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# HETEROTIC EFFECTS AND ASSOCIATION OF *CHILO PARTELLUS* (SWINHOE) RESISTANCE PARAMETERS WITH MATURE PLANT TRAITS IN SOME MAIZE POPULATIONS

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## ABSTRACT

**Stem borer resistance and grain yield are known to be quantitatively inherited, but it is not known whether the heterotic levels observed for resistance are translated directly to grain yield production. Results of correlations between vigour associated with resistance and that of mature plant traits suggest that, although most of the crosses had lower damage levels and increased grain yield, the vigour associated with resistance traits may not actually predict the amount of grain yield gain obtained in the set of maize genotypes studied.**

***Key Words:*** **Heterosis, resistance, *Chilo*, stem borer.**

## INTRODUCTION

The spotted stem borer *Chilo partellus* (Swinhoe) damages maize plants by the feeding activities of its larvae. The young larvae feed on young leaves within the whorl of plants causing lesions and, when the feeding activities extend to the meristematic region, deadheart. When the leaves unfurl and no longer offer protection, larvae bore into the stems where they continue to feed thereby causing extensive stem tunnelling.

Inheritance studies on parameters of maize resistance to the spotted stem borers have shown resistance to be quantitative and predominantly additive (1; 11). Extensive studies on the inheritance pattern of maize grain yield and its components (5) have also revealed the preponderance of additive gene action. Because of this similarity in gene action, it seems likely that selection applied on one will affect the other. A recent study (3) indeed suggests that selection for increased level of resistance to *C. partellus* in maize populations has a correlated effect on grain yield. Hybrid vigour had been reported for *C. partellus* resistance parameters (1) and second generation of European corn borer (6).

The present study was undertaken to further test the hypothesis that factors such as hybrid vigour observed for resistance traits will affect other agronomic traits including grain yield.

## MATERIALS AND METHODS

A complete set of crosses and their reciprocals were made among four open pollinated white grained maize populations having moderate levels of resistance to *C. partellus* attack. The four populations are ICZ3, MMV 600, Population 10 and ER29SVR. ICZ3 is a composite population developed at the ICIPE while MMV 600 is a Mt. Makulu genotype developed in Zambia. Both Population 10 and ER29SVR are of CIMMYT origin.

The 12 crosses made up of six main and six reciprocal crosses, the parents and four checks totalling 20 genotypes, were evaluated for yield and damage parameters under artificial infestation by *C. partellus* larvae at Mbita and Ungoye in the long rainy season (April–July) of 1992. Both Mbita and Ungoye are on the shores of Lake Victoria in Western Kenya and are about 35 km apart.

For the evaluation trials, two-row plots of 3 m length were used. The trials were planted at a spacing of 0.75 m between rows and 0.25 m within rows. All plants were artificially infested with 30 first instar *C. partellus* larva reared on artificial diet (10) three weeks after emergence. Appropriate cultural practices, such as fertilizer application, weeding, bird or monkey scaring were carried out as deemed necessary during the season.

Data on foliar lesions and deadheart were taken at four weeks after infestation. Foliar lesion was scored on a 1–9 scale (1=resistant and 9=susceptible) while deadheart was assessed as the proportion of plants in a plot showing the symptom. Extent of stem tunnelling by the larvae was estimated at harvest as a percentage of the plant height. Other agronomic data recorded were days to tasselling (Mbita), plant height, stands at harvest, number of ears harvested, length of five ears per plot, moisture content at harvest and grain yield. Grain yield was obtained as grain weight adjusted to 14% moisture content.

Deadheart and stem tunnelling data for each location were transformed into the arcsine values before subjecting to analysis of variance (ANOVA). Even on this transformed scale, error variances were highly heterogeneous according to Barlett's test (4). No combined ANOVA was therefore, carried out. A rank summation index (RSI) of Mulumba and Mock (9) was constructed to group the entries for overall resistance. For the RSI, entries were ranked for each of the resistance parameters and the ranks summed to obtain the index. The best entry would theoretically have a value of 3. Both mid- (MP) and high-parent (HP) heterosis were estimated as follows:

Mid-parent (MP) heterosis = $100[(F_1\text{-MP})/\text{MP}]$,

and

High-parent (HP) heterosis = $100[(F_1\text{-HP})/\text{HP}]$,

where $F_1$ is the mean of the main and reciprocal cross.

Phenotypic correlations were obtained using entry means, while genotypic correlations were obtained using expectation of mean cross product and mean squares from analysis of covariance and variance, respectively.

## RESULTS

The resistance parameters and grain yield did not vary significantly among parents and crosses in the two locations (Table 1). Mean squares due to parents vs crosses, the main comparison of interest in this study, were not also significant, although the mean parental values for the traits seem to differ from that of the crosses (Table 1). In general, mid-parent heterosis values were negative for foliar lesion, stem tunnelling and RSI but positive for yield (Table 2). In a few crosses, positive heterosis were obtained for both the resistance parameters and grain yield.

Phenotypic correlations among the resistance parameters (Table 3) were low, with the highest (0.30) being that between foliar lesion and deadheart at Mbita. Corresponding genotypic correlations were much higher, in most cases exceeding unity. However, genotypic correlation between foliar lesion and stem tunnelling for Ungoye location (-0.43) was relatively high. Correlation of *C. partellus* resistance parameters with mature-plant characteristics, including grain yield (Table 4), were not significant except for those between stem tunnelling with stand count or grain yield for Ungoye location. Correlation between other agronomic traits with stem tunnelling or RSI were generally negative but positive for foliar lesion.

A few significant correlations were obtained for heterotic values among resistance parameters and grain yield (Table 5). Although quite a number of correlations among heterotic values

TABLE 1. Pertinent sources of ANOVA for foliar lesion (FL), deadheart (DH), stem tunnelling (ST) and grain yield

| Source | df | Mbita | | | | Ungoye | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | FL | DH | ST | Yield | FL | DH | ST | Yield |
| Genotypes | 19 | 1.65 | 38.37 | 42.01 | 3.55* | 0.35 | 3.08 | 26.32 | 4.97* |
| Parents (P) | 3 | 2.60 | 14.61 | 24.98 | 0.21 | 0.05 | 0.00 | 9.49 | 3.07 |
| Crosses (C) | 11 | 0.91 | 41.62 | 40.01 | 2.21 | 0.24 | 2.71 | 26.91 | 2.85 |
| P vs C | 1 | 0.01 | 23.86 | 130.15 | 3.39 | 0.31 | 0.68 | 24.06 | 2.90 |
| Checks | 3 | 3.72 | 67.35 | 29.55 | 8.01* | 0.75 | 8.12 | 22.22 | 4.30 |
| Error | 38 | 1.53 | 28.92 | 47.51 | 1.67 | 0.29 | 3.33 | 18.99 | 1.54 |
| Means | | | | | | | | | |
| Parents | | 4.04 | 1.72 | 33.95 | 5.45 | 2.46 | 0.00 | 8.68 | 6.66 |
| Crosses | | 4.01 | 1.14 | 27.89 | 6.07 | 2.27 | 0.08 | 7.49 | 7.23 |

*Significant at $P = 0.05$.

TABLE 2. Mid- (MP) and high-parent (HP) heterosis values for *Chilo partellus* resistance parameters, resistance index (RSI) and grain yield evaluated at Mbita (1) and Ungoye (2) locations of Western Kenya

| Cross | Location | Foliar lesion | | Deadheart | | Stem tunnelling | | RSI | | Yield | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | MP | HP | MP | HP | MP | HP | MP | HP | MP | HP |
| ICZ3 x MMV 600 | 1 | 6.29 | 19.61 | -100.00 | -100.00 | -22.38 | -48.95 | -50.68 | -35.71 | 10.33 | 4.55 |
| | 2 | -3.17 | 59.45 | 0.00 | 0.00 | -12.51 | 143.85 | -20.83 | -17.39 | 12.56 | -3.95 |
| ICZ3 x ER29SVR | 1 | 14.65 | 27.97 | -66.67 | -50.00 | -9.68 | -1.43 | -18.33 | -12.50 | 6.15 | 1.60 |
| | 2 | -17.86 | -12.99 | 0.00 | 0.00 | -45.49 | -43.15 | -69.09 | -66.00 | 0.40 | -4.46 |
| ICZ3 x Pop 10 | 1 | -6.43 | 27.01 | 50.00 | 50.00 | -34.62 | -28.74 | -31.17 | -5.36 | 6.11 | 3.73 |
| | 2 | -17.43 | -16.42 | 0.00 | 0.00 | -13.27 | -5.54 | -41.82 | -36.00 | 10.83 | -0.77 |
| MMV 600 x ER29SVR | 1 | 12.91 | 13.75 | -20.00 | 0.00 | 13.10 | 29.38 | 14.29 | 37.50 | 20.28 | 19.23 |
| | 2 | -0.98 | 1.20 | 100.00 | 100.00 | 33.89 | 47.03 | 39.62 | 60.87 | 20.00 | 6.93 |
| MMV 600 x Pop 10 | 1 | -8.27 | 8.74 | 50.00 | 200.00 | 30.83 | -27.95 | -25.53 | -22.22 | 1.26 | -1.92 |
| | 2 | -1.02 | 1.26 | 0.00 | 0.00 | -15.94 | 6.37 | -7.55 | 6.52 | -1.88 | -7.11 |
| ER29SVR x Pop 10 | 1 | -15.78 | 0.70 | -100.00 | -100.00 | -17.60 | -1.33 | -50.62 | -35.50 | 22.59 | 19.96 |
| | 2 | -4.40 | 0.00 | 0.00 | 0.00 | -21.99 | -11.09 | 23.33 | -23.33 | 9.65 | 2.83 |

TABLE 3. Phenotypic (upper diagonal) and genotypic (lower diagonal) correlations among the three *Chilo partellus* resistance parameters evaluated at Mbita (a) and Ungoye (b) locations of Western Kenya

| Parameter | Location | 1 | 2 | 3 |
|---|---|---|---|---|
| 1. Foliar lesion | a | | 0.30 | 0.17 |
| | b | | 0.23 | 0.13 |
| 2. Deadheart | a | 0.37 | | -0.13 |
| | b | + | | 0.14 |
| 3. Stem tunnelling | a | + | + | |
| | b | -0.43 | + | |

+ Correlation >1.00.

TABLE 4. Simple linear correlations of *Chilo partellus* resistance parameters including resistance index (RSI) on mature plant traits and grain yield for Mbita (1) and Ungoye (2) locations of Western Kenya

| Trait | Location | Foliar lesion | Deadheart | Stem Tunnelling | RSI |
|---|---|---|---|---|---|
| Plant ht. (cm) | 1 | -0.01 | 0.25 | -0.18 | -0.03 |
| | 2 | 0.25 | 0.03 | -0.13 | 0.14 |
| Stand count | 1 | -0.06 | 0.17 | 0.29 | 0.25 |
| | 2 | 0.11 | -0.14 | -0.54* | -0.34 |
| Ear length (cm) | 1 | 0.04 | 0.05 | -0.12 | 0.03 |
| | 2 | 0.21 | -0.16 | -0.43 | -0.23 |
| Ear number | 1 | 0.03 | 0.30 | -0.40 | -0.05 |
| | 2 | 0.25 | 0.19 | 0.28 | 0.33 |
| Moisture (%) | 1 | 0.38 | 0.35 | -0.23 | 0.24 |
| | 2 | 0.39 | -0.09 | -0.23 | -0.04 |
| Grain yield (t/ha) | 1 | 0.14 | 0.21 | -0.09 | 0.14 |
| | 2 | 0.11 | -0.08 | -0.47* | -0.32 |
| Tasselling (days) | 1 | 0.42 | 0.26 | -0.19 | 0.25 |
| | 2 | – | – | – | – |

*Significant at $P = 0.05$.

TABLE 5. Correlation matrix for the mid- (MP) and high-parent (HP) heterosis of foliar lesion (FL), deadheart (DH), stem tunnelling (ST), resistance index (RSI) and grain yield for Mbita (upper diagonal) and Ungoye (lower diagonal) locations

| Trait | | FL | DH | ST | RSI | Yield |
|---|---|---|---|---|---|---|
| FL | MP | | -0.21 | 0.10 | 0.60 | -0.05 |
| | HP | | -0.05 | -0.22 | 0.23 | -0.54 |
| DH | MP | 0.40 | | 0.35 | 0.38 | -0.56 |
| | HP | -0.07 | | -0.12 | 0.21 | -0.51 |
| ST | MP | 0.58 | 0.88* | | 0.54 | -0.14 |
| | HP | 0.94** | 0.18 | | 0.71 | 0.68 |
| RSI | MP | 0.81* | 0.81* | 0.93** | | 0.09 |
| | HP | 0.15 | 0.83* | 0.38 | | 0.32 |
| Yield | MP | 0.28 | 0.69 | 0.79 | 0.61 | |
| | HP | -0.18 | 0.75 | 0.02 | 0.55 | |

*,**Significant at $P = 0.05$ and 0.01, respectively.

were high, they were not significant. For example, correlation of mid-parent heterotic values between deadheart, stem tunnelling or RSI with grain yield were 0.69, 0.79 and 0.61, respectively for Ungoye location (Table 5).

## DISCUSSION

Although the non-significance of mean squares due to parents vs crosses for all traits is an indication of a general lack of heterosis, negative mid-parent heterotic values associated with leaf feeding and stem tunnelling in general imply that some hybrids had better levels of resistance. However, dramatic increases in levels of heterosis for resistance traits were not expected for the four populations because they were known *a priori* to have moderate to high levels of resistance to *C. partellus* attack (2; 8). It was of interest to find out whether the levels of heterosis observed for resistance parameters were translated directly to increased grain yield.

The low levels of correlation among resistance traits suggests that genotypic ranking for each of the parameters were highly dissimilar. It is, however, known that each resistance trait would on its own affect yield (7; 8). To determine the overall effect of damage caused by infestation on yield, resistance index (RSI) was constructed. Correlations between the resistance parameters and the index with mature plant characteristics including grain yield were very low, implying that damage levels cannot be used as a measure of expected yield for the materials studied. It should be noted that correlation among heterotic values for resistance traits, especially deadheart and yield, were relatively high but not significant due to low number of entries ($n$=6). Perhaps situations would be different if genotypes having widely different levels of resistance and/or more entries were used for the study.

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