MEASUREMENT OF RESISTANCE TO CORN BORER (*OSTRINIA FURNACALIS*, GUENEE) IN A COMPOSITE VARIETY OF MAIZE *)

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RINGKASAN

Banyak kriteria digunakan untuk menentukan tingkat ketahanan suatu varietas jagung terhadap serangan hama penggerek batangnya. Kriteria mana yang didahulukan untuk bisa dimanfaatkan dalam pekerjaan pemuliaan tanamannya perlu kiranya mendasarkan kepada mudah tidaknya kriteria tersebut diperoleh atau dikerjakan, bisa dipercaya ditinjau dari segi-segi pewarisan sifatnya.

Percobaan lapangan dengan menggunakan rancangan genetik I dari Comstock dan Robinson (1948) digunakan dalam penelitian ini untuk mengetahui seberapa jauh sifat-sifat seperti kemampuan berproduksi, kerusakan pada daun, kerusakan keseluruhan tanaman, panjang alur dalam batang serta jumlah lobang pada batang bisa digunakan sebagai kriteria untuk menentukan ketahanan suatu varietas jagung terhadap serangan penggerek batang jagung (*Ostrinia furnacalis*, Guenee). Penelitian menggunakan varietas jagung CBWR Composite # 2.

Dari kelima sifat yang dipelajari, kerusakan pada daun merupakan kriteria yang paling baik untuk menentukan ketahanan terhadap serangan penggerek batang jagung. Selain mudah dikerjakan, hasil analisa menunjukkan "heritability" yang tinggi yaitu 46,3 persen dan korelasi negatif yang sangat nyata dengan besarnya produksi yang diberikan. Kerusakan keseluruhan tanaman merupakan kriteria tambahan yang berguna dalam pelaksanaan seleksi sesudah tanaman berbunga. Panjang alur dalam batang serta jumlah lobang pada batang selain sulit pengamatannya, hasil analisa juga merupakan untuk kepentingan pemuliaan tanamannya.

INTRODUCTION

Corn borer is known to be principal limiting factors of corn production is most of corn growing areas in the world.

Damage due to this pest is manifested in several ways and ultimately in loss of yield. Jarvis et al. (1961) reported that several methods have been used in the past for evaluating damage done to field corn by the European corn borer. The early attempt at assaying losses were based on the amount of stalk breakage in a field and farmer estimates of yield. Several authors indicated that number of holes on the stalk, extent of tunneling and lessions in the leaves are reliable indices for yield loss. Overall plant damage was also mentioned by Guthrie and Dicke (1972) to be a better index than insect counts. Chartterji et al. (1966) reported that the survival counts of larvae will not give a correct picture of resistance; the extent of tunneling is more important from the grain yield point of view.

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An effective methods of controlling corn borer requires a concerted effort on the part of entomologists, agronomists and plant breeders. Breeding for resistant genotype provides a more permanent and sound ecological solution to this problem. Studies on the type of gene action and inheritance of resistance to the pest are very important prior to developing an effective breeding program.

The objective of this study is to evaluate the usefullness of grain yield, leaf feeding injury rating, overall plant damage rating, number of holes and length of tunnels as indices for evaluating resistance to corn borer (*Ostrinia furnacalis,* Guenee).

MATERIALS AND METHODS

A Design I mating system of Comstock and Robinson (1948) was used in this study. Biparental crosses were made within a population of CBWR Composite # 2 variety of maize in the early 1977. Each of the plants used as male parents was crossed to four plants used as females parents. A total progenies of 140 representing half-sib and/or 560 full-sib families was evaluated at USM (The University of Southern Mindanao) Experiment Station during 1977 wet season. A nested randomized complete block design was used in which the progenies were divided into 20 sets and each set of 56 plots contained 2 replications of 28 progenies randomly arranged. The progenies represented 28 full-sib and/or 7 half-sib families. One entry was planted in one row of 5 meters length with 50 centimeters space between hills and 75 centimeters between rows. Two plants per hill were maintained in order to get a uniform stand. To evaluate their corn borer resistance, all plants were not protected against the corn borer attacked. The evaluation was based on natural field infestation which had been considered having enough egg-masses.

The data recorded were 1) leaf feeding injury, it was evaluated at 35 days after planting on ten plants per plot which randomly sampled and rated individually by using a rating scale ranging from 1 to 9 classes as described by Penny and Dicke (1956). Classes 1–2 were considered to be highly resistant and classes 7–9 were considered to be highly susceptible. 2) Overall plant damage was recorded at dry silk stage on ten plants per plot selected at random, rated individually using 1 to 9 rating scale as described by Chiang and Hudon (1976) in which rating scale 1 was given to plants with slight leaf feeding and little or no damage on stems while rating scale 9 was given to plants broken above the ear with extensive leaf feeding and completely destroyed of the ear. 3) Number of holes on the stalk were recorded during the dissection of the plants. Immediately after harvest the stalk of five plants per plot from each of two replications were randomly sampled; stripped all of the leaves and leaf sheath to expose the holes and individually counted for their number. 4) Length of tunnels in the stalk were recorded during the dissection of the plant. After counting the number of holes, the stalk of five plants were dissected longitudinally and measured each of their length of tunnel. 5) Grain yield per plot was calculated in ton per hectare on 15 percent moisture content basis.

The form used for analysis of variance is given in Table 1. Prior to estimating genetic variances, estimated C.V. (%) were computed as affected by increasing sample size and replications.

An estimate of the variance among males, $\sigma^2 M$, and variance among females mated to the same males, $\sigma^2 F$, were obtained from computing.

$$\sigma^2 F = \frac{1}{r}(M_2 - M_3), \text{ and}$$

$$\sigma^2 M = \frac{1}{rf}(M_1 - M_2)$$

The genetic interpretations associated with $\sigma^2 M$ and $\sigma^2 F$ permit the estimation of additive genetic variance, $\sigma^2 A$, dominance variance, $\sigma^2 D$, phenotypic variance among full-sib, $\sigma^2 P(FS)$, and heritability among full-sib, $H_{(FS)}$ (Robinson et al. 1949; Robinson et al. 1951).

Genotypic correlation between any given pair of characters was estimated as follows,

$$r_{G_{ij}} = \frac{\sigma_{M_{ij}}}{\sqrt{\sigma^2 M_i \cdot \sigma^2 M_j}}$$

Phenotypic correlation between any given pair of characters among full-sib families was estimated as follows,

$$r_{P(FS)_{ij}} = \frac{\sigma_{P(FS)_{ij}}}{\sqrt{\sigma^2 P(FS)_i \cdot \sigma^2 P(FS)_j}}$$

Table 1. Form of analysis of variance and the expectation of mean squares in a Design I mating system for single environment.

Source of Variation	df	MS	EMS
Sets (S)	(s–1)		
Replication/Sets	s(r–1)		
Males/Sets	s(m–1)	M_1	$\sigma^2 + r\,\sigma^2_F + rf\,\sigma^2_M$
Females/Males/Sets	sm(f–1)	M_2	$\sigma^2 + r\,\sigma^2_F$
Pooled Error	s(mf–1)(r–1)	M_3	σ^2

where, s, r, m, and f refer to sets, replications, males, and females, respectively.

σ^2 is the error variance among plots of the same progeny.

$\sigma^2 F$ is the variance due to differences among females mated to the same male = covariance of full-sib minus covariance of half-sibs = ¼ σ^2_A + ¼ σ^2_D.

$\sigma^2 M$ is the variance due to differences among males = covariance of half-sibs = ¼ σ^2_A.

RESULTS AND DISCUSSION

Based on a sample size of 5 plants per plot and 2 replications, Table 2 shows the estimated C.V. (%) for four different entomological characters with varying number of sample plants per plot for different number of replications.

These estimates show that much improvement can be done on the reliability of the data on leaf feeding injury and overall plant damage by merely increasing sample plot size to 20 plants. Such increase in sample size would not require so much additional time and effort on the part of the rater in as much as these characters are easily obtained. For number of holes and length of tunnels, estimates show that little improvement on the reliability of the data can be obtained by increasing either number of replication and sample size or both. Increasing number of replication and sample size may also become very prohibitive in practical sense since these characters require a lot of labour and time in cutting and dissecting individual plants.

The relative magnitude of the different genetic parameters presented in Table 3 may be used as a set of criteria for determining the usefulness of the characters measured in selecting for resistance to corn borer.

Yield is usually assumed will provide the ultimate measure of resistance since all effects of the corn borer on the plant would ultimately show in the grain yield. However, with the present observations that large phenotypic variations occur, grain yield become a poor parameter in measuring resistance.

The type of gene action due to leaf feeding was additive and its heritability among full-sib was estimated at 46.3 percent. This estimate was comparable to that obtained by Mohamed et al. (1966) of 60.0 percent and by Gahukar and Chiang (1976) of 40.0 percent on European corn borer. Characters giving estimate of heritability within such ranges can be considered highly heritable and therefore, leaf feeding could serve as a useful criterion in selecting for resistance against corn borer.

The dominance variance for overall plant damage was much larger than the additive genetic variance and the heritability was estimated at 6.3 percent. This results do not agree with the finding of Singh (1953) and Mohamed et al. (1966), respectively. Larger dominance variance and larger additive genetic variance were obtained for length of tunnel and number of holes. A large estimate of the phenotypic variance due to females in males resulted low heritability for both characters.

Estimates of genotypic and phenotypic correlations presented in Table 4. may also be used as another criterion in determining the usefulness of a pair of each traits in screening for corn borer resistance.

Leaf feeding injury which is a highly heritable character and can be obtained with great reliability and ease, showed a highly significant negative correlation with yield. However, negative correlations with number of holes and length of tunnels, pose some problems in selection. Number of holes and length of tunnels as previously mentioned, are obtained with great difficulty and with little reliability. Estimates also showed that overall plant damage gives a highly significant negative correlation with grain yield and positive genotypic correlations with leaf feeding, length of tunnel and number of holes, respectively.

In determining the usefulness of these characters, a number of criteria have to be considered namely, ease and reliability of obtaining the data, heritability and correlation with grain yield. In this experiment grain yield by itself was shown to provide a poor parameter in measuring resistance. Leaf feeding injury which its reliability of the data can be easily improved by merely increasing plot size to 20 plants, satisfactory shows the need of other considerations. Therefore, it seems to be good parameter measuring resistance. The other advantage of leaf feeding injury is that the data are obtained prior to tasseling or silking. As such, pollination can be made on some selected plants or families, thereby increasing afficiency of selection.

Overall plant damage in which several criteria taken into consideration, even with a low error variance, estimates showed a low heritability. The difficulty arises from the very subjective nature of the scale. Therefore, may have little importance as an index for screening corn borer resistance. However, it may be of some helps as a supplementary or secondary observation in selection work. It is suggested that families or individual plants should be selected based on leaf feeding injury before or during pollination. Some of the pollinated plants may be discarded later based on overall plant damage.

Number of holes and length of tunnel observed, unsatisfactory meet the considerations previously mentioned. Therefore, seem to be difficult and impractical in obtaining the data especially when hundreds of families or thousands of plants are evaluated.

Table 2. Estimated C.V. (%) for four different entomological characters with varying number of sample plants per plot for different number of replications.

Number of replication	Number of sample plants per plot			
	5	10	15	20
Leaf feeding				
2	13.17	10.99	10.16	9.72
3	10.75	8.97	8.29	7.93
4	9.31	7.77	7.18	6.87
Overall plant damage				
2	16.42	13.94	13.01	12.52
3	13.41	11.38	10.62	10.22
4	11.61	9.86	9.20	8.85
Number of holes				
2	14.57	14.33	14.24	14.20
3	11.90	11.70	11.63	11.60
4	10.30	10.13	10.07	10.04
Length of tunnels				
2	52.14	43.50	40.21	38.46
3	42.58	35.52	32.83	31.40
4	36.87	30.76	28.43	27.19

Table 3. Estimates of various genetic parameters of five characters measured.

Parameter	Estimates				
	Grain yield	Leaf feeding	Overall plant damage	Length of tunnel	Number of holes
σ^2_A	0.00413 ±0.18544	0.03428 ±0.00083	0.00242 ±0.00280	0.59531 ±0.61360	0.01887 ±0.01158
σ^2_D	2.14115 ±0.49822	−0.00506 ±0.01410	0.02872 ±0.00512	1.96744 ±1.66536	−0.00115 ±0.02862
$\sigma^2_{P(FS)}$	1.26465 ±0.10877	0.03702 ±0.00326	0.01920 ±0.00116	3.87017 ±0.35612	0.06875 ±0.00650
$H_{(FS)}$	0.00163	0.46311	0.06291	0.07691	0.13723

Table 4. Genotypic and phenotypic correlations among five characters measured among full-sib families (Phenotypic correlations in parentheses).

	Leaf feeding	Overall plant damage	Length of tunnel	Number of holes
Grain yield	–0.39094** (–0.07020)	–0.25306** (–0.13238)**	–0.46412** (–0.00024)	–0.15336** (–0.01030)
Leaf feeding		0.00166 (0.03038)	–0.08447 (–0.00805)	–0.11801** (–0.18372)**
Overall plant damage			0.04297 (–0.13554)**	0.18346** (0.01197)
Length of tunnel				0.32696** (0.84784)**

*) – significant at 0.05 level
**) – significant at 0.01 level

CONCLUSION

Among the different characters studied, leaf feeding seems to be the best parameter to evaluate resistance to corn borer. It gave the highest heritability of 46.3 percent which is comparable with the former findings and showed a highly significant negative correlation with grain yield. Overall plant damage may also be used as secondary character for evaluating resistance.

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Appendix, Table 1. **Estimates of the component of variance and covariance resulting from female differences for five characters measured (Components of variance in parentheses)**

	Grain yield	Leaf feeding	Overall plant damage	Length of tunnel	Number of holes
Grain yield	(0.53632)	–0.04911	–0.02333	0.45371	–0.03558
Leaf feeding		(0.00351)	–0.00573	–0.03336	–0.00999
Overall plant damage			(0.00778)	–0.05042	–0.02562
Length of tunnel				(0.64069)	0.24745
Number of holes					(0.00356)

Appendix, Table 2. **Estimates of the component of variance and covariance resulting from male differences containing ¼ σ^2_A for five characters measured (Components of variance in parentheses).**

	Grain yield	Leaf feeding	Overall plant damage	Length of tunnel	Number of holes
Grain yield	(0.00103)	–0.00116	–0.00020	–0.00575	–0.00034
Leaf feeding		(0.00857)	0.00017	–0.00302	–0.00075
Overall plant damage			(0.00060)	0.00041	0.00031
Length of tunnel				(0.14883)	0.00866
Number of holes					(0.00472)

Appendix, Table 3. **Estimates of phenotypic variance and covariance among full-sib families for five characters measured (Estimates of phenotypic variance in parentheses).**

	Grain yield	Leaf feeding	Overall plant damage	Length of tunnel	Number of holes
Grain yield	(1.26465)	–0.01519	–0.02063	–0.00053	0.00304
Leaf feeding		(0.03702)	0.00080	–0.00305	–0.00293
Overall plant damage			(0.01920)	–0.03695	0.00137
Length of tunnel				(3.87017)	0.43734
Number of holes					(0.06875)