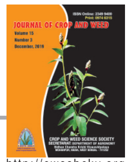
Journal of Crop and Weed, 18(1): 174-178 (2022)

ISSN- O : 2349 9400 ; P : 0974 6315



http://cwssbckv.org
www.cropandweed.com

Principal component analysis and assessment of out cross potential traits associated with grain yield in maintainer lines of rice (*Oryza sativa* L.)

[*]K. KRISHNA [1]Y. C. MOHAN, V. GOURI SHANKAR, [2]CH. V. DURGA RANI AND [1]L. KRISHNA

Department of Genetics and Plant Breeding,
[1]Rice Research Centre, [2] IBT, PJTSAU,
Rajendranagar, Hyderabad- 500030, Telangana, India.

Received : 27.09.2021 ; Revised : 21.01.2022 ; Accepted : 31.01.2022

DOI: https://doi.org/10.22271/09746315.2022.v18.i1.1549

ABSTRACT

In the present study, forty genotypes were evaluated for the mutual influence of multiple parameters for aggregate genetic variability available in rice maintainer lines by Principal Component Analysis and out cross potential traits associated with grain yield. This experiment was performed out during 2018-19 in kharif season and the genotypes were classified in the Standard Evaluation System (SES) scale (IRRI-2013) for angle of flower opening and stigma exsertion. Accordingly, based on the scoring, angle of glume opening showed 6 genotypes fell under moderate/medium angle of glume opening and 34 genotypes fell under low angle of glume opening (SES-2013). In the stigma exsertion, 38 genotypes were categorized as moderate/medium exertion and 2 genotypes were categorized as low exertion, PCA showed that a cumulative variance of 53.7% from kernel length, kernel length after cooking and number of grains per panicle contributing almost all the variation of traits.

Keywords: Angle of glume opening, amylose content, gel consistency, principal components,stigma exsertion.

Exploiting heterosis through commercial hybrid rice technology has proven to be a viable alternative for addressing food security in South Asian countries in which rice (*Oryza sativa* L.) is a main food source. Rice heterosis was found in 1926 (Jones, 1926 and Ramaiah, 1933) However, Yuan Long Ping, the father of hybrid rice, initiated the first attempts to deploy hybrid technology in China in 1966 (Yuan, 1997). The discovery of the wild abortive (WA) form of cytoplasmic male sterility (CMS) in 1970 was a defining moment in rice breeding since it enabled the use of heterosis. China has created a large area of rice hybrids since 1974. When compared to inbred lines/high yielding, hybrid rice increases yield by 20-25 per cent (Yuan, 2005). Following the success of China's demonstration of rice hybrid farming, hybrid rice production has begun in India, but on a small scale due to a variety of factors. One of the most significant of these is the high cost of seed. Rice is a self-pollinating crop, so ensuring natural out-crossing on male sterile plants is becoming increasingly important in order to cut seed production costs (Virmani, 1994). The number of opened spikelets, duration and angle of glume opening, pollen load, pollen persistence, length of style, panicle exertion, flag leaf angle and length, and stigma exsertion features all influence out-crossing. Rice researchers consistently place a premium on stigma characteristics because they provide opportunity to boost outcrossing percentages (Kato and Namai, 1987).

Several factors influence hybrid seed production efficiency, including stigma exertion and flower opening angle, which are important for Cytoplasmic Male Sterile lines and account for higher seed set (Sheeba *et al.*, 2006). Stigma exsertion is a significant factor that assists to the enhancement of hybrid rice seed production and is directly linked to hybrid rice seed output. (Takano *et al.,* 2011). One of the hurdles to the current lack of economic success of hybrid rice seed production is low seed set, which is dependent on the general low out rate (Mao *et al.*, 1998). Despite the fact that several new CMS lines were developed natively, majority of them had limited outcross potential (Tallebois *et al.,* 2017).

PCA may be used to establish similarities across variables and categorize genotypes, while cluster analysis is associated with defining pre-existing unlabelled materials (Oyelola, 2004). A correlation matrix or a covariance matrix is often used to compute principal components. Scaling effects can modify the composition of the derived components when the variables are measured in different units. In such instances, variable standardization becomes desirable. This is accomplished by finding directions (both positive and negative), known as principal components, on which the variability in the data is greatest (Singh and Narayanan, 2013). Thus, the fundamental benefit of PCA arises from determining the importance of each dimension in expressing the variation of a data set.

Email: kasanaboinakrishna@gmail.com

MATERIALS AND METHODS

During *kharif* 2018, an investigation was performed at the Rice Research Centre, Agriculture Research Institute (ARI), Rajendranagar, Hyderabad, Telangana State, in a Randomized Block Design with three replications. All the 40 genotypes (Table 1) were seeded separately in the raised nursery beds. 30 days-old seedlings of each genotype were transplanted in two rows in a 4 m-long plot, with 20cm between rows and 15cm between plants. Plant height (cm), number of effective tillers plant^{-1}, panicle length (cm), number of grains panicle^{-1}, kernel length (mm), grain yield plant^{-1} (g) were measured on randomly selected five plants in each replication for each genotype and the angle of flowering opening and stigma exertion were recorded on randomly selected ten plants for each replication in each genotype. When rice florets were flowering, the angle of flower opening (°) was monitored between 9:00 AM and 12:00 noon. Ten blooming florets of a maintainer line were chosen from various plants, and the greatest flower opening angle of each floret was recorded using a protractor and displayed in degrees and the mean values of each genotype are subjected to categorize them into low, medium and high lines angle of glume opening using IRRI, SES-2013. Stigma exsertion (%) was measured as the ratio of length of stigma exerted outside of glumes and the total length of stigma using stereo zoom microscope and was expressed in per cent. Two lobes of stigma have been exerted outside the glumes in majority of the genotypes, the length of lobe which was exerted more was recorded on ten randomly selected plants, and the mean values of each genotype were subjected to categorize them into low, medium and high exertion lines using IRRI, SES-2013. Juliano's (1971) simplified technique was utilized to estimate amylose content. Cagampang *et al.* (1973) method for analyzing gel consistency was utilized. A total of five grams of unbroken milled kernels were taken to a test tube and 15 ml of water was added to it. The kernels were soaked for ten minutes then cooked for twenty minutes on a water bath at 100ºC. The cooked rice was put on blotting paper. Ten cooked grains (intact at both) were selected and the length of the kernel was measured in millimeter scale for computing the kernel length after cooking, principal component analysis was performed using windostat software ver 9.2.

$$\text{Stigma exertion (\%)} = \frac{\text{Length of stigma exerted outside of floret}}{\text{Total length of stigma}}$$

RESULTS AND DISCUSSION

Principal component analysis

The first five PCs explained 91.72 % of the diversity among 40 genotypes in yield component and quality attributes, according to PCA (Table 2).The first principal component (PC1) accounted for 53.7% of total variation, with kernel length, kernel length after cooking and number of grains per panicle contributing more favourably. The second primary component (PC2), which was predominantly contributed by kernel breadth, amylose content, grain yield plant^{-1}, and plant height, accounted for an additional 13.7 % of total variation. Finally, the third, fourth, and fifth principal components (PC3, PC4, and PC5) contributed approximately 12.5, 7.4, and 4.5% of the variability present among the accessions for the attributes studied in this study, respectively. PC3 described the patterns of variation in kernel breadth and gel consistency, while PC4 supplied variance through plant height, panicle length,numberof grains panicle^{-1}, and grain yield plant^{-1}. Finally, days to 50% flowering and kernel length after cooking, were major contributors to PC5 variability.

Angle of glume opening (°)

The presence of an appropriate number of alien pollen grains on the stigmatic surface of each seed parent's spikelet determines the efficiency of hybrid seed production. This is performed through a combination of environmental and plant-provided circumstances. Some of the floral traits in rice that provided out crossing conditions were the angle of floret opening, stigma size, style length, and stigma exertion rate. According to Oka (1988), out crossing in rice is dependent on the capacity of the stigma to absorb pollen, and this capacity was increased by modifying out crossing floral features.

The angle of glume opening ranged from 24.2º to 35.9º, with a mean of 28.5º. Six genotypes had a moderate/medium angle of glume opening, while the rest 34 have a low angle of glume opening (SES-2013). Sharbati (35.9º) had the greatest angle of floret opening, followed by RNR 26032 (33º), IR 10 F 388 (32.7º), OR 2573-11 (30.7º), IR – BLZ-F4 (30.7º), JMS 14B (30.1º), CMS 14B (29.8º), CMS 64B (29.5º), and RNR 26992 (29.4º). As a result of larger hybrid seed production, these lines may be superior as females in hybrid development. The larger the angle between the lemma and palea resulted the greater the exertion and surface of the stigma, and hence the higher the percentage of seed setting.

GNV 14-05, RNR 21280, CMS 23B, JMS 11B, GNV 14-25, and CMS 11B showed the lowest angle of glume opening, indicating that these lines may not be

Table 1: List of genotypes (maintainer lines) utilized for the research programme in rice.

S.No.	Genotype	Source
1	CMS 11B	IRRI, Philippines
2	CMS 14B	IRRI, Philippines
3	CMS 23B	IRRI, Philippines
4	CMS 46B	IRRI, Philippines
5	CMS 52B	IRRI, Philippines
6	CMS 59B	IRRI, Philippines
7	CMS 64B	IRRI, Philippines
8	JMS 11B	RARS, Jagtial
9	JMS 13B	RARS, Jagtial
10	JMS 14B	RARS, Jagtial
11	JMS 17B	RARS, Jagtial
12	JMS 18B	RARS, Jagtial
13	JMS 20B	RARS, Jagtial
14	JMS 21B	RARS, Jagtial
15	RNR 21280	RRC, ARI, Hyderabad
16	WGL 44	RARS, Warangal
17	TELLAHAMSA	RRC, ARI, Hyderabad
18	RP 5950-24-6-2-1-1-B	IIRR, Hyderabad
19	GNV 14-25	IIRR, Hyderabad
20	GNV 14-05	IIRR, Hyderabad
21	R 1919-537-1-160-1	IIRR, Hyderabad
22	RP 4993-183-9-2-1-1	IIRR, Hyderabad
23	SYE 160-7-19-7-23-16	IIRR, Hyderabad
24	MTU 1216	RARS, Maruteru
25	TP 30494	IRRI, Philippines
26	JGL 1798	RARS, Jagtial
27	HMT Sona	RRC, ARI, Hyderabad
28	IR 10 F 388	IIRR, Hyderabad
29	CT – 18615-1-S-1-2-4	IIRR, Hyderabad
30	TULASI	IIRR, Hyderabad
31	RNR 26119	RRC, ARI, Hyderabad
32	RNR 26032	RRC, ARI, Hyderabad
33	RNR 26061	RRC, ARI, Hyderabad
34	RNR 26075	RRC, ARI, Hyderabad
35	OR 2573-11	IIRR, Hyderabad
36	Sharbati	NRRI, Cuttack
37	IR – BLZ-F4	IIRR, Hyderabad
38	RNR 26992	RRC, ARI, Hyderabad
Checks		
39	RNR 15048	RRC, ARI, Hyderabad
40	MTU1010	RARS, Maruteru

suitable for use as females due to low hybrid seed production yields.

Stigma exertion (%)

Stigma exsertion (SE) is a crucial floral characteristic for increasing hybrid seed output. Breeding for completely exerted stigmas is one of the key techniques to solve the problem of low seed yield in hybrid seed production.The stigma exertion feature in hybrid rice maintainer lines is investigated in this work. Stigma exertion ranged from 37.8 to 53.6 per cent, with a mean of 44.4 per cent. In the phenotypic examination of the stigma effort trait, 38 genotypes were classified as moderate/medium exertion and 2 genotypes were classified as low exertion. (SES-2013).CMS 14B had the highest stigma exertion of 53.63 per cent, followed

Table 2: Principal component analysis of yield component and quality traits in rice

	PC1	PC2	PC3	PC4	PC5
Eigen value	21.2	5.4	4.9	2.9	1.7
Variability %	53.7	13.7	12.5	7.4	4.5
Cumulative %	53.7	67.4	79.9	87.2	91.7
Traits			**Eigen vectors**		
DFF	0.15	0.17	0.01	0.31	0.77
NET	-0.08	-0.10	0.14	-0.03	-0.02
PH	-0.21	0.18	0.22	0.58	-0.22
PL	-0.10	0.02	-0.09	0.35	0.13
NGP	0.23	0.06	-0.04	0.33	0.28
TW	-0.33	0.31	0.19	-0.17	0.15
GYP	-0.01	0.27	0.12	0.21	-0.25
HRR	0.11	0.10	-0.01	-0.01	-0.12
KL	0.70	0.02	-0.14	0.10	0.15
KB	-0.15	0.63	0.45	-0.16	-0.01
AC	0.12	0.32	-0.48	-0.16	-0.00
GC	-0.26	-0.46	0.45	0.15	0.13
KLAC	0.35	-0.10	-0.46	-0.33	0.21

DFF: Days to 50% flowering, **NET:** Number of effective tillers plant^{-1}, **PH:** Plant height (cm), **PL:** Panicle length (cm), **NGP:** Number of grains panicle^{-1}, **TW:** 1000-grain weight, **HRR:** Head rice recovery percentage, **KL:** Kernel length (mm), **KB:** Kernel breadth (mm), **AC:** Amylose content, **GC:** Gel consistency**, KLAC:** kernel length after cooking, **GYP:** Grain yield plant^{-1} (g).

Table 3: Angle of glume opening scale given by IRRI (SES, 2013)

Scale	Angle of glume opening (%)	Classification
1	Above 50	High
3	40-49	Medium/Moderate
5	30-39	
7	20-29	Low
9	Below 20	

Table 4: **Stigma exertion rate scale given by IRRI (SES, 2013)**

Scale	Stigma exertion rate (%)	Classification
1	Above 70	High
3	40-69	Medium/Moderate
5	21-39	Low
7	11-20	
9	0-10	

by RNR 26119 (50.6 %), IR – BLZ-F4 (49.9), Sharbati (49.6%), CMS 59B (48.6%), RNR 26032 (48.3 %), and TP 30494 (48.0%).

The proportion of stigma exertion was higher in genotypes with a higher angle of flower opening. This trait had a positive and significant association with grain yield plant^{-1} at both the phenotypic and genotypic levels. Choosing genotypes with a moderate angle of flower opening and a high proportion of stigma exsertion will result in improved out crossing and higher yields.

CONCLUSION

PCA identified grain yield plant^{-1}, days to 50% flowering, number of grains per panicle, kernel length, kernel length after cooking, and plant height as key principal components in identifying the variation present in germplasm accessions. As a result, the current study's findings revealed a significant amount of genetic variety in the population, which has enormous implications for rice breeding programmes. Angle of glume opening based on SES-2013 scoring revealed that 6 genotypes fell into the moderate/medium range of glume opening and 34 genotypes fell into the low range of glume opening. In terms of stigma exertion, 38 genotypes were classified as moderate/medium and 2 genotypes as low. Choosing genotypes with a moderate angle of flower opening and a high proportion of stigma exertion will result in improved outcrossing and higher yields.

REFERENCES

Cagampang, G.B., Pere, Z.C.M. and Juliano, B.O. 1973. A gel consistency test for eating quality of rice. *J. Sci. Food and Agric.* **24**:1589- 1594.

IRRI 2013.Standard evaluation system for rice, International Rice Research Institute, Philippines.

Jones, J. W. 1926. Hybrid vigour in rice.*J. American Soc. Agron.* **18**(3):424-428.

Juliano, B.O. 1971. A simplified assay for milled rice amylose.*Cereal Science Today.***16**: 334-339.

Kato, H. and Namai, H. 1987. Floral characteristics and environmental factors for increasing natural outcrossing rate for F1 hybrid seed production of rice (*Oryza sativa* L). *Jpn. J. Breed*.**37**:318-330.

Mao, C.X., Vimani, S.S. and Kumar, I. 1998. Technological innovations to lower the costs of hybrid rice seed production. Proceeding of the International Symposium on Hybrid Rice, Hyderabad, India, Manila (Philippines) International Rice Research Institute pp: 443.

Oka, H.I. 1988. *Origin of cultivated rice*. Japan Scientific Societies Press, *Elsevier,*Amsterdam, p. 254

Oyelola, B.A. 2004. The Nigerian Statistical Association preconference workshop; Sep 20-21; University of Ibadan.

Ramaiah, K. 1933. Inheritance of flowering duration in rice. *Indian J. Agric. Sci.*,**3** (3):377-410.

Sheeba, A., Vivekanandan, P. and Ibrahim, S.M. 2006. Genetic variability for floral traits influencing out crossing in the CMS lines of rice. *Indian J. Agric. Res*., **40** (4): 272 -276.

Singh, P. and Narayanan, S.S. 2013. Principal component analysis. In. Biometrical Techniques in Plant Breeding (6th revised edition), *Kalyani Publishers*. India, pp. 80

Takano-Kai, N., Doi, K. and Yoshimura, A. 2011. GS3 participates in stigma exertion as well as seed length in rice. *Breeding Sci.,* **61**: 244-250.

Tallebois, J., Dosmann, J., Cronemberger, H., Paredes, H., Cao, T.V., Neves, P. and Ahmadi, N., 2017. Breeding for outcrossing ability in rice, to enhance seed production for hybrid rice cropping.

Virmani, S.S. 1994. Heterosis and hybrid rice breeding. Monograph *Theor.Appl. Gent*. 22. *Springer-Verlag.*

Yuan, L. P. 2005. Development of hybrid rice to ensure food security. *Rice science*, **21**(1):1.

Yuan, L.P. 1997. Exploiting crop heterosis by two-line system hybrids: current status and future prospects. In: Proceedings of the International Symposium on Two-Line System of Heterosis Breeding in Crops, September 1997, Changsha, China.