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Research Article

Evaluation of TGMS lines for good floral and out crossing related traits in rice

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Abstract
The objective of present study is to identify promising TGMS lines with desirable floral and out crossing related traits for hybrid rice breeding. A total of seven new TGMS lines were raised during summer 2017 and observed under sterility favouring environment for tgms gene expression. Out of seven TGMS lines, four lines showed the stable performance and two TGMS lines *viz.,* TNAU45S,TNAU60S were shown completely pollen sterile throughout the summer. Variability studies revealed that the characters *viz*., glume angle, stigma exertion percent and out-crossing per cent showing high GCV, Heritability and Genetic advance could be effectively utilized in selection. Correlation studies showed that the trait glume angle exhibited significant and positive correlation with extent of out crossing and spikelet sterility percent. The four TGMS lines *viz.,* TNAU 39S, TNAU 45S, TNAU 60S, TNAU 95S registered the highest value for angle of glume opening (> 35%), panicle exertion percentage (> 90%) and stigma exertion percentage (> 65%). These lines had wider sterility expression period with very good floral traits *viz*., higher pollen sterility per cent, panicle and stigma exertion per cent, wider glume opening favorable for enhanced out-crossing rate and seed set percentage during seed production. From this study, the TGMS lines TNAU 39S, TNAU 45S, TNAU 60S and TNAU 95S were identified as promising based on floral and out crossing related traits and will be utilized for future hybrid breeding programmes towards the development of two line hybrids.

Introduction

Heterosis in rice was observed as early as in 1926 (Jones, 1926andRamaiah, 1933).However, attempts for the adaptation of hybrid technology were initiated only in 1966 by Yuan Long Ping, father of Hybrid rice, in China (Yuan, 1997). The identification of wild abortive (WA) type of cytoplasmic male sterility (CMS) in 1970 was a breakthrough in exploiting heterosis in rice breeding. Rice hybrids have a yield advantage of 15 to 20 per cent over the best conventionally bred varieties. China's success in commercial hybrid rice production clearly demonstrates that hybrid rice is the most significant practical tool for increasing global rice production. Success in the use of hybrid rice technology depends on the extent of heterosis and efficiency of the seed production techniques. One of the major anticipated constraints to the sustenance of heterosis breeding in rice is the availability of quality seed within an affordable price range.

There are two types of hybrid systems to develop hybrid rice. The first system is called a three-line hybrid, which is based on cytoplasmic genic male sterility (CGMS). The second system is called two line hybrid or environment-sensitive genic male sterility, (EGMS); these systems are controlled by nuclear gene expression, which is influenced by environmental factors (Virmani *et al.*, 2003). The EGMS system using a two-line hybrid has a great number of advantages over the CMS system as the EGMS system is simpler and more effective due to the removal of the maintainer line from the three-line hybrid. EGMS genes are more easily transferred into almost any rice line.

Moreover, the ratio of the cultivated area to EGMS line, seed production, and commercial production can be multiplied which reduces the hybrid rice seed cost and furthermore, the EGMS hybrid seed has a 5–10% greater yield than the CMS hybrid (Lopez and Virmani, 2000). In addition, there are no negative effects on the agronomic performance of the EGMS line itself and its resulting hybrids from male sterile cytoplasm and the critical temperature or photoperiod for inducing sterility should be as low as possible for greater stability of the EGMS lines with regard to seed production (Virmani *et al.*, 2003).

Material and Methods

The seven TGMS lines *viz.,* TNAU 39S, TNAU 45S, TNAU60S, TNAU 95S, TNAU 18S, TNAU 100S and TNAU 147S were raised during summer 2017 at

Agricultural college and Research Institute, Killikulam. The materials were collected from Paddy breeding station, Tamil Nadu Agricultural University, Coimbatore. The temperature exceeds 32°C/24°C (day/night), pollen expressed as sterile condition and if the temperature is below 24°C/18°C (day/night), pollen becomes fertile condition. About 10-15 spikelets from the freshly emerged panicles of all the plants were collected and examined under microscope with the help of staining agent 1% Iodine Potassium Iodide (IKI) solution used to check the pollen sterility. Five elite plants in the middle row of each genotype from each replication were randomly selected to record the observations on days to fifty percent flowering, plant height, number of productive tillers per plant, panicle length, panicle exertion percentage, stigma exertion percentage, anther length, anther breadth, angle of glume opening, pollen sterility percentage, spikelet sterility percentage and extent of out crossing percentage.

The mean data from each character individually was subjected to statistical analysis. Statistical analysis was done with the help of the package AGRES and GENRES. Mean data of genotypes for all characters was subjected to statistical procedure, ANOVA to separate the total variation in to different components and to test their significance (Panse and Sukhatme, 1995).Genetic parameters like GCV, PCV, heritability and genetic advance were calculated. Genotypic variance (GV) and phenotypic variance (PV) were computed according to the method suggested by Johnson *et al.* (1955).Genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) were calculated using the formula suggested by Johnson *et al.* (1955).Categorization of the range of variation was effected as proposed by Sivasubramanian and Madhavamenon (1973).Genetic advance was estimated by the method given by Johnson *et al.* (1955).The association between floral characters and among themselves was computed based on genotypic and phenotypic correlation coefficients(Goulden,1952).

Results and Discussion

The first step in exploitation of two line rice hybrids is the identification of TGMS lines with stable sterility behavior. The major advantages of EGMS system are simplicity, overcoming the negative effects of male sterile cytoplasm, no need of maintainer line, less area required, less time and the seed multiplication is easy under restoration (Yuan, 1997). These two line hybrids have 5-10 % yield advantage over the three line hybrids. The observations recorded on the floral and morphological characters of TGMS lines are listed in Table 1. Out of seven TGMS lines, four lines showed the stable performance and two TGMS lines *viz.*, TNAU45S,TNAU60S were completely pollen sterile throughout the summer period at Killikulam. These lines had complete pollen sterility under the high temperature. These lines could be utilized for two line hybrid rice breeding as they can be multiplied during winter month due to alternative temperature and hybrid seed production can be taken up during summer months. Similar results were reported by Thiyagarajan, 2010in their study with seven TGMS lines. The TGMS lines *viz.*, TNAU39S, TNAU45S, TNAU60S, and TNAU95Sregistered the highest value for angle of glume opening (> 35%), panicle exertion percentage (> 90%) and stigma exertion percentage (> 65%).

Among these lines, the trait of glume angle opening was varied from 22˚C to 37˚C. In the present study maximum glume angle opening was observed in TNAU45S (36.66˚) and minimum glume angle opening was observed in TNAU100S (22.17˚).Similar results were observed by Ravneet Behta *et al*., 2007 with the range of 23.43 ˚ to 30.20 ˚. The anther length ranges varied from 2.66 (TNAU 60S) to 1.89 mm (TNAU 18S). The general mean was 2.36 and two lines *viz.*, TNAU 60S and TNAU 95S exceeded the general mean significantly. The range of anther breadth was from 0.56 mm (TNAU 39S) to 0.43 mm (TNAU147S). The general mean was 0.51 and none of the lines exceeded the general mean significantly. The range of panicle exertion percentage was from 95.87 (TNAU 45S) to 85.93 (TNAU 147S).The general mean was 91.12, and four lines exceeded the general mean significantly. The range observed for stigma exertion percent was varied from 43.13 (TNAU 18S) to 82.48 per cent (TNAU 60S). Spikelet sterility percent had a range of 93.43 (TNAU 147S) and 100.00 per cent (TNAU 45S, TNAU 60S). Three lines exceeded significantly over the general mean (96.77). The out crossing potential varied from 24.76 to 48.75 per cent. Minimum out crossing percent was obtained by TNAU18S (24.76) while the maximum out crossing per cent was recorded by TNAU 60S (48.75).

Success of any plant breeding programme mainly depends upon the knowledge on genetic variability. The genotypic coefficient of variation measures the range of variability available in a crop and also enables to compare the amount of variability present among different characters. The phenotypic expression of the character is the result of interaction between genotype and environment. Heritability indicates the relative degree at which a character is transmitted from parent to offspring. High heritability values indicate that the characters under study are less influenced by environment in their expression and such characters could be improved by adopting simple selection methods. Furthermore, the information on genetic variation, heritability and genetic advance as per cent of mean helps to predict the genetic gain that could be obtained in later generations. The comparison of heritability values and expected genetic advance expressed as per cent of mean gives an idea about the nature of gene action governing a particular character.

In the present investigation, the floral traits *viz.* Glume angle, stigma exertion per cent recorded higher GCV and PCV. Moderate GCV was observed for panicle length, anther length and anther breadth traits. The low GCV was observed in the pollen sterility per cent and panicle exertion per cent (Table 2). Behera *et al*. (2018) reported the panicle length trait showed low GCV and High PCV while Kalyan *et al*., 2017reported the high PCV and low GCV for panicle length character. Akinwale *et al* (2011) reported lower values of GCV and PCV for panicle length. Similar findings of low GCV for panicle exertion were reported by Umadevi *et al.* (2010).Lower GCV and PCV estimates indicated narrow genetic base for these traits. Improvement in these characters can be brought about by hybridization or induced mutagenesis to widen genetic base followed by pedigree selection in advanced generations. The variability in glume angle, panicle exertion, pollen sterility, anther length and stigma length were presented in Plates 1.

In the present study, high heritability and genetic gain was observed for spikelet sterility, pollen sterility and panicle length, glume angle, out crossing per cent, stigma exertion and panicle exertion per cent and these indicated the predominant of additive gene action in the inheritance of these characters which suggested heir amenability for effective phenotypic selection. Manikavelu *et al.* (2006) reported low heritability and genetic advance for panicle length character. The same results found by Umadevi *et al.* (2010)who registered the high heritability for panicle exertion and stigma exertion percent. Similar findings reported by Umadevi *et al.* (2010) high genetic advance for stigma exertion percent and extent of out crossing percent. In present study, the characters *viz*., glume angle, stigma exertion percent, out crossing per cent shown higher GCV, Heritability and Genetic advance and hence could be effectively utilized in selection.

Character association studies are of primary importance to know the relationship among various characters which will be useful for direct or indirect selection because selection of particular trait may induce desirable or undesirable change in the associated characters. Generally, high genotypic and environmental interactions are likely to restrict the improvement. Therefore, correlation between out crossing and its components are of considerable importance in selection programme.

The present study indicated that the panicle length had highly significant and positive correlation with anther length and stigma length while significant and positive correlation with panicle exertion, stigma exertion, Anther length, Anther breadth and glume angle opening per cent(Table3). Similar findings were reported by Ramakrishna *et al.* (2006) and Salgotra *et al.* (2012).The results of the evaluation studies showed that TGMS lines *viz*., TNAU 39S, TNAU 45S, TNAU 60S, TNAU 95S had wider sterility expression period with very good floral traits viz., higher pollen sterility per cent, panicle and stigma exertion per cent, wider glume opening favorable for enhanced out-crossing rate they can be utilized for the development of two line hybrids with superior yield.

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Table1. Floral and out crossing related traits of different TGMS lines

Character Lines	Panicle length (cm)	Panicle exertion %	Stigma Exertion %	Anther length (mm)	Anther breadth (mm)	Glume angle(˚)	Spikelet sterility %	Pollen sterility %	Extent of Out crossing%
TNAU39S	25.50	93.50*	66.10	2.56	0.56	32.66*	93.87	95.10	41.83*
TNAU45S	28.03*	95.86*	73.96*	2.39	0.53	36.66*	100.00*	100.00*	45.53*
TNAU60S	26.20	93.22*	82.48*	2.66*	0.56	33.16*	100.00*	100.00*	48.75*
TNAU95S	31.66*	92.74*	72.70*	2.65*	0.56	36.36*	96.80	96.93	39.89*
TNAU18S	24.16	85.44	43.13	1.89	0.45	23.33	94.13	97.13	24.76
TNAU100S	22.73	91.16	57.40	2.12	0.46	22.16	99.17*	99.37*	40.20*
TNAU147S	22.23	85.93	58.76	2.21	0.42	24.40	93.43	95.16	39.90*
MEAN	**25.79**	**91.12**	**64.93**	**2.35**	**0.51**	**29.82**	**96.77**	**97.67**	**40.12**
SED	**0.41**	**0.45**	**0.75**	**0.10**	**0.04**	**0.85**	**0.30**	**0.19**	**0.87**
CD(5%)	**0.886**	**0.979**	**1.637**	**0.230**	**0.092**	**1.854**	**0.667**	**0.412**	**1.89**

Table 2. Estimates of parameters of variability for floral traits

Characters	GCV %	PCV %	ECV %	Heritability (h^2)	GA (%) of Mean
Panicle length(cm)	12.66	12.80	1.93	97.73	25.77
Panicle exertion %	4.34	4.38	0.61	98.10	8.85
Stigma exertion%	20.07	20.12	1.41	99.50	41.25
Anther length(mm)	12.01	13.21	5.49	82.71	22.51
Anther breadth(mm)	10.36	14.52	10.16	50.99	15.24
Glume angle(˚)	21.06	21.36	3.49	97.32	42.81
Spikelet sterility	3.06	3.09	0.38	98.43	6.26
Pollen sterility	2.18	2.19	0.23	98.84	4.47
Extend of Outcrossing %	16.73	16.80	1.39	99.31	34.36

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Table 3. Genotypic correlation coefficient among floral and outcrossing related traits

Floral Traits	Panicle length (cm)	Panicle Exertion (%)	Stigma Exertion (%)	Anther Length (mm)	Anther Breadth (mm)	Glume Angle (^{0})	Spikelet Sterility (%)	Pollen Sterility (%)	Extent of outcrossing (%)
Panicle length(cm)	1	0.62**	0.60**	0.69**	0.87**	0.88*	0.31	0.17	0.33
Panicle Exertion (%)		1	0.81*	0.78**	0.94**	0.82**	0.68**	0.49*	0.79**
Stigma Exertion (%)			1	0.94**	0.91**	0.83**	0.61**	0.40*	0.85**
Anther Length (mm)				1	1.03**	0.87**	0.32	0.06	0.80**
Anther Breadth (mm)					1	1.01**	0.41*	0.23	0.67**
Glume Angle(^{0})						1	0.38*	0.19	0.61**
Spikelet Sterility (%)							1	0.96**	0.54**
Pollen Sterility (%)								1	0.28
Extent of outcrossing (%)									1