Oryza Vol. 50 No.2, 2013 (110-114)

Variations in morphological characteristics of floral organs and pollen fertility in medicinal landraces and selected segregants in rice

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ABSTRACT

Morphological characteristics of different floret traits are considered as greater importance in rice to increase the self pollination for reliable seed production. Synchrony between floret opening and anther dehiscence may contribute to the high rate of self pollination. However, the synchronization is not always perfect and some rice florets hybridize naturally. The rate of natural hybridization varies among varieties of rice, suggesting that there is a difference in the reliability of self pollination among varieties. The experimental material consisted of four traditionally grown and nutrient rich medicinal landraces, and two improved high yielding varieties along with selected F_2 segregants raised in randomized block design during wet season 2012-2013. Among them the medicinal landrace Kavuni of Tamil Nadu recorded hightest significant mean value for anther breadth, stigma length, stigma breadth, style length, style breadth and pollen fertility. Higher values of PCV and GCV were recorded for stigma breadth followed by ovary breadth. All the characters exhibited high heritability. High heritability and genetic advance were observed for stigma breadth, ovary breadth, style length, anther breadth, ovary length, anther length and style breadth revealed the role of additive gene action. This paper reports a correlation between morphological characteristics of floral organs and the reliability of self pollination in rice.

Key words: *rice, genetic variability, heritability, self pollination, floral traits*

Manipulation of pollen fertility in rice is particularly important to increase rice grain yield by way of reducing chaffiness. A small increase in nutritive content in rice would have a significant impact on human health. Conventional biofortification of cultivated varieties using nutritionally rich landraces of rice can serve the purpose. Medicinal landraces like Navara is highly nutritive and are rich in minerals like potassium, sodium, calcium, micronutrients *viz.,* iron and zinc. It also contains higher proteins, carbohydrates and vitamins like thiamine, riboflavin and niacin *etc.* Though there is no scientific data on the medicinal properties, they are being used in ayurveda in treating diseases like arthritis, cervical spondylitis, skin diseases and neurological problems (Deepa *et al.*, 2008). Many high yielding modern rice varieties, some landraces are still popular in farmer's fields due to their adaptability to different agro climatic conditions, unique characteristics and special uses. Microsporogenesis and male gametogenesis are essential for the alternating life cycle of flowering plants between diploid sporophyte and haploid gametophyte generations. For a better understanding of the mechanisms controlling rice male and female reproductive development, structural variations are important. The rice inflorescence architecture is quite different from those major cereal crops, in addition rice florets have an asymmetric structure with five types of floral organs with one lemma and one palea in the first whorl, two lodicules in the second whorl, six stamens in the third whorl and one pistil in the innermost whorl. Rice is basically an autogamous plant propagating through seeds produced by self pollination. Fertilization occurs in a spikelets which has six anthers with more than 1,000 pollen grains in each and an ovule with a branched stigma. Immediately after the spikelet opens at flowering, pollen is dispersed and germinates on the surface of the stigma. Each rice flower contains both male and female parts, which allow each flower to pollinate itself. Breeding for high-yielding rice is one of the pragmatic solution in addressing a food shortage problem that is caused by a marked increase in the global population coupled with decreasing trend in available land and limited water for agriculture (Shanti *et al.,* 2010). The study revealed a wide variation for several phenotypic floral traits contributing to the seed production efficiency of nutrionally rich rice, such as pollen fertility and morphological traits of floret such as length and breadth of anther, stigma, style and ovary. Among them anther length is especially emphasized as a major component in increasing pollination and seed set (Keto and Namai, 1987). Insight into the characteristics of florets that control the reliability of self pollination may help breeders to improve the seed setting percentage (Matsui *et al*., 2000*b)*.

MATERIALS AND METHODS

The experimental material consisted of four medicinal landraces *viz.,* Navara, Kavuni, Veeradangan and Kathanellu of rice having superior grain quality with tall stature and low yielder and two improved semi-dwarf high yielding varieties *viz.,* ADT 43, TPS4 with medium grain quality along with selected F_2 segregants (ADT43 x Navara, TPS4 x Kathanellu) raised in randomized block design replicated thrice by adopting a spacing of 30 x 10 cm at Agricultural College and Research Institute, Madurai during wet season 2012. Necessary agronomical practices and plant protection measures were followed as per recommendations. Genetics of floral traits was worked out by the method suggested by Burton (1952) and Lush (1940).

The dissection of the spikelets was done using stereomicroscope and images were taken with the image analyser measurements of the floral traits were taken using Biowizard software available with the image analyser (length and breadth of anther, stigma, style and ovary) (Fig. 1. a, b, c, d, e & f). In each genotype, 15 florets from the primary tiller were sampled about 3 h after anthesis. Florets closed about 1 h after they began to open. Spikelets collected with minimum disturbance were used to record the floral traits. Three florets were selected at random to measured the length and breadth of the anther, stigma, style, ovary using software. The length and breadth of the stigma was measured from the tip of the stigma to the base of both stigma branches (expressed in mm^2) and the mean was taken for analysis. Measurements were repeated more than three times for each land race and segregating generations of the crosses.

Pollen fertility also influence the spikelet fertility in high yielding hybrid combinations in rice. For pollen fertility studies three randomly chosen spikelets covering the whole panicle (bottom, middle and top) of the every two panicles of each randomly selected three plants in each of the variety, land races and F_2 segregants having fully matured anthers (about to dehisce) were collected in a vial containing 70 % alcohol. Two to three anthers from each spikelets were placed

Fig. 1. Floral traits of the landraces studied

together on a glass slide, squashed and pollen grains were stained with 1% iodine-potassium iodide and observations for fertile pollen grains were recorded under stereo microscope in three microscopic fields and expressed in percentage (Virmani *et al.,* 1982). Unstained, half stained, shriveled and empty pollen grains were classified as sterile, while well filled, stained and round pollen grains were recorded as fertile and those mixed with both the types were classified as partially fertile (Govinda Raj and Virmani (1988). Standard statistical procedures were used for the analysis of variance, mean performance, genotypic and phenotypic coefficients of variation (Burton 1952), heritability (Lush 1940) and genetic advance.

RESULT AND DISCUSSION

Analysis of variance exhibited highly significant differences among all the characters studied, indicating that those varieties differed significantly among themselves for these characters (Table 1). The results are in conformity with the findings of Sheeba *et al.,* 2006.

0.685 mm to 0.933 mm and 0.336 mm to 0.589 mm, respectively. Among the landraces, Kavuni registered maximum stigma length and style length. The range of 0.100 mm to 0.278 mm for stigma breadth and 0.073 mm to 0.094 mm for style breadth were observed. The line Navara registered (0.278 mm) maximum stigma breadth and Veeradangan (0.094 mm) recorded the highest style breadth. The range of 0.323 mm to 0.533 mm for ovary length and 0.073 mm to 0.326 mm for ovary breadth were observed. The line Navara recorded maximum ovary length (0.533 mm) and Veeradangan recorded recorded the highest ovary breadth (0.326 mm). The range of pollen fertility observed was from 86.83 to 94.81 per cent. The maximum percentage of pollen fertility was registered by Kavuni (94.81 %).

Genetic variability analyses revealed narrow difference between phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV) for all the characters indicating the reliability of PCV as a measure of GCV. In general the PCV were higher than the corresponding GCV.

Table 1. Analysis of variance for various floral traits and pollen fertility in rice

Source	Anther length (mm)	Anther breadth (mm)	Stigma length (mm)	Stigma breadth (mm)	Style length (mm)	Style breadth (mm)	Ovary length (mm)	Ovary breadth (mm)	Pollen fertility (%)
Replication	0.0015	0.0001	0.0002	0.0000	0.0000	0.0000	0.0000	0.0000	4.9141
Treatment	0.0640*	0.0099*	0.0179*	0.0139*	0.0213*	0.0002*	0.0178*	0.0102*	18.4695*
Error	0.0008	0.0000	0.0004	0.0000	0.0000	0.0000	0.0001	0.0001	3.1771

*Significance at 5% level.

The mean values indicated considerable variation for all traits under study revealing scope of development of more pollen shed in the surface of the stigma (Table 2). The range for anther length varies from 1.145 to 1.591 mm and the maximum was recorded by ADT 43 x Navara (1.591mm) followed by Kathanellu (1.470 mm), Navara (1.462 mm) and ADT 43 (1.441 mm). The range of anther breadth was 0.270 mm to 0.454 mm and the maximum was recorded by Navara followed by Veeradangan. All the varieties registered significant mean performance. Stigma of sufficiently larger size is known to facilitate better self pollination. The range for stigma and style length were

High value of phenotypic coefficient of variation and genotypic coefficient of variation show that the genotypes exhibit much variation among themselves with respect to these characters. Further high phenotypic coefficient of variation and genotypic coefficient of variation for any characters indicated more scope for selection. Wide variation was observed for the characters stigma length (0.685 to 0.933 mm) and percentage of pollen fertility (86.83 to 94.81 %).

The values for genotypic co-efficients of variation ranged from pollen fertility (2.47 %) to stigma breadth (33.12 %). The high GCV was observed for stigma breadth (33.12 mm) and ovary breadth (20.99

Table 2. Mean performance of floral traits and pollen fertility in rice

Source	Anther length (mm)	Anther breadth (mm)	Stigma length (mm)	Stigma breadth (mm)	Style length (mm)	Style breadth (mm)	Ovary length (mm)	Ovary breadth (mm)	Pollen fertility (%)
ADT 43	1.441*	0.283*	0.826	0.257*	0.449	0.074	0.355	0.257	93.04*
TPS 4	1.370	0.270*	0.850*	0.235*	0.383	0.075	0.323	0.262	91.22
Veeradangan	1.292	0.328*	0.868*	0.100	0.389	0.094*	0.470*	0.326*	89.88
Kavuni	1.227	0.308*	0.933*	0.272*	0.589*	0.088*	0.449*	0.276	94.81*
Navara	1.462*	0.454*	0.793	0.278*	0.453*	0.073	0.533*	0.073	86.83
Kathanellu	1.470*	0.310*	0.685	0.183	0.428	0.093*	0.493*	0.334*	93.23*
ADT 43 x Navara	1.591*	0.290*	0.748	0.206	0.545*	0.081	0.478*	0.313*	89.87
TPS 4 x Kathanellu	1.145	0.317*	0.860*	0.116	0.336	0.080	0.355	0.151	91.33
Grand mean	1.374	0.206	0.820	0.206	0.447	0.082	0.432	0.277	91.277
CD	0.049	0.009	0.037	0.010	0.016	0.0004	0.019	0.013	3.122

*Significance at 5% level.

mm). Moderate GCV was observed for style length (18.83 mm), anther breadth (17.91 mm), ovary length (17.77 mm), anther length (10.55 mm) and style breadth (10.14 mm). The lowest GCV was recorded for stigma length (9.29 mm) and pollen fertility (2.47 %).

The values for PCV ranged from pollen fertility (3.15 %) to stigma breadth (33.23 mm). The highest magnitude of phenotypic co-efficient of variation was observed for stigma breadth (33.23 mm) and ovary breadth (21.17 mm). Moderate PCV was observed for style length (18.93 mm), anther breadth (17.98 mm), ovary length (17.96 mm), anther length (10.75 mm) and style breadth (10.52 mm). The lowest PCV was recorded for stigma length (9.64 mm) and pollen fertility (3.15 %). Those results are in conformity with those of Sheeba *et al.,* 2006.

High heritability coupled with low genetic advance, low heritability with high genetic advance or low heritability and low genetic advance offer less scope for selection, as they were more influenced by environment and accounted for non-additive gene effects. High heritability coupled with high genetic advance is indicative of greater proportion of additive genetic variance and consequently a high genetic gain is expected from selection (Singh and Rai 1981). The characters having high heritability with low genetic advance as per cent of mean appeared to be controlled by non-additive gene action and selection for such characters may not be effective (Singh and Singh 2007).

The genotypes recorded high heritability values for all the characters under study. The presence of high heritability indicates that those characters are least influenced by environment.

As heritability in broad sense includes both additive and epistatic gene effects, it will be reliable only if accompanied by high genetic advance. Genetic advance as per cent of mean ranged from pollen fertility (3.99 %) to stigma breadth (67.99 mm) studies are presented in (Table 3). Stigma breadth (67.99 mm) recorded the highest genetic advance. Moderate genetic advance was recorded by ovary breadth (42.89 mm), style breadth (38.57 mm), anther breadth (36.72 mm) and ovary length (36.24 mm). The lowest genetic advance was recorded by anther length (21.36 mm), style breadth (20.12 mm), stigma length (18.44 mm) and pollen fertility (3.99 %). High genetic advance indicated that these characters are governed by additive genes and selection will be rewarding for improvement of these traits. According to Jhonson *et al.* (1995), high heritability and genetic advance for a character would indicate the predominance of additive gene action such trait is likely to respond effectively to phenotypic selection. Among the female lines for floral traits studied the cultivated high yielding varieties ADT 43 and TPS 4 and the medicinal land races *viz.,* Kavuni, Navara, Kathanellu and Veeradangan along with selected F_2 segregants of the crosses ADT 43 x Navara and TPS 4 x Kathanellu had the high significant mean performance and genetic variability. The present results

Table 3. Estimates of genetic variability for floral traits and pollen fertility in rice

Traits	Range	Mean	GCV(%)	PCV(%)	h^2 (%) (broad sense)	GA as per cent of mean
Anther length (mm)	1.145-1.591	1.3747	10.55	10.75	96.42	21.36
Anther breadth (mm)	0.270-0.454	0.2055	17.91	17.98	99.13	36.72
Stigma length (mm)	0.685-0.933	0.8204	9.29	9.64	92.32	18.44
Stigma breadth (mm)	0.100-0.278	0.2055	33.12	33.23	98.32	67.99
Style length (mm)	0.336-0.589	0.4466	18.83	18.93	98.89	38.57
Style breadth (mm)	0.073-0.094	0.0822	10.14	10.52	92.84	20.12
Ovary length (mm)	0.323-0.533	0.432	17.77	17.96	97.97	36.24
Ovary breadth (mm)	0.073-0.334	0.2766	20.99	21.17	98.38	42.89
Pollen fertility (%)	86.83-94.81	91.2767	2.47	3.15	61.60	3.99

also suggest that length and breadth of anther, stigma, style and ovary is related to increase the number of pollen grains deposited on the stigmata ultimately to increase the productivity. The genetic improvement in rice floral traits is possible through selection exercised for reliable self pollination those characters which showed high values of phenotypic coefficient of variation and genotypic coefficient of variation, heritability and genetic advance. However, characters predominantly controlled by additive gene action would be amenable to conventional breeding methods (Roy *et al.* 2012). This will provide an opportunity to select better recombinants for various characters and thereby creating large variability for these characters to increase the yield in the future generations.

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