either from this factor or from the fact that it is a longer term sorghum than the others and was being tested outside its own area of adaptation.

CONCLUSIONS.—Results of the 5 tests showed some inconsistencies and did not supply sufficient information about some factors. However, certain conclusions can be drawn.

(1) Resistance to *C. zonellus* exists in maize and sorghum material in present use in breeding programs in East Africa.

(2) Maize could be rated for resistance by using a leaf-feeding system provided the plant entries are all inbreds, but inbreds cannot be included in the same test with hybrids or segregating material.

(3) Sorghum will be difficult to rate for resistance by using leaf feeding, but rating for overall damage seems to have possibilities. Any rating system must be standardized so consistent results can be obtained among trials.

(4) A larval count and possibly holes caused by borers in stalks could perhaps be used to rate for resistance. However, larval counts necessitate destruction of the plant and should probably be made about 30 days after infestation. Tunneling is highly variable as a measure of resistance in both sorghum and maize.

(5) Agronomic measurements can provide information about resistance in studies with *C. zonellus*, but they may depend more on other factors, e.g., genetic differences or other insect damage, than on the presence of borer larvae. Certainly, yield in the presence of severe borer infestation should be considered in any preliminary studies.

(6) Infestation about 20 days after plant emer-

gence seems to give the largest differences in both leaf feeding and yield among plant entries.

(7) Infesting with 1 batch of egg masses seems adequate for most screening tests.

(8) An effective method of developing varieties and hybrids possessing enhanced resistance to *C. zonellus* in both maize and sorghum would involve infesting all plants in a composite population or the S_1 lines from a composite population with 1–3 egg masses in the funnel (whorl) of each plant some 20 days after plant emergence and then using recurrent selection for yield.

REFERENCES CITED

Brindley, T. A., and F. F. Dicke. 1963. Significant developments in European corn borer research. Annu. Rev. Entomol. 8: 155–76.

Doggett, H, and Eberhart, S. A. 1968. Recurrent selection in sorghum. Crop Sci. 8: 119–21.

Doggett, H., K. J. Starks, and S. A. Eberhart. 1970. Breeding for resistance to the sorghum shoot fly. Ibid. (In press.)

Gupta, B. D. 1940. The anatomy, life and seasonal histories of striped moth-borers of sugar-cane in North Bihar and West United Provinces. Indian J. Agr. Sci. 10: 787–817.

Guthrie, W. D., F. F. Dicke, and C. R. Neiswander. 1960. Leaf and sheath feeding resistance to the European corn borer in eight inbred lines of dent corn. Ohio Agr. Exp. Sta. Bull. 860, 38 p.

Guthrie, W. D., E. S. Raun, F. F. Dicke, G. R. Pesho, and S. W. Carter. 1965. Laboratory production of European corn borer egg masses. Iowa State J. Sci. 40: 65–83.

Ingram, W. R. 1958. The lepidopterous stalk borers associated with gramineae in Uganda. Bull. Entomol. Res. 49: 367–83.

Keaster, A. J., and K. Harrendorf. 1965. Laboratory rearing of Southwestern corn borer, *Zeadiatraea grandiosella* (Dyar) on a wheat germ medium. J. Econ. Entomol. 58: 923–4.

Nye, I. W. B. 1960. The insect pests of graminaceous crops in East Africa. Colon. Res. Stud. 31, 48. p.

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