

Original Research Article

Identification of transgressive segregation for yield and resistance to yellow stem borer (*Scirpophaga incertulas* Walker) in F₂ segregating generation of six rice crosses (*Oryza sativa* L.)

Abstract

The research investigates the occurrence of transgressive segregation in F₂ populations derived from six rice crosses namely: ADT 43 X TKM 6, ADT 43 X ASD 12, ADT 45 X TKM 6, ADT 45 X ASD 12, ASD 16 X TKM 6 and ASD 16 X ASD 12 with the aim of identifying superior genotypes for yield and resistance to the yellow stem borer (YSB). The crosses involved high-yielding but susceptible female parents (ADT 43, ADT 45, ASD 16) and YSB resistant but low yielding male parents (TKM 6, ASD 12). In the F₂ generation, a wide range of phenotypes was observed for yield-related traits and YSB resistance. Twelve superior transgressive segregants were identified in each cross, exhibiting increased grain yield per plant, number of productive tillers, and number of grains per panicle, coupled with high levels of resistance to YSB. The results suggest that the parents carried different alleles and genes governing yield and its component traits, allowing the accumulation of favorable alleles in the F₂ progeny through recombination. The identification of these high-performing transgressive segregants provides opportunities for further evaluation and potential use in rice breeding programs to develop improved cultivars with enhanced yield and biotic stress resistance.

Keywords: Rice, Transgressive segregation, Yellow stem borer and F₂ generation.

Introduction

Rice is an Asian crop with a chromosome number of $2n = 2x = 24$ and belongs to the family of Poaceae, as most of the rice is produced and consumed in Asia. Global rice (paddy) production increased more than threefold between 1961 and 2019, from 215 million tonnes to 755 million tonnes; most of the production was from Asia. In 2020, over 756 million tons of rice were produced in 143 countries, however, it was 598 million tons in 2000. This depicting that production was increased and the cultivated area was decreased (FAO, 2022). In 2019, the global agricultural land area was 4.8 billion hectares (ha), down 3 percent or 0.13 billion hectares

compared with 2000 (FAO, 2022). The transgressive segregation in plants refers to the phenomenon, where the offspring of a cross between two parent plants exhibit traits that fall outside the range of variation observed in the parental lines. This can result in the emergence of novel and sometimes improved phenotypes in the progeny. Transgressive segregation has important implications in plant breeding and genetics. It allows breeders to access a wider range of phenotypic diversity, which can be valuable for the selection and development of improved crop varieties. Transgressive segregation can lead to the identification of superior individuals with desirable traits, such as increased yield, disease resistance, or abiotic stress tolerance. Additionally, understanding the genetic basis of transgressive segregation can provide insights into the complex interactions between genes and the potential for generating novel and beneficial phenotypes. This knowledge can inform strategies for plant breeding, genetic engineering, and the conservation of genetic diversity in plant populations.

The main objective of the present investigation is to identify the transgressive segregants for yield and resistant sources of rice yellow stem borer from the six crosses under field conditions.

Materials and Methods

The field experiments were conducted at Plant Breeding Farm, Department of Genetics and Plant Breeding, Faculty of Agriculture, Annamalai University during *Kharif* season of 2022 with F₂ segregating generation of six crosses of rice viz., ADT 43 X TKM 6, ADT 43 X ASD 12, ADT 45 X TKM 6, ADT 45 X ASD 12, ASD 16 X TKM 6 and ASD 16 X ASD 12. The F₂ generation along with parents was grown and all the required data was recorded from 350 F₂ plants of each cross. The phenotypic data of yield and yield related traits was recorded along with resistance to YSB.

In F₂ segregating generation of six cross the mean performance of the individual progenies in the population was compared with the parental mean and the superior progenies were identified. Yield characters considered for identification of transgressive segregants are,

- i. Number of productive tillers per plant,
- ii. Number of grains per panicle,
- iii. Grain yield per plant and
- iv. Resistance status to yellow stem borer.

Results and Discussion

Transgressive segregation produced hybrid progeny phenotypes that were superior to the parental phenotypes. Such plants were produced by accumulation of favourable genes (positive alleles) from both the parents as a consequence of recombination followed by segregation and additive gene action are also the main reasons for the occurrence of transgressive segregants. Unlike heterosis, extreme phenotypes caused by transgressive segregation were heritably stable. Kshirsagar *et al.* (2013) suggested that transgressive segregation could be exploited for development of genotypes with positive characters from both the parents.

Performance of parents

The female parents ADT 43 and ASD 16 had high grain yield per plant, number of productive tillers per plant and number of grains per panicle but has a susceptible status (scale 7) to yellow stem borer and ADT 45 had even higher grain yield per plant, number of productive tillers per plant and number of grains per panicle but was highly susceptible (scale 9) to yellow stem borer. In case of male parents, both TKM 6 and ASD 12 has shown highly resistant status (scale 0) to yellow stem borer. TKM 6 and ASD 12 had the lowest grain yield but TKM 6 had grain yield higher than ASD 12 but lower than all other female parents.

Performance of six rice crosses

In the present investigation 12 superior transgressive segregants for high grain yield per plant, number of panicles per plant and number of grains per panicle were identified in each of the F₂ segregating generations of all the six crosses *viz.*, ADT 43 X TKM 6, ADT 43 X ASD 12, ADT 45 X TKM 6, ADT 45 X ASD 12, ASD 16 X TKM 6 and ASD 16 X ASD 12 of rice. In all the six crosses wide range of phenotypes were observed for most the characters in the F₂ generation. This clearly suggested that all traits were governed by many genes (polygenes) and alleles governing these traits seemed to act in additive manner showing polygenic inheritance. High variability for number of tillers per plant and grain yield per plant in F₂ populations of rice was reported by Balat *et al.* (2018); Kiran *et al.* (2012); Shet *et al.* (2012); Reddyamini *et al.* (2019) and Bollineni *et al.* (2021). The F₂ plants that surpassed the parental limits were observed in all the six crosses for all the traits *viz.*, plant height, number of productive tillers, total number of tillers, panicle length, number of grains per panicle, grain yield per plant, and thousand grain weight. Reddy (2008) reported transgressive segregants over both the parents for panicle length,

filled grains, spikelet number, spikelet fertility and single plant yield in Basmati 370 x Jaya derived F₂ population. This clearly indicated that the parents had different alleles and genes governing yield and its component traits. Hence, there was a lot of scope to bring in beneficial alleles into a single genotype through rigorous selection in later generations for yield and yield attributes.

The significant superior performance of segregants due to the contribution of component characters. The plant number 320 (ADT 43 X TKM 6), plant number 100 (ADT 43 X ASD 12), plant number 289 (ADT 45 X TKM 6), plant number 138 (ADT 45 X ASD 12), plant number 48 (ASD 16 X TKM 6), and Plant number 228 (ASD 16 X ASD 12) exhibited highest grain yield per plant which was due to contribution of component characters like number of tillers per plant, productive tillers per plant and number of grains per panicle. While superior performance was also due to the highly resistance and resistance status observed during screening for yellow stem borer (YSB) of the segregants in all the six crosses. The crossing between high yielding parents (ADT 43, ADT 45, ASD 16) with yellow stem borer resistant parents (TKM 6, ASD 12) brought together beneficial alleles from both parents in transgressive segregants. High yielding transgressive segregants also showed resistance to rice yellow stem borer. Superior transgressive segregants were identified in all six crosses for grain yield and contributing traits along with YSB insect resistance. It would be worthwhile to evaluate the performance of progenies derived from desirable transgressive segregants in future generations for their further use in breeding programmes of rice. the list of desirable transgressive segregants in F₂ population of the six rice crosses were tabulated from Table 1 to Table 6. The similar studies on identification of transgressive segregation in rice were done by Mahalingam *et al.* (2012); Varma *et al.* (2012); Kumari *et al.* (2013); Manjappa *et al.* (2014); Uday *et al.* (2014); Reddyamini *et al.* (2019) and Swarajyalakshmi *et al.* (2021).

Conclusion

It is possible to introduce a number of beneficial alleles into a single genotype through careful selection in subsequent generations, as evidenced by polygenic inheritance and high frequencies of favourable transgressive segregants for yield and resistant traits. The F₂ population which confers the maximum genotypic variation provides the opportunity for individual plants selection, which may help in the development and release of a new variety that

combines high yielding capacity with yellow stem borer resistance. The single plants with a greater number of favourable characters can be selected in F₂ generations of rice crosses, which significantly boosts the rice crop production.

Table 1. List of desirable transgressive segregants in F₂ population of the cross ADT 43 X TKM 6 along with their parents

| S. No | F ₂ plant number | Number of productive tillers plant ⁻¹ | Number of grains panicle ⁻¹ | Grain yield plant ⁻¹ | Scoring for YSB |
|-------|-----------------------------|--|--|---------------------------------|------------------|
| 1 | Plant 104 | 29.00 | 159.00 | 71.00 | Highly Resistant |
| 2 | Plant 320 | 29.00 | 164.00 | 73.71 | Highly Resistant |
| 3 | Plant 103 | 28.00 | 167.00 | 72.47 | Highly Resistant |
| 4 | Plant 132 | 28.00 | 164.00 | 71.63 | Highly Resistant |
| 5 | Plant 326 | 28.00 | 160.00 | 70.78 | Highly Resistant |
| 6 | Plant 348 | 28.00 | 165.00 | 72.07 | Highly Resistant |
| 7 | Plant 22 | 27.00 | 163.00 | 67.77 | Highly Resistant |
| 8 | Plant 131 | 27.00 | 164.00 | 69.07 | Highly Resistant |
| 9 | Plant 258 | 27.00 | 165.00 | 67.71 | Highly Resistant |
| 10 | Plant 287 | 27.00 | 160.00 | 68.25 | Resistant |
| 11 | Plant 106 | 26.00 | 167.00 | 69.03 | Resistant |
| 12 | Plant 109 | 26.00 | 168.00 | 69.45 | Resistant |
| S. No | Parents | Number of productive tillers plant ⁻¹ | Number of grains panicle ⁻¹ | Grain yield plant ⁻¹ | Scoring for YSB |
| 1 | ADT 43 | 18.00 | 156.00 | 47.36 | Susceptible |
| 2 | TKM 6 | 12.00 | 137.00 | 22.07 | Highly Resistant |

Table 2. List of desirable transgressive segregants in F₂ population of the cross ADT 43 X ASD 12 along with their parents

| S. No | F ₂ Plant Number | Number of productive tillers plant ⁻¹ | Number of grains panicle ⁻¹ | Grain yield plant ⁻¹ | Scoring for YSB |
|-------|-----------------------------|--|--|---------------------------------|------------------|
| 1 | Plant 211 | 31.00 | 158.00 | 73.99 | Highly Resistant |
| 2 | Plant 100 | 30.00 | 181.00 | 89.59 | Highly Resistant |
| 3 | Plant 89 | 28.00 | 180.00 | 81.64 | Highly Resistant |
| 4 | Plant 207 | 30.00 | 166.00 | 77.68 | Highly Resistant |
| 5 | Plant 67 | 29.00 | 162.00 | 72.83 | Highly Resistant |
| 6 | Plant 116 | 29.00 | 167.00 | 78.45 | Highly Resistant |
| 7 | Plant 186 | 28.00 | 181.00 | 82.64 | Highly Resistant |
| 8 | Plant 267 | 28.00 | 173.00 | 77.98 | Highly Resistant |
| 9 | Plant 95 | 27.00 | 175.00 | 74.18 | Highly Resistant |
| 10 | Plant 318 | 27.00 | 173.00 | 77.07 | Highly Resistant |
| 11 | Plant 340 | 26.00 | 180.00 | 82.83 | Highly Resistant |
| 12 | Plant 319 | 25.00 | 182.00 | 80.99 | Resistant |
| S. No | Parents | Number of productive tillers plant ⁻¹ | Number of grains panicle ⁻¹ | Grain yield plant ⁻¹ | Scoring for YSB |
| 1 | ADT 43 | 18.00 | 156.00 | 47.36 | Susceptible |
| 2 | ASD 12 | 14.00 | 110.00 | 20.98 | Highly Resistant |

Table 3. List of desirable transgressive segregants in F₂ population of the cross ADT 45 X TKM 6 along with their parents

| S. No | F ₂ Plant Number | Number of productive tillers plant ⁻¹ | Number of grains panicle ⁻¹ | Grain yield plant ⁻¹ | Scoring for YSB |
|-------|-----------------------------|--|--|---------------------------------|--------------------|
| 1 | Plant 93 | 25.00 | 192.00 | 94.56 | Highly Resistant |
| 2 | Plant 289 | 25.00 | 220.00 | 102.30 | Highly Resistant |
| 3 | Plant 26 | 24.00 | 217.00 | 99.47 | Highly Resistant |
| 4 | Plant 272 | 24.00 | 196.00 | 89.84 | Highly Resistant |
| 5 | Plant 342 | 23.00 | 201.00 | 87.83 | Highly Resistant |
| 6 | Plant 281 | 23.00 | 200.00 | 88.78 | Highly Resistant |
| 7 | Plant 286 | 23.00 | 200.00 | 88.32 | Highly Resistant |
| 8 | Plant 308 | 23.00 | 207.00 | 81.41 | Highly Resistant |
| 9 | Plant 323 | 23.00 | 199.00 | 88.11 | Resistant |
| 10 | Plant 297 | 23.00 | 212.00 | 91.66 | Resistant |
| 11 | Plant 127 | 23.00 | 211.00 | 81.53 | Resistant |
| 12 | Plant 120 | 23.00 | 196.00 | 81.59 | Resistant |
| S. No | Parents | Number of productive tillers plant ⁻¹ | Number of grains panicle ⁻¹ | Grain yield plant ⁻¹ | Scoring for YSB |
| 1 | ADT 45 | 19.00 | 186.00 | 69.35 | Highly Susceptible |
| 2 | TKM 6 | 12.00 | 137.00 | 22.07 | Highly Resistant |

Table 4. List of desirable transgressive segregants in F₂ population of the cross ADT 45 X ASD 12 along with their parents

| S. No | F ₂ Plant Number | Number of productive tillers plant ⁻¹ | Number of grains panicle ⁻¹ | Grain yield plant ⁻¹ | Scoring for YSB |
|-------|-----------------------------|--|--|---------------------------------|------------------|
| 1 | Plant 59 | 25.00 | 199.00 | 89.35 | Highly Resistant |
| 2 | Plant 70 | 25.00 | 212.00 | 94.65 | Highly Resistant |
| 3 | Plant 339 | 25.00 | 197.00 | 92.24 | Highly Resistant |
| 4 | Plant 263 | 25.00 | 220.00 | 90.97 | Highly Resistant |
| 5 | Plant 276 | 25.00 | 203.00 | 86.07 | Highly Resistant |
| 6 | Plant 331 | 25.00 | 219.00 | 91.15 | Highly Resistant |
| 7 | Plant 343 | 25.00 | 203.00 | 90.99 | Highly Resistant |
| 8 | Plant 208 | 25.00 | 218.00 | 89.97 | Highly Resistant |
| 9 | Plant 138 | 24.00 | 222.00 | 94.67 | Highly Resistant |
| 10 | Plant 305 | 24.00 | 209.00 | 88.48 | Resistant |
| 11 | Plant 313 | 24.00 | 219.00 | 86.88 | Resistant |
| 12 | Plant 300 | 23.00 | 228.00 | 89.88 | Resistant |
| S. No | Parents | Number of productive tillers plant ⁻¹ | Number of grains panicle ⁻¹ | Grain yield plant ⁻¹ | Scoring for YSB |
| 1 | ADT 45 | 19.00 | 186.00 | 69.35 | Susceptible |
| 2 | ASD 12 | 14.00 | 110.00 | 20.98 | Highly Resistant |

Table 5. List of desirable transgressive segregants in F₂ population of the cross ASD 16 X TKM 6 along with their parents

| S. No | F ₂ Plant Number | Number of productive tillers plant ⁻¹ | Number of grains panicle ⁻¹ | Grain yield plant ⁻¹ | Scoring for YSB |
|-------|-----------------------------|--|--|---------------------------------|------------------|
| 1 | Plant 13 | 25.00 | 204.00 | 112.79 | Highly Resistant |
| 2 | Plant 317 | 25.00 | 210.00 | 114.21 | Highly Resistant |
| 3 | Plant 181 | 25.00 | 186.00 | 111.06 | Highly Resistant |
| 4 | Plant 215 | 24.00 | 210.00 | 114.18 | Highly Resistant |
| 5 | Plant 235 | 24.00 | 208.00 | 119.45 | Highly Resistant |
| 6 | Plant 340 | 24.00 | 199.00 | 107.03 | Highly Resistant |
| 7 | Plant 45 | 24.00 | 208.00 | 121.69 | Highly Resistant |
| 8 | Plant 190 | 24.00 | 193.00 | 107.43 | Highly Resistant |
| 9 | Plant 179 | 23.00 | 198.00 | 110.17 | Highly Resistant |
| 10 | Plant 267 | 23.00 | 212.00 | 117.49 | Highly Resistant |
| 11 | Plant 82 | 23.00 | 210.00 | 117.46 | Highly Resistant |
| 12 | Plant 129 | 23.00 | 209.00 | 117.33 | Highly Resistant |
| S. No | Parents | Number of productive tillers plant ⁻¹ | Number of grains panicle ⁻¹ | Grain yield plant ⁻¹ | Scoring for YSB |
| 1 | ASD 16 | 18.00 | 182.00 | 87.82 | Susceptible |
| 2 | TKM 6 | 12.00 | 137.00 | 22.07 | Highly Resistant |

Table 6. List of desirable transgressive segregants in F₂ population of the cross ASD 16 X ASD 12 along with their parents

| S. No | F ₂ Plant Number | Number of productive tillers plant ⁻¹ | Number of grains panicle ⁻¹ | Grain yield plant ⁻¹ | Scoring for YSB |
|-------|-----------------------------|--|--|---------------------------------|------------------|
| 1 | Plant 239 | 27.00 | 188.00 | 112.82 | Highly Resistant |
| 2 | Plant 268 | 26.00 | 204.00 | 118.69 | Highly Resistant |
| 3 | Plant 310 | 26.00 | 192.00 | 123.60 | Highly Resistant |
| 4 | Plant 228 | 26.00 | 205.00 | 126.16 | Highly Resistant |
| 5 | Plant 217 | 25.00 | 202.00 | 122.60 | Highly Resistant |
| 6 | Plant 334 | 25.00 | 199.00 | 119.45 | Highly Resistant |
| 7 | Plant 240 | 25.00 | 200.00 | 111.62 | Highly Resistant |
| 8 | Plant 247 | 24.00 | 199.00 | 113.27 | Highly Resistant |
| 9 | Plant 211 | 24.00 | 217.00 | 125.04 | Highly Resistant |
| 10 | Plant 329 | 24.00 | 212.00 | 121.82 | Highly Resistant |
| 11 | Plant 95 | 23.00 | 214.00 | 114.51 | Highly Resistant |
| 12 | Plant 348 | 23.00 | 201.00 | 112.23 | Highly Resistant |
| S. No | Parents | Number of productive tillers plant ⁻¹ | Number of grains panicle ⁻¹ | Grain yield plant ⁻¹ | Scoring for YSB |
| 1 | ASD 16 | 18.00 | 182.00 | 87.82 | Susceptible |
| 2 | ASD 12 | 14.00 | 110.00 | 20.98 | Highly Resistant |

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