# Preliminary study on resistance against maize weevil (*Sitophilus zeamais* MOTSCH) in tropical maize lines

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Maize cultivar with resistant to maize weevil is desirable for overcoming storage difficulty and maintaining its seed quality. Using maize resistant cultivars is closely related to sustainable agriculture since they can avoid utilizing chemical pesticides; hence, it is considered to be much friendly to the environment. Preliminary study on the screening of resistant against this pathogen has been performed. Seed hardness, seed damage and seed weight losses were measured. Six lines namely $S_5A_1$-8, $S_5A_1$-58, $S_5A_1$-59, $S_5A_1$-64, $S_5A_1$-69 and $S_5A_1$-92 were categorized as highly resistant lines, supposed these lines carry genes for insect resistant. Broad genetic and phenotypic variabilities were found for grain damage and grain weight loss. Phenotypic variability estimate for grain hardness was broad as well. Heritability estimates for grain damage and grain weight loss were medium. Grain hardness was found to be negatively correlated with grain damage and grain weight loss. The harder the seed the lower the seed damages and the lower the grain weight loss as well.

**Keywords** Screening . Resistance . *Sitophilus zeamais* MOTSCH . Tropical maize

Maize weevil (*Sitophilus zeamais* MOTSCH) is an important pest in stored maize grain, particularly in tropical country, as reported by many authors (Longstaff, 1981; Bedjo and Indiarti, 1995). Its attack starts from the field until the storage, as result, this pathogen causes harmful damage. *S. zeamais* mainly consumes the embryo and the endosperm of seed. However, maize cultivar with resistant to maize weevil is desirable for overcoming storage obstacle as well as for maintaining its seed quality. Moreover, using maize resistant cultivars would reduce the use of chemical pesticides that damaging the environment, and this method, as far as we concerned, is the most economic and sustainable way to control this pathogen in maize.

Resistant cultivar is obtained by breeding research and resistance governed by genetic component is the ultimate goal of breeding program. Moreover, a set of breeding experiment should be performed appropriately in order to develop maize cultivars having resistance to this pathogen. The first step for achieving such objective is a screening procedure by means of resistant testing to the number of germplasm collection (Sumarno, 1991).

Resistant to maize weevil is affected by additive and dominant gene action (Widstrom *et al.*, 1975 *cit*. Ortega *et al*. 1980). And in addition, concerning to resistance mechanism, the antibiosis and nonpreference are observed acting together in maize grain against maize weevil (Santos and Foster, 1983 *cit*. Santos *et al.*, 1992). Other finding reported that grain hardness plays an important role in pathogen infestation (Ortega *et al.*, 1980). Bergvinson (2000) stated that grain hardness was found to be a negatively correlated with grain damage. Each genotype, as well known, has a different level of resistancy depending mainly on its composing genetic background. Result of Santos' *et al*. (1992) experiment discovered that from 23 tested genotypes, 9 genotypes categorized as resistant and 14 genotypes classified as susceptible.

Other components that have to be considered in relation to breeding activity is the estimation of variability and heritability in character observed, since variability evaluates the observed variation of certain character and heritability estimate determines whether the phenotypic appearance is more controlled either by genetic, environment or genetic-environment interaction. Correlation is also important because it measures degree of association, genetic or non-genetic between two or more characters (Hallauer and Miranda, 1981).

This study proposed to evaluate a selected group of $S_5$ maize lines derived from single cross and double cross of cv. Bisma, Cargil 5 and Pioneer 4 for genetic resistance to the maize weevil.

**Materials and methods**

To obtain a uniform *S. zeamais* in terms of its size and age, a rearing of this pathogen was conducted in the glass jar containing 0.75 kg-1.00 kg of maize grain. Arround 200 imagos of *S. zeamais* were then infested. After 4 weeks, imagos were separated from the pupa.

The experiment was arranged in randomized block design with 52 maize lines used as treatment and replicated twice. 50 g maize grains were infested by 10 *S. zeamais* for 60 days. At the end of experiment, *S. zeamais*, powder grain, and maize grain were carefully separated to ease the observation.

Grain hardness in mm/sec/100g was measured by using Penetrometer. Grain damage (%) was calculated according to Sastrosiswojo *et al*. (1996), and grain weight loss was measured based on Pranata (1979). Resistant category was evaluated following Kirk and Manwiller (1964) *cit*. Ortega *et al*. (1980). Phenotypic varians for grain hardness was calculated according to Steel and Torrie (1995). Deviation standard of phenotypic varians for grain hardness was estimated using Anderson and Bancroft (1952) *cit*. Mansyah *et al*. (1999). From the anova table, varians genetic as well as varians phenotypic for both seed damage and grain weight loss were counted. Allard's (1960) formula was employed to estimate broad-sense heritability. A correlation coefficient was calculated according to Steel and Torrie (1995).

## Results and discussion

From Table 1, showed that grain hardness in 52 maize lines ranged from 0.280 mm/sec/100 g to 1.24 mm/sec/100 g. The lower the grain hardness coefficient the higher the grain hardness level. Seed with high hardness level or low grain hardness coefficient could inhibit pathogen infection. Each line had different grain hardness coefficient. Grain hardness displays grain protein content, which is majority exist in endosperm. The higher the grain hardness level, the lower the protein content (Poehlman and Sleper, 1995). However, this statement is not really true, as an example, the case of QPM (Quality Protein Maize) lines; they have both higher in protein content and improved hardness of endosperm compared to other normal lines. Modifier gene action could improve significantly the hardness of QPM endosperm in materials containing the recessive *opaque2* gene (Dreher *et al.*, 2000).

Table 1 lists the resistancy category for all genotypes tested. The higher the grain damage or the higher the grain weight loss, the more susceptible the genotype. And as the opposite, the lower the grain damage or the lower the grain weight loss, the more resistant the genotype. Six lines namely $S_5A_1$-8, $S_5A_1$-58, $S_5A_1$-59, $S_5A_1$-64, $S_5A_1$-69 and $S_5A_1$-92 were categorized as highly resistant lines, supposed these lines carry genes for maize weevil resistant. As the contrary, four lines i.e. $S_5A_1$-7, $S_5A_1$-24, $S_5A_1$-70, and $S_5A_1$-85. Both groups can be used to develop a segregating population through crossing; as a result it may be possible to increase insect resistance by means of specific selection.

Broad genetic and phenotypic variabilities were found for grain damage and grain weight loss. Phenotypic variability estimate for grain hardness was broad as well (Table 2). Broad variability for three characters can be explained since 52 maize lines are derived from different genetic background composing the material used in this experiment. Lines are originated from single and double-way cross of different cultivars i.e. cv. Bisma, Cargil 5, and Pioneer 4. Other possible explanation can be proposed. Resistancy screening to maize weevil is not undertaken yet in the early generation, as a consequence, the broad variability for these traits is found.

Tabel 1. Grain hardness, grain damage, grain weight loss and resistancy category of 52 maize lines

| Nr | Lines | Grain hardness (mm/sec/100g) | Grain damage (%)* | | Grain weight loss (%)** | | Resistancy category |
|---|---|---|---|---|---|---|---|
| 1. | $S_5A_1$-3 | 0,560 | 16,852 | b | 1,900 | a | MR |
| 2. | $S_5A_1$-5 | 0,280 | 5,746 | a | 1,100 | a | R |
| 3. | $S_5A_1$-7 | 0,420 | 41,115 | b | 5,200 | b | S |
| 4. | $S_5A_1$-8 | 0,370 | 1,423 | a | 0,000 | a | HR |
| 5. | $S_5A_1$-10 | 0,470 | 28,140 | b | 4,600 | b | MR |
| 6. | $S_5A_1$-11 | 0,440 | 9,879 | a | 1,100 | a | R |

Tabel 1. (Continued)

| Nr | Lines | Grain hardness (mm/sec/100g) | Grain damage (%)* | | Grain weight loss (%)** | | Resistancy category |
|---|---|---|---|---|---|---|---|
| 7. | $S_5A_1$-12 | 0,460 | 31,122 | b | 4,800 | b | MR |
| 8. | $S_5A_1$-14 | 0,560 | 10,925 | a | 1,300 | a | R |
| 9. | $S_5A_1$-15 | 0,760 | 30,524 | b | 5,000 | b | MR |
| 10. | $S_5A_1$-16 | 1,240 | 22,522 | b | 5,100 | b | MR |
| 11. | $S_5A_1$-19 | 0,840 | 8,999 | a | 1,400 | a | R |
| 12. | $S_5A_1$-22 | 0,790 | 19,362 | b | 2,800 | b | MR |
| 13. | $S_5A_1$-23 | 0,800 | 35,902 | b | 3,000 | b | MR |
| 14. | $S_5A_1$-24 | 0,890 | 43,776 | b | 6,000 | b | S |
| 15. | $S_5A_1$-25 | 0,710 | 35,097 | b | 4,300 | b | MR |
| 16. | $S_5A_1$-26 | 0,780 | 24,399 | b | 3,600 | b | MR |
| 17. | $S_5A_1$-27 | 0,720 | 20,161 | b | 3,900 | b | MR |
| 18. | $S_5A_1$-32 | 0,740 | 6,632 | a | 0,500 | a | R |
| 19. | $S_5A_1$-36 | 0,680 | 9,217 | a | 0,600 | a | R |
| 20. | $S_5A_1$-37 | 0,750 | 16,305 | a | 1,500 | a | MR |
| 21. | $S_5A_1$-41 | 0,960 | 22,700 | b | 2,700 | b | MR |
| 22. | $S_5A_1$-42 | 0,600 | 9,535 | a | 1,500 | a | R |
| 23. | $S_5A_1$-43 | 0,560 | 23,297 | b | 4,200 | b | MR |
| 24. | $S_5A_1$-44 | 0,660 | 18,248 | b | 2,700 | b | MR |
| 25. | $S_5A_1$-50 | 0,760 | 19,954 | b | 2,000 | a | MR |
| 26. | $S_5A_1$-54 | 0,650 | 23,039 | b | 3,100 | b | MR |
| 27. | $S_5A_1$-56 | 0,680 | 26,485 | a | 3,600 | b | MR |
| 28. | $S_5A_1$-57 | 0,660 | 17,637 | b | 4,100 | b | MR |
| 29. | $S_5A_1$-58 | 0,520 | 5,128 | a | 0,700 | a | HR |
| 30. | $S_5A_1$-59 | 0,640 | 4,144 | a | 0,600 | a | HR |
| 31. | $S_5A_1$-64 | 0,660 | 4,841 | a | 2,500 | b | HR |
| 32. | $S_5A_1$-65 | 0,710 | 10,798 | a | 1,900 | a | R |
| 33. | $S_5A_1$-67 | 0,690 | 22,414 | b | 3,800 | b | MR |
| 34. | $S_5A_1$-68 | 0,380 | 11,548 | a | 1,100 | a | R |
| 35. | $S_5A_1$-69 | 0,560 | 2,400 | a | 0,900 | a | HR |
| 36. | $S_5A_1$-70 | 0,670 | 42,389 | b | 5,600 | b | S |
| 37. | $S_5A_1$-71 | 0,420 | 26,245 | b | 2,100 | a | MR |
| 38. | $S_5A_1$-73 | 0,550 | 28,417 | b | 3,900 | b | MR |
| 39. | $S_5A_1$-78 | 0,400 | 8,873 | a | 1,800 | a | R |
| 40. | $S_5A_1$-79 | 0,590 | 15,306 | a | 2,300 | a | R |
| 41. | $S_5A_1$-80 | 0,460 | 24,773 | b | 3,600 | b | MR |
| 42. | $S_5A_1$-82 | 0,580 | 24,875 | b | 2,300 | a | MR |
| 43. | $S_5A_1$-83 | 0,720 | 17,042 | b | 2,300 | a | MR |
| 44. | $S_5A_1$-84 | 0,450 | 12,064 | a | 1,600 | a | R |
| 45. | $S_5A_1$-85 | 0,890 | 43,716 | b | 3,700 | b | S |
| 46. | $S_5A_1$-88 | 0,590 | 35,063 | b | 6,600 | b | MR |
| 47. | $S_5A_1$-89 | 1,000 | 6,523 | a | 0,900 | a | R |
| 48. | $S_5A_1$-90 | 0,860 | 14,658 | a | 2,200 | a | R |
| 49. | $S_5A_1$-92 | 0,540 | 3,950 | a | 1,200 | a | HR |

Tabel 1. (Continued)

| Nr | Lines | Grain hardness (mm/sec/100g) | Grain damage (%)* | | Grain weight loss (%)** | | Resistancy category |
|---|---|---|---|---|---|---|---|
| 50. | $S_5A_1$-93 | 0,520 | 6,383 | a | 0,700 | a | R |
| 51. | $S_5A_1$-94 | 0,440 | 19,281 | b | 2,600 | b | MR |
| 52. | $S_5A_1$-99 | 0,890 | 6,160 | a | 0,800 | a | R |

* data were transformed by using arcsin $x^{1/2}$; ** data were transformed by using $(x+1)^{1/2}$; mean values followed by the same letters do not differ significantly at 5% according to Scott Knott Multiple Range Test; HR= highly resistant, R= resistant, MR= moderately resistant, S= susceptible.

Heritability estimates for grain damage and grain weight loss were medium (Table 2). It is thought that genetic and environment factors contribute equally to both characters. However, this result should be considered carefully since a number of factors affecting the estimation of heritability such as population characterized, sample of genotypes evaluated, mode of calculation, extensively of genotype evaluation, linkage disequilibrium and conduct of experiment (Fehr, 1987).

Tabel 2. Variabily and heritability estimates for characters observed

| Character | Variability | | | | | | Heritability estimates | |
|---|---|---|---|---|---|---|---|---|
| | Genotipic | | | Phenotypic | | | | |
| | $_g$ | 2 $^{2}_{g}$ | Category | $_f$ | 2 $^{2}_{f}$ | Category | Value | Category |
| Grain hardness | - | - | - | 0.034 | 0.006 | Broad | - | - |
| Grain damage | 48.502 | 34.154 | Broad | 114.221 | 31.610 | Broad | 0.425 | Moderate |
| Grain weight loss | 0.116 | 0.048 | Broad | 0.322 | 0.024 | Broad | 0.360 | Moderate |

- = not determined

Grain hardness was found to be negatively correlated with grain damage and grain weight loss (Table 3). It is showed that inceasing hardness of grain will cause decreasing in grain damage as well as grain weight loss. The harder the seed the lower the seed damages and the lower the grain weight loss as well. Since the experiment was conducted in the laboratory with temperature and relative humidity controlled properly, therefore a correlation that found is mainly regulated by genetic factors. Pleiotropism and/or linkage disequilibrium are possible genetic causes for two traits correlated, in this case, between grain hardness and grain damage, and between grain hardness and grain weight loss. This result was also supported by Bergvinson (2000).

Tabel 3. Correlation coefficient between grain hardness with grain damage and grain weight loss

| Character | Correlation coefficient | | | |
|---|---|---|---|---|
| | $r_{xy}$ | $t_t$ | $t_{tabel}$ | |
| | | | 0.050 | 0,010 |
| Grain hardness: | | | | |
| - Grain damage | - 0.269 | 2.225* | 1.662 | 2.369 |
| - Gain weight loss | - 0.285 | 2.383** | 1.662 | 2.369 |

* Significantly different at 5% according to t test; ** significantly different at 1% according to t test

## Conclusion

Six lines namely $S_5A_1$-8, $S_5A_1$-58, $S_5A_1$-59, $S_5A_1$-64, $S_5A_1$-69 and $S_5A_1$-92 were categorized as highly resistant lines. Broad genetic and phenotypic variabilities were found for grain damage and grain weight loss. Phenotypic variability estimate for grain hardness was broad as well. Heritability estimates for grain damage and grain weight loss were medium. Grain hardness was found to be negatively correlated with grain damage and grain weight loss. The harder the seed the lower the seed damages and the lower the grain weight loss as well.

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