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Greenhouse Screening Peanut Germ Plasm for Resistance to the Lesser Cornstalk Borer[1]

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ABSTRACT

An objective, rapid technique was developed for greenhouse screening of peanuts, (*Arachis hypogaea* L.), germ plasm for resistance to lesser cornstalk borer, *Elasmopalpus lignosellus* (Zeller). Seedlings planted one per container were infested with first instar larvae. Twenty-one days after infestation the plants were scored for damage visible above the soil surface, damage concealed by the soil surface, and survival. Larvae were scored for developmental stage and survival. Entries were screened in groups of 16 including the cultivar 'Starr' as a standard.

Evaluations were made of 490 cultivars, introductions and selections. Eighty-one cultivars scored significantly lower ($p \geq .05$) than Starr in one or more rating categories. Re-evaluation of certain cultivars coupled with an analysis of the Starr standard entry show the techniques to be effective in selecting for resistance to the lesser cornstalk borer.

Key Words: *Elasmopalpus lignosellus* (Zeller), lesser cornstalk borer, plant resistance, peanut, greenhouse evaluation technique, *Arachis hypogaea* L., groundnut.

Peanuts, *Arachis hypogaea* L., are attacked by several insect pests in the Southwestern U. S., but the lesser cornstalk borer (LCB), *Elasmopalpus lignosellus* (Zeller), is the most economically destructive (1, 17). The larvae are soil inhabitants which feed on the pods and subterranean parts of the pegs and branches, often tunneling into the crown and the stem. This insect prefers dry, loose soils, and exists in the upper five cm near the soil surface. Under favorable conditions the life cycle from egg to adult moth require 25 days, and 6 larval instars (7).

Control of the LCB historically has been dependent on the use of insecticides. However, the unilateral use of insecticides does not always provide long term solutions for insect pest problems. Heavy insecticide use on peanuts in Texas has created outbreaks of secondary pests, insecticide resistant pest strains, and adversely affected natural enemies of pests (18). These problems dictate a search for alternative, and integrated methods of pest control including resistant host plants.

Peanut resistance to arthropods has been reported in peanuts for southern corn rootworm, *Diabrotica undecimpunctata howardi* Baker, (2, 3, 4, 5, 15, 16); tobacco thrips, *Frankliniella fusca* (Hinds), (8, 12, 20); corn earworm, *Heliothis zea* Boddie, fall armyworm, *Spodoptera frugiperda*, J. E. Smith), and velvetbean caterpillar, *Anticarsia gemmatalis* Hubner, (11, 12); twospotted spider mite *Tetranychus urticae* Koch, (6); and to a mite, *T. tumidellus* Prichard and Baker (10).

Evaluations for seedling resistance to the LCB were conducted on 108 peanut lines by Leuck and Harvey (9). Results were inconclusive for identifying larval preference for varieties although a wide range of values for seedling survival were obtained. This varied response indicated possible resistance to LCB larvae which could be ascertained with an improvement in screening technique. The purpose of this investigation was to establish a rapid screening technique for objectively selecting peanut genotypes with LCB resistance.

Materials and Methods

A total of 490 peanut cultivars, introductions and selections (here-after termed cultivars), representing the Spanish, Valencia, Virginia and Runner market types were evaluated for resistance. The evaluations were made in sets of 16 entries with Starr included as the standard in each set. The screening was initiated May 18 and concluded October 5 of the same year.

Seeds treated with Arasan^R fungicide were planted singly in 15.2 cm high x 7.6 cm diameter white, plastic, sewer pipe cylinders filled with moist sand. Eight cylinders were planted to each cultivar to insure five uniform plants for infesting with LCB larvae. After plant emergence, the five most uniform plants were selected and the cylinders transferred to predetermined positions in a greenhouse sand bed for infestation. The cylinders were placed in rows of 16 with 2.54 cm within and 5 cm between rows. The bottom of the cylinder was recessed 2.54 cm deep in sand beds to facilitate subirrigation. Irrigation as required was provided with distilled water from the sand bed. This technique provided adequate soil moisture for normal plant growth and a loose dry soil surface favorable for larval survival within the cylinder.

Each seedling was infested in the two-leaf stage with three newly hatched LCB larvae. Larvae were obtained from a parent colony reared on modified Adkisson-Vanderzant diets (19) at a 29.5°C, 50% RH, and 14 hour light:10 hour dark photoperiod regimen. The larvae were placed at the base of the plants with a fine camel hair brush.

After 21 days, the estimated time required for normal larval development, all plants and insects in a set were scored according to the rating systems developed by Posada (13). Based on the characteristic injury caused by the LCB larvae to

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the peanut seedling and the stage of larval development, five rating categories were established to evaluate the cultivars. Three categories, visual damage, concealed damage and plant survival, estimated plant response to larval feeding. The other two categories, instar and survival rating, estimated larvae growth and survival as affected by the host cultivar.

Visual damage. Larval damage was evaluated objectively by scoring the number of dead and/or wilted plant branches prior to removal of the plant from the soil. Plants exhibiting no dead or wilted lateral branches were given a score of 1. Plants with one dead or wilted branch, two dead or wilted branches, or the entire plant dead or wilted were scored 2, 3 and 4 respectively (Figure 1).

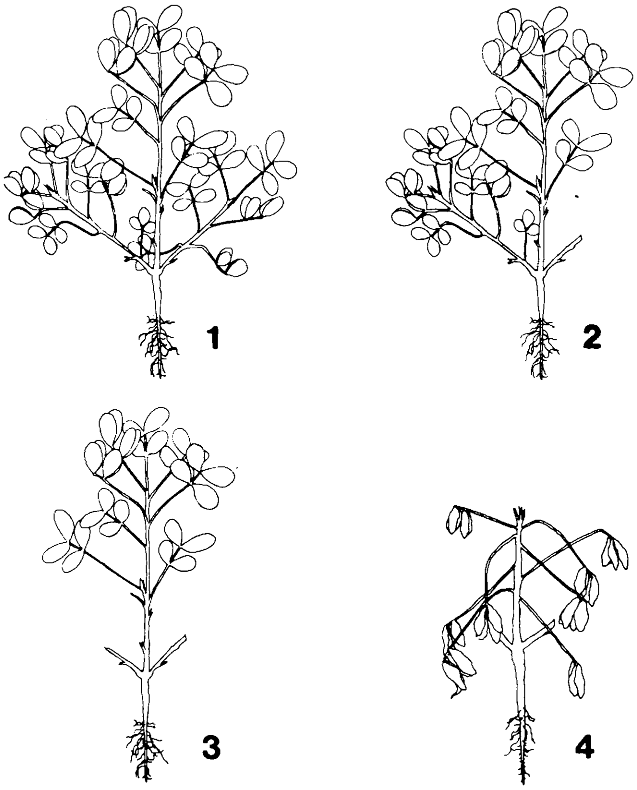

Fig. 1. Graphical representation of the visual damage rating.

Concealed damage. After the visual rating, plants were removed from the soil and rated for total damage including that previously obscured from view by the soil. Many plants which appeared healthy during the visual rating were found heavily damaged after removal from the soil. An extension of the evaluation period would have resulted in death or severe stunting of such a plant. Thus, the concealed rating supplemented the visual rating as a total measure of plant response.

Plant damage classes and the respective scores were: no damage, 1; one branch or main stem injured, 2; two branches or one branch plus main stem injured, 3; and two branches plus main stem injured, 4. Damage was defined as evidence of feeding regardless of the extent of feeding. In most instances where visual damage was apparent, the visual and concealed damage ratings were the same. However, some vigorously growing or possibly tolerant plants rated differently in the two categories.

Plant survival index. Cultivars that perished prior to the predetermined evaluation date were scored for concealed and visual damage and the date of death was recorded. A plant survival index was calculated as a ratio of the days the plant survived after infestation to the duration of the evaluation period for the respective set. The ratio was multiplied by ten to give an index from 1 to 10 with the lower values indicating the higher degree of susceptibility to larval damage. No statistical analysis was made for this rating system due to the method of calculation.

Instar rating. Larval development was recorded at the end of the evaluation period. Numerical values assigned to larval development ranged from 1 to 7 where 1 corresponded to the first instar, 2 to the second instar . . . . 6 to the sixth instar and 7 to the pupa. On occasions when a larva was not found and evidence of earlier activity was evident, the instar was estimated based on the amount and thickness of the abandoned webbed feeding tubes. In several instances the last larval instar had abandoned the feeding site, crawled out of the cylinder, and pupated in the bench soil. These larvae were given ratings of 6 as the last evidence indicated the sixth instar.

Survival rating. Survival was recorded as the percentage of larvae recovered at the end of the evaluation relative to the number applied for infestation. The scale utilized was: 3 recovered = 100%, 2 recovered = 80%, 1 recovered = 40% and 0 recovered = 10%.

Results and Discussion

The distribution of the 490 cultivars screened for resistance by Posada (13) are shown in Table 1. Eighty entries has significantly better scores than Starr in one or more categories (Table 2). Only 10.8% and 6.7% of the cultivars responded significantly ($p \geq .05$) less than 'Starr' for the visual and concealed plant damage, respectively. Even fewer cultivars produced significantly lower insect responses: instar (5.9%) and survival rating (0.4%). Twelve percent of the cultivars scored significantly less than Starr in at least one rating category while 5% scored less in multiple categories. If the criterion for re-evaluation was to score significantly less than Starr in one or more categories, only 16% of the entries would require re-testing.

The effectiveness of the technique for identifying resistant or susceptible genotypes was tested by re-evaluating 30 cultivars. The cultivars chosen for re-evaluation (Table 3) had either scored significantly lower in one or more categories than Starr (Table 2) or scored lower, but not significantly lower, in an individual evaluation set. Cultivars were chosen in this manner to ascertain if significantly better scores were repeatable and if low scoring cultivars from individual sets would again score low. In the re-evaluation only three cultivars ('Virginia Bunch 67', 'Florunner' and 'Early Run-

Table 1. Distribution of peanut cultivars scored significantly higher, equal to and lower than Starr for each category as shown by Duncan's New Multiple Range Test ($p \geq 0.05$).

	Number of cultivars		
categories	> Starr	= Starr	< Starr
visual damage	4	432	53
concealed damage	0	456	33
instar rating	15	445	29
survival rating	14	473	2

Table 2. Peanut cultivars that scored significantly less ($p \leq 0.05$) than Starr for indicated rating categories.

Variety or P.I. No.	Visual	Concealed	Instar	Survival	Variety or P.I. No.	Visual	Concealed	Instar	Survival
152137		X			240558	X			
161306		X	X		240572	X			
161312		X			240578	X			
162524	X				246388	X			
162525	X				246389	X			
162598	X				246390	X			
162604	X				247378	X	X	X	
162657	X	X	X		248756	X			
162659	X	X			248758	X			
208966		X			248760	X	X	X	
210828	X				248762	X	X	X	
221707	X				248765	X			
226250	X	X	X		259588		X	X	
234421	X	X	X		259611	X	X	X	
237337	X	X	X		259651	X	X	X	
237338	X				259659	X	X	X	
239038	X				259662	X	X	X	
239040	X				259667		X	X	
240553	X	X	X		259669	X	X	X	
240555	X				259692	X			
259701	X	X	X		268806	X			
259704			X		268811			X	
259707		X			268819			X	
259728				X	270793			X	
259753				X	270830	X			
259765			X		270836	X			
259843	X				279627		X	X	
261987	X				288912	X			
262017	X				290538			X	
268600			X		290553	X			
268602	X				290555	X			
268617		X			291628		X		
268621	X				295988A	X			
268694			X		323582		X		
268695	X				329223		X	X	
268697		X			331748		X		
268707	X				Florigiant	X	X		
268742	X				Florunner	X			
268754		X			Early runner	X			
268774		X	X						
268794	X		X						

Table 3. Response of peanut cultivars re-evaluated for resistance to lesser cornstalk borer larvae.

Variety or P. I. No.	Average Values [a/] Visual damage	Concealed damage	Instar rating	Survival rating	Plant survival index
			Test 1[b/]		
330644	3.5 a	4.0 a	4.8 bc	26.6 ab	9.0
259651	3.4 a	4.0 a	5.0 abc	19.5 b	10.0
268776	3.4 a	4.0 a	5.0 abc	27.3 ab	9.1
Starr	3.1 ab	4.0 a	5.1 abc	26.6 ab	9.5
247378	3.0 ab	4.0 a	5.5 ab	23.3 ab	9.1
152146	3.0 ab	4.0 a	4.8 bc	41.3 ab	8.3
152137	3.0 ab	4.0 a	4.9 abc	39.3 ab	9.4
237337	3.0 ab	4.0 a	5.2 abc	16.1 b	9.5
268626	3.0 ab	4.0 a	5.0 abc	34.9 ab	9.7
329223	3.0 ab	4.0 a	5.9 ab	33.6 ab	9.4
265485	2.8 abc	4.0 a	5.2 abc	30.0 ab	10.0
248762	2.6 abc	4.0 a	5.5 ab	54.1 a	10.0
234421	2.2 bcd	3.5 ab	5.1 abc	23.3 ab	9.6
Va. Bunch 67	1.9 cde	3.2 b	5.4 ab	32.5 ab	9.5
Florunner	1.5 de	3.9 a	6.0 a	30.7 ab	10.0
Early runner	1.2 e	2.6 c	4.1 c	22.7 ab	10.0
			Test 2[c/]		
246389	3.8 a	4.0 a	5.2 ab	52.2 ab	7.9
268829	3.8 a	4.0 a	5.0 ab	42.0 ab	8.6
270830	3.8 a	4.0 a	5.2 ab	52.2 ab	8.6
261962	3.8 a	4.0 a	5.8 a	56.5 a	7.2
337286 (P)	3.8 a	4.0 a	4.8 ab	25.4 ab	6.7
Starr	3.8 a	4.0 a	5.6 ab	30.0 ab	8.4
268668	3.6 a	4.0 a	5.4 ab	32.0 ab	7.6
268685	3.6 a	4.0 a	5.4 ab	33.0 ab	7.8
313192	3.6 a	4.0 a	5.6 ab	19.4 ab	8.3
261957	3.6 a	4.0 a	5.0 ab	19.4 ab	8.2
262017	3.4 a	4.0 a	5.8 a	19.4 b	8.2
268732	3.4 a	4.0 a	4.6 ab	19.4 ab	9.4
318741S	3.2 a	4.0 a	5.4 ab	19.4 ab	8.6
268755	3.0 a	4.0 a	4.4 b	10.0 b	10.0
268621	3.0 a	4.0 a	5.0 ab	21.7 ab	8.7
306362	3.0 a	4.0 a	4.4 b	10.0 b	10.0

[a/] By Duncan's New Multiple Range Test, values in a column having a letter in common are not significantly different ($p \geq 0.05$)

[b/] average of 8 replications

[c/] average of 5 replications

ner') scored significantly lower than Starr (Table 3). Although P. I. 259651, 248762, 247378 and 234421 had scored significantly lower than Starr in three rating categories in the previous screening trials (Table 2), their superiority was not apparent in the re-evaluation (Table 3). Also, 15% of the 13 cultivars that scored significantly less than Starr in one or more categories in the first evaluation, received equivalent or better scores in the re-evaluation. Virginia Bunch 67 was the only cultivar with significantly less damage than Starr in the re-evaluation but not in the first evaluation. However, its superiority over Starr in the first evaluation narrowly missed the 5% probability acceptance level. Although the technique was not completely successful in ascertaining resistant and susceptible genotypes, it was effective in reducing the number of cultivars to be further evaluated.

Data presented by Leuck and Harvey (9) suggested 'Virginia Bunch 67' was more resistant than Starr while Florunner and Florigiant were more susceptible. The differences were not large and insect preference might have been a factor.

The consistency among tests representing different calendar dates was examined by analyzing the data for Starr in each of the 33 sets. Mean ± standard error values were: visual damage, 3.06± 0.50; concealed damage, 3.94 ± 0.14, instar rating, 5.79 ± 0.61; and survival rating, 25.04 ± 11.72. The ratings for concealed damage were more consistent than the other selection criteria as measured by the standard error and coefficient of variability. However, the variation in visual damage and instar ratings does not negate their use for initial screening purposes. No association was apparent between scores and screening trial date. Although the variability among tests required inclusion of a standard in each set, the uniformity among sets appeared adequate for an effective mass screening procedure.

This screening technique offers a rapid objective method of scoring seedling damage inflicted by LCB larvae and larval growth. Some insights concerning the type(s) of resistance also may be obtained by scoring both host and insect development. Repeated evaluations of putative resistant cultivars are needed to confirm classification of cultivars as resistant. This can be accomplished relatively easily due to the smaller number of entries needing further testing.

Early Runner, Virginia Bunch 67, Florunner, Florigiant, and Dixie Spanish (PI 265485) were classified as more resistanct than Starr in the greenhouse screening trials and were subsequently evaluated for LCB resistance under field conditions in Oklahoma (14). In these field trials Early Runner, Virginia Bunch 67, Florigiant, Florunner and Dixie Spanish had significantly lower percentages of plants infested with LCB larvae than "Comet", a selection from Starr. Also, the persentage yield reduction was significantly less than Comet for all the varieties except Dixie Spanish. All varieties showed lower values in average number of larvae, larval length, and pupae than Comet although the values were not significantly different. These results support the usefulness of the greenhouse trials in identifying resistant germplasm.

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