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*Full Length Research Paper*

# Combining ability for grain yield, agronomic traits and *Striga lutea* tolerance of maize hybrids under artificial striga infestation

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**A study was carried out using diallel crosses in maize to determine the general and specific combining abilities in the mode of inheritance of tolerance to *Striga lutea*. Ten inbred parents of varying tolerance to *S. lutea* were crossed in half diallel to generate 45 $F_1$ hybrids. The hybrids were evaluated in three striga endemic locations of Southwestern Nigeria under artificial infestation in 1998 growing seasons. The results showed that general combining ability effects were significant for almost all traits under infested and uninfested conditions. Progeny performance showed that hybrids were 86 and 40% better than their parent inbreds for striga tolerance rating and maize grain yield under artificial infestation. General combining ability (gca) effects for striga syndrome ratings were generally low with negative gca effects of -080. -0.40, -0.21,-0.15 and -0.26 in parents Tzi 97, Tzli100, Tzpi43-22, Tzmi105 and Tzpi260, respectively. Parents inbreds Tzpi97, Tzmi104, Tzpi57 and Tzli10 are good sources of gene for higher grain yield. Specific combining ability (sca) effects were also generally low for striga syndrome rating with values of -0.94, -0.77, -1.14 and 0.83 showing good tolerance. These tolerant inbreds may be adopted for commercial hybrid maize production for *S. lutea* endemic areas of south western Nigeria.**

**Key words**: *Striga lutea*, tolerance levels, combining ability, grain yield.

## INTRODUCTION

Maize is a popular cereal crop in Africa. It is a staple food that constitutes the main diet of many people in the tropical and subtropical Africa (Oyekan et al., 1989). Maize also constitutes the bulk of raw materials for the live stock and agro-based industries. As a component of farming system in Nigeria, it is increasingly becoming important in Sudan and guinea savanna ecologies where it is gradually replacing sorghum and millet.

The production and utilization potential of maize in the recent times is not only attracting the attention of research scientists, but also evolving major national and international research thrusts, with a view to providing solutions to various problems of maize. Some of these problems include low seed yield, poor resistance to pests and diseases, poor adaptation to various agro ecologies, and yield loss resulting from the devastating effects of striga parasitic weeds (Kim, 1993, 1994).

Maize breeding programmes designed for specific-end uses, improved maize genotypes tolerant to pests/disease, and development of commercial maize hybrids usually require a good knowledge of combining ability of the breeding materials to be used. Hence, the relevance of combining ability studies for successful maize breeding such as the development of *Striga lutea* tolerant varieties. Many breeders have used combining ability to solve many maize agronomic problems. These include breeding for higher grain yield and adaptation to tropical Africa (Vasal et al., 1992), selecting for high heterosis and adaptation to Colombian agro-ecologies (Peresvelasques et al., 1995), developing maize varieties with good ear height and uniform flowering days

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**Table 1.** Agronomic and striga related parameters of the maize inbred lines selected for use in the diallel crosses.

| Maize parent inbred | Origin | Seed texture | +Tolerance to *S.hermonthica* | Days to tasseling | Days to silking | Mean striga (1-9) rating | Tolerance to *S. lutea* |
|---|---|---|---|---|---|---|---|
| Tzpi 97 | Cote de voire | Dent | Tolerant | 60 | 63 | 7.0 | Moderately susceptible |
| TzLi 100 | " " | Dent | Highly tolerant | 62 | 65 | 2.0 | Highly tolerant |
| Tzpi 43-22 | " " | Flint/dent | Moderately susceptible | 62 | 66 | 3.0 | Highly tolerant |
| Tzmi 104 | I.I.T.A, Ibadan | Flint | Moderately susceptible | 65 | 68 | 3.0 | Highly tolerant |
| Tzmi 105 | " " | Flint | Moderately susceptible | 67 | 64 | 4.0 | Moderately tolerant |
| TzLi 57 | Cote de voire | Flint/dent | Susceptible | 67 | 72 | 5.0 | Moderately tolerant |
| Tzi 10 | I.I.T.A, Ibadan | Flint | Very susceptible | 58 | 62 | 9.0 | Highly susceptible |
| TzLi 6-1 | Cote de voire | Dent | Tolerant | 58 | 60 | 9.0 | Highly susceptible |
| Tzi 4 | I.I.T.A, Ibadan | Flint/dent | Susceptible | 59 | 59 | 6.0 | Moderately tolerant |
| Tzpi 260 | Cote de voire | Dent | Susceptible | 59 | 66 | 5.0 | Moderately tolerant |

+IITA Code 'Voire record (1995 and 1996).

(Martinez et al., 1993), and identifying suitable maize inbreds for higher grain yield and improved agronomic traits (Iken et al., 2001).

Similarly, Kim (1994) used diallel and combining ability approach to study the genetics to maize tolerance of *Striga hermonthica* in southern guinea savanna of Nigeria. The results showed that such study was highly suitable for the development of striga tolerant maize genotypes. Breeding for *Striga asiatica* resistance had also been reported by Ransom et al. (1990). Hence, development of *S. lutea* tolerant genotypes appears feasible and promising.

Striga infestation on the other hand has reached an endemic status not only in the northern guinea savanna, but also in the southern guinea savanna of Nigeria where it now constitutes a serious threat to maize production, and, farmers are being compelled to abandon their farm lands to striga, or change to production of less susceptible crop hosts. The objectives of this study therefore were (1) to assess the general and specific combing abilities of some selected maize inbreds for tolerance to *S. lutea* (2) to identify inbreds with suitable agronomic traits for use in commercial hybrid maize production, and (3) to recommend the promising commercial hybrids maize genotypes for use in the *S. lutea* endemic regions of south western Nigeria.

## MATERIALS AND METHODS

Twenty four maize inbreds identified to be tolerant to *Striga hernonthica* were seed–increased in 1996 by sib mating during the cropping season. The screening was carried out on an abandoned farmer's field because of *S. lutea* infestation at Temidire in Ibarapa Local Government Area of Oyo State. The experiment was again super-imposed with about 44000 germinable *S. lutea* seeds/hill according to Berner (1997). Striga related parameters such as striga count, mean syndrome rating, days to anthesis and maize grain yield were determined. By 1997 growing season, half diallel crosses were made between the ten selected inbreds (Table 1) in all possible combinations. The resultant $F_1$ hybrids were harvested, processed, and stored in the cold room prior to field evaluation.

The 45 $F_1$ hybrids from diallel crosses were evaluated under artificial inoculation in the early season of 1998 at Eruwa and Temidire, and in the late season at Ilora ( all in south western Nigeria). These locations were also farmers' abandoned plots due to *S. lutea* infestation. Ilora location was a derived savanna, while Temidire and Eruwa were both in the transitional rainforest ecology. The trial was in single row plots of 10 m long with 1.5 m between infested and uninfested plots in each row. The trial was replicated thrice in each of the three locations with two maize hybrids (Tzpi 97x Tzpi 9 and Tzi 950 x Tzi 10) were used as tolerant and susceptible checks, respectively. Planting was done on striga inoculated hills (44000 striga seeds/hill) to avoid possible erosion of the striga inoculi. Three maize seeds were planted on a hill at the spacing of 75 x 50 cm but were thinned to two, two week after planting, to obtain a population density of 53,555/ha. Low fertilizer dosage (50kg/ha NPK 20-10-10) was applied by broadcast before ridging, during the land preparation to minimize the likelihood of nitrogen (N) suppressing striga emergence. Other weeds except striga seedlings were constantly removed by hand to ensure the survival of the emerged striga.

Striga related parameters were assessed, such parameters include: maize establishment count, striga count/$m^2$, at 10 week after planting, and striga syndrome rating (using ratings 1-9), where 1= normal plants with no feasible symptom 9 = complete scorching of leaves causing premature death or collapse of the host plants and no ear formation. In striga tolerant breeding, the lower the values of the parameters, the better. Other maize agronomic traits included: plant and ear heights(cm); days to anthesis (day to 50% silking and tasseling); flag leaf length (cm); plant and ear aspects (using ratings 1-5) where 1= excellent and 5= poor; kernel rows/cob and numbers of kernels/row both for the artificially and naturally infested maize plants.

Data generated were subjected to diallel analysis using Griffing (1956) method 1, model 11. The general and specific combining abilities (gca and sca) were computed for the 10 parent inbreds and their 45 $F_1$ hybrids with respect to striga and maize agronomic traits. Progeny performance were also computed using the procedure of Baker (1978) [MSgca/(MSgca+ MSsca)] for the parameters taken (MS = mean squares).

## RESULTS AND DISCUSSION

Table 2 presents the analysis of variance (ANOVA) for the general and specific combining abilities for the parent inbreds and the $F_1$ hybrids respectively. The gca and sca

**Table 2.** Mean squares (MS) for the gca and sca effects and prediction of progeny performance in under *S. lutea* artificial infestation.

| Source | Df | Striga count | Striga rating | Yield | Plant height | Ear height | Days to silking | Day to tasselling | husk tip cover | ear aspect | kernel rows/ ocb |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Gca | 9 | 25.37*<br>1.29* | 13.23*<br>16.20* | 1.71*<br>1.94* | 243.60*<br>251.61* | 251.60*<br>465.05* | 36 .88*<br>71.04* | 77.18*<br>93.15* | 4.17*<br>4.96* | 2.45*<br>1.22* | 6.03*<br>13.66* |
| Sca | 45 | 7.33*<br>0.61* | 2.21*<br>1.17* | 1.40*<br>1.94* | 1775.0*<br>497.6* | 765.31*<br>465.05* | 33.31*<br>7.04* | 24.46*<br>32.75* | 2.49*<br>1.56* | 1.28*<br>1.02* | 10.56*<br>7.35* |
| Error | 108 | 1.87<br>0.43 | 0.90<br>0.86 | 0.64<br>0.68 | 493.17<br>497.63 | 259.25<br>216.91 | 9.98<br>6.64 | 6.89<br>44.29 | 0.20<br>0.30 | 0.70.<br>0.81 | 3.18<br>3.72 |
| Gca/gca +sca | | 0.78*<br>0.68* | 0.86*<br>0.93* | 0.42*<br>0.44* | 0.49*<br>0.59* | 0.02<br>0.35* | 0.53*<br>0.91* | 0.76*<br>0.74* | 0.63*<br>0.76* | 0.65*<br>0.54* | 0.37*<br>0.65* |

Values at the lower portion in the same column are for naturally infested plots.

**Table 3.** General combining ability (gca) in striga and maize agronomic traits under artificial *S.lutea* infestation.

| Parent inbred | Striga count | Striga rating | Grain yield | Plant height | Ear height | No of days to 50% silking | No of days to 50% tasseling | Husk tip cover | Ear aspect | Kernel rows/ear |
|---|---|---|---|---|---|---|---|---|---|---|
| Tzpi 97 | 0.264 | -0.281 | 0.061 | 3.181 | 0.406 | -0.514 | 0.342 | -0.178 | -0.092 | -0.050 |
| Tzli100 | -0.514 | -0.406 | 0.039 | 4.417 | 1.767 | -0.167 | -0.144 | -0.192 | -0.175 | -0.106 |
| Tzpi43-22 | -0.083 | -0.211 | 0.022 | 2.986 | 0.836 | 0.431 | 0.397 | 0.100 | 0.089 | -0.189 |
| Tzmi104 | 0.861 | 0.206 | 0.060 | -4.389 | -2.400 | 0.444 | -0.103 | 0.086 | 0.103 | 0.200 |
| Tzmi 105 | -0.042 | -0.156 | -0.164 | -1.028 | -0.55 | -0.83 | 0.814 | 0.169 | 0.144 | 0.381 |
| Tzli57 | -0.444 | 0.400 | 0.084 | -0.931 | 0.044 | 0.514 | -1.078 | 0.039 | -0.203 | 0.328 |
| Tzli10 | -0.361 | 0.442 | 0.064 | 1.125 | 0.794 | -0.861 | -1.078 | -0.039 | -0.203 | -0.328 |
| Tzli6-1 | 0.014 | 0.067 | -0.029 | 3.139 | 1.378 | -0.417 | -1.061 | -0.247 | -0.064 | -0.133 |
| Tzi4 | -0.33 | 0.206 | -0.118 | -4.569 | -0.956 | -0.140 | 0.244 | 0.239 | -0.022 | 0.061 |
| TZpi 260 | -0.250 | -0.267 | -0.019 | -3.931 | -1.317 | 0.667 | -0.408 | -0.081 | 0.061 | 0.075 |

effects were significant for almost all the traits measured under both infestation conditions showing the significant variability of the materials used. Significant gca effect for grain yield was also reported by Sfakianaksis et al. (1996) using similar approach. The magnitude of MS values for maize agronomic traits in this study were relatively larger under natural infestation, just as reported by Nevado et al. (1989), when compared to artificial infestation, showing the obvious adverse effects of artificial inoculation on maize general performance. Although, Baker et al. (1990) and Everest et al. (1995) have reported progeny performance of 65.0 and 76.0% respectively for husk cover and ear aspect, prediction of progeny performance in this study shows that hybrid maize was 86% and 42% better than their parent inbreds with respect to striga tolerance rating and maize grain yield. Similarly, a progeny performance of about 37% was recorded for kernel rows/cob (Table 2).

General combining ability (gca) effect of the parent inbreds for striga and maize agronomic traits under artificial inoculation are presented in Table 3. Gca effects for striga count and syndrome ratings were generally low with some parents recording negative values. The gca effects for this value is in the range of -0.51 and 0.86 showing high tolerance levels of the parents to striga emergence count. Parents such as Tzi100, Tzli57, Tzi4 and Tzli10 are exceptionally resistant to striga emergence count with gca effects of -0.51, -0.44, -0.33 and -0.36, respectively. Parents Tzp197, Tzli100, Tzpi43-22, Tzmi105 and Tzpi260 were also highly tolerant to striga syndrome rating with gca effects of -0.8, -0.40, -0.21, -0.15 and -0.26, respectively, under artificial inoculation (Table 3). These parents are good sources of gene for *S. lutea* tolerance. Ulrich and Carroll (1990) reported similar negative gca effects while breeding for gray leaf resistant maize genotypes.

Similarly, parent inbreds Tzpi97, Tzmi104, Tzli57 and Tzli10 are good sources of gene for higher grain yield, while parent Tzmi105 and Tzli57 possessed the inherent ability to increase kernels rows/cob (Table 3). Tzmi104 and Tzli97 were however, the best in terms of kernel rows/cob under natural striga infestation while the highest grain yielder was Tzli10 under natural infestation (Table 4).

Table 5 presents the specific combining ability of the hybrid maize for striga count under both infestation conditions. The sca effects were generally low for all the hybrids with respect to striga emergence under natural

**Table 4.** General combining abilities for striga and maize agronomic characters under *S.lutea* natural infestation.

| Parent inbred | Striga count | Striga rating | Grain yield | Plant height | Ear height | No of days to 50% silking | No of days to 50% tasseling | Husk tip cover | Ear aspect | Kernel rows/ear |
|---|---|---|---|---|---|---|---|---|---|---|
| Tzpi 97 | 0.019 | -0.378 | 0.067 | 2.889 | 1.092 | -0.350 | -0.100 | -0.119 | -0.036 | 0.222 |
| Tzli100 | 0.092 | -0.332 | 0.023 | 6.069 | 1.689 | -0.808 | -0.628 | -0.244 | -0.147 | -0.347 |
| Tzpi43-22 | -0.078 | -0.121 | -0.017 | 0.847 | -0.950 | 0.622 | 0.303 | -0.022 | -0.09 | -0.028 |
| Tzmi104 | 0.061 | 0.226 | -0.069 | -0.806 | 0.689 | -0.225 | 0.956 | 0.019 | 0.019 | 0.472 |
| Tzmi 105 | -0.022 | 0.032 | -0.112 | 0.125 | 0.856 | 0.831 | 0.761 | 0.186 | 0.033 | 0.208 |
| Tzli57- | -0.161 | 0.432 | 0.136 | 1.403 | 0.897 | 1.053 | 0.608 | -0.078 | 0.006 | 0.083 |
| Tzli10 | 0.075 | 0.560 | 0.187 | -1.514 | 0.550 | -0.489 | -0.975 | 0.186 | 0.200 | 0.181 |
| Tzli6-1 | 0.144 | 0.046 | 0.033 | 0.083 | -1.714 | -0.711 | -1.1364 | -0.203 | -0.036 | -0.597 |
| Tzi4 | 0.089 | -0.038 | -0.133 | -4.431 | -0.964 | -0.544 | -0.308 | 0.339 | 0.006 | -0.125 |
| TZpi 260 | -0.036 | -0.440 | 0.019 | -4.667 | -2.144 | 0.622 | 0.747 | -0.064 | 0.047 | -0.069 |

**Table 5.** Specific Combining abilities (sca) of maize Kernel row s/cob under *S.lutea* artificial ansd natural infestation.

| | Tzpi97 | Tzli100 | Tzpi43-22 | Tzmi1o4 | Tzmi105 | Tzli57 | Tzi10 | Tzli6-1 | Tzi4 | Tzpi260 |
|---|---|---|---|---|---|---|---|---|---|---|
| **Tzpi97** | -2.34 | -1.12 | 0.40 | -0.56 | -0.25 | 0.05 | 1.33* | -1.09 | 1.72* | 1.14 |
| **Tzli100** | -0.79 | -2.23 | 1.02* | 1.30* | -0.14 | 1.96* | 0.13 | -0.50 | -1.11 | -0.85 |
| **Tzpi43-22** | 0.13 | 0.18 | -1.73 | -0.43 | -0.27 | 0.40 | -.70* | 1.79* | 1.15 | 0.50 |
| **Tzmi104** | 0.75 | 0.12 | -0.46 | -1.18 | 1.33* | 0.30 | 0.14 | -0.47 | 0.61 | -0.08 |
| **Tzmi105** | 1.39* | 0.61 | 1.03 | -0.36 | -1.54 | -0.46 | 0.00 | -0.36 | -0.49 | 1.04* |
| **Tzli57** | 0.26 | 0.65 | 0.74 | 0.68 | 0.50 | -0.36 | -0.05 | 1.17 | 0.29 | -0.40 |
| **Tzi10** | 1.18 | -0.09 | 0.32 | 0.60 | -0.25 | 0.50 | -1.29 | 0.0 | -0.51 | 0.72 |
| **Tzli6-1** | 0.40 | 1.46* | -0.13 | 0.82 | -0.36 | 0.02 | -0.07 | 0.29 | 0.77* | 2.25* |
| **Tzi4** | -0.46 | 0.26 | 0.68 | 1.29 | -0.22 | 1.15 | 1.07 | 0.80 | 0.29 | 1.19* |
| **Tzpi260** | 1.86* | 2.08* | 0.99 | -1.06 | 0.76 | 1.14 | -0.61 | 1.94* | -3.76* | -3.76 |

P<0.05; values in the upper diagonal are for naturally infested plots while those in the lower diagonal are for artificially infested plots.

**Table 6.** Specific combining abilities (sca) for striga rating under *S. lutea* arificial and natural infestation.

| | Tzpi97 | Tzli100 | Tzpi43-22 | Tzmi104 | Tzmi105 | Tzli57 | Tzi10 | Tzli6-1 | Tzi4 | Tzpi260 |
|---|---|---|---|---|---|---|---|---|---|---|
| **Tzpi97** | 0.26 | 0.41* | 0.I0 | 0.44 | -0.02 | 0.32 | -0.60 | 0.20 | -0.09 | 0.01 |
| **Tzli100** | 0.30 | 0.43* | 0.43* | 0.52 | -0.01 | 0.02 | 0.81* | 0.03 | 0.14 | 0.34* |
| **Tzpi43-22** | -0.05 | 0.59* | 0.02 | -0.03 | -0.23 | -0.07 | 0.34 | 0.05 | 0.10 | 0.448 |
| **Tzmi104** | -0.14 | 0.84* | 0.21 | 0.03 | -0.07 | -0.23 | -0.06 | 0.47* | -0.32 | 0.79 |
| **Tzmi105** | -0.94 | 1.17* | -0.81 | -0.43 | 0.08 | 0.23 | -0.32 | 0.34 | 0.63* | -0.23 |
| **Tzli57** | 0.33* | 0.45* | 1.26* | -0.98 | -0.96 | -0.07 | -0.-07 | 0.52 | -0.17 | -0.61 |
| **Tzi10** | -0.54 | -1.08 | -0.77 | 0.30 | -0.83 | 0.48* | 0.19 | -0.21 | 0.54 | 0.12 |
| **Tzli6-1** | -0.001 | -0.22 | -0.73 | 0.36* | 0.37* | 1.48* | 0.27 | -0.32 | 0.53 | -0.28 |
| **Tzi4** | 0.36* | -0.18 | -0.04 | -0.46 | 0.06 | -1.14 | 0.30 | 0.32 | 1.04 | 0.31 |
| **Tzpi260** | 0.33 | 0.45* | -0.07 | 0.32 | -0.46 | -0.18 | -0.55 | 1.52* | -0.32 | 0.15 |

P<0.05; values in the upper diagonal are for naturally infested plots while those in the lower diagonal are for artificially infested plots.

infestation, showing good tolerance to striga emergence under this infestation condition, except in hybrid Tzpi97 x Tzpi43-22 where striga emergence was significant with sca effect of 0.39. Similarly, sca effect for this trait was generally low showing tolerance to emergence under artificial infestation. Out of the 45 $F_1$ hybrids tested, only 8 were moderately susceptible to striga emergence. Parents of these susceptible hybrids were Tzmi104, Tzpi43-22, Tz10 and Tzli57. The rest of the hybrids were generally tolerant to striga emergence with crosses Tzpi43-22 x Tzpi97, Tzli10 x Tzpi97, Tzli6-1 x Tzpi43-22 and Tzpi 2260 x Tzpi43-22 being noteworthy with sca effects of less than 0.09 (Table 5).

Sca effects for striga rating are presented in Table 6.

**Table 7.** Specific combining abilities (Sca) of maize grain yield under *S. lutea* artificial and natural infestation.

| | Tzpi97 | Tzli100 | Tzpi43-22 | Tzmi1o4 | Tzmi105 | Tzli57 | Tzi10 | Tzli6-1 | Tzi4 | Tzpi260 |
|---|---|---|---|---|---|---|---|---|---|---|
| **Tzpi97** | -0.71 | 0.007 | 0.34 | 0.44 | 0.79 | -0.23 | -0.06 | 0.12 | -0.28 | 0.31 |
| **Tzli100** | -0.151 | -0.68 | -0.08 | 0.14 | 0.09 | -0.32 | 0.63 | -0.17 | 0.54* | 0.53* |
| **Tzpi43-22** | 0.33* | -0.38 | 0.20 | 0.03 | 0.04 | 0.46 | 0.46 | 0.33 | 0.51 | -0.21 |
| **Tzmi1o4** | 0.62* | 0.38* | -0.02 | -0.83 | -0.06 | 0.80* | 0.34 | -0.06 | -0.32 | 0.19 |
| **Tzmi105** | 0.43* | 0.34 | -0.25 | -0.24 | -0.43 | 0.32 | -0.02 | -0.01 | -0.23 | -0.07 |
| **Tzli57** | -0.56 | -0.29 | -0.14 | 0.85* | 0.18 | -0.79 | 0.14 | 0.18 | 0.28 | 0.52* |
| **Tzi10** | -0.45 | 0.08 | 0.57* | -0.31 | 1.22* | 1.16* | -1.29 | 0.60 | 0.51 | -0.03 |
| **Tzli6-1** | 0.37* | 0.28 | 0.45* | -0.16 | 0.10 | 0.48* | 0.14 | -0.56 | 0.43 | -0.33 |
| **Tzi4** | 0.05 | 0.33* | 1.20* | 0.05 | -0.26 | 0.12 | -0.25 | -0.09 | -0.81 | 0.15 |
| **Tzpi260** | 0.23 | 0.67* | -0.29 | 0.25 | -0.54 | -0.04 | -0.66 | -0.21 | 0.36* | -0.45 |

P<0.05; values in the upper diagonal are for naturally infested plots while those in the lower diagonal are for artificially infested plots.

Although, 12 out of the 45 $F_1$ crosses were moderately susceptible, with sca effects of between 0.33 and 1.48. The rest were highly tolerant to *S. lutea* infestation with sca effects of -0.94, -0.77, -1.14 and -0.83 respectively (Table 6). Kim, (1994) also reported a negative sca effect of -1.0 for striga tolerant rating while studying the genetics of *S. hernonthica* tolerance in maize. Sca effect for grain yield is presented in Table 7. Grain yields were generally high in these hybrids even under artificial infestation with significant sca effects of between 0.33 and 1.22. Combinations Tzi4 x Tzpi43-22, Tzmi105 x Tzi10 and Tzli57 x Tzi10 are high-yielding combinations with significant sca effects of 1.20, 1.22 and 1.66 for grain yield (Table 7).

These resistant and high-yielding inbreds may be adopted for commercial hybrid maize production, while the promising hybrids are recommended for farmers in *S. lutea* endemic ecologies to boost maize production.

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