

Evaluation of Elite WA CMS Lines of Rice: Characterization and Variability Analysis with Special Reference to Floral Traits

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Abstract: A study was conducted utilizing 20 elite WA (Wild Abortive) Cytoplasmic Male Sterile lines in Kharif season of 2014. Genotypes were planted in RCBD (Randomized Complete Block Design) in three replications with IR58025A as check. Information related to 11 vital traits were recorded and Analysis of Variance was performed suggesting significant variance among the genotypes. Correlation coefficient analysis was performed and significant correlations were observed among vital traits especially with Outcrossing % of the genotypes studied. A dendrogram was constructed following a Cluster analysis using UPGMA and the phylogenetic characterization was done among the genotypes. Based on the cluster analysis the population could be classified under three groups at 70% similarity coefficient.

Keywords: Correlation, Dendrogram, Outcrossing%, Variability, Wild Abortive CMS

I. Introduction

Rice is the most important cereal crop for Asian countries. Worldwide, more than 3.5 billion people depend on rice and it supplies more than 20 % of their daily calorie intake. The present world population of 6.3 billion which may reach 8.5 billion by 2030 with an approximate rice consumers of 5 billion people thereby, increasing the demand of rice upto 38% by 2030. To meet this challenge there is a need to develop rice varieties with higher yield potential and greater yield stability (Khush, 2005). Among the various options, exploitation of hybrid vigor is the most important genetic tool to augment the crop productivity and it has been already proven as an effective solution in increasing crop productivity (Virmani 2006). WA (Wild Abortive) Cytoplasmic Male sterile line based hybrid rice development is presently the most effective process of exploitation of heterosis in rice. But rice being a strictly autogamous plant, development of new and effective WA CMS lines and its utilization in hybridization program can be quite challenging. Presently IR58025A is the most extensively utilized WA CMS line in the tropics. But dependence on IR58025A solely has brought the increase in yield potential in hybrid rice to a standstill and in order to remove the bottle neck situation especially in the tropics, development of new breeding programs utilizing a diverse range of WA CMS lines is highly important. Thus the present study deals with characterization of some new WA CMS lines with respect to IR58025A along with estimation of the diversity among them.

II. Material & Method

20 WA CMS lines consisting of IR58025A as the check was grown in the wet season of 2014 at Rice Research Station, Chinsurah, West Bengal, India. The experiment was conducted using Randomized Complete Block Design (RCBD) using three replications. 11 important traits like Days to 50% flowering, Plant Height, effective tillers per plant, panicle length, panicle exertion %, number of spikelets per panicle, pollen sterility%, spikelet fertility % , Outcrossing % , stigma exertion %, test weight were recorded. In case of pollen sterility %, 1% iodine potassium iodide solution was used for staining of pollens collected from 15 to 20 spikelets of newly emerged panicles of each variety under investigation (Virmani et al 1997). Analysis of variance (ANOVA) was conducted and variance within the population was determined; along with important parameters like genotypic coefficient of variability (GCV), Phenotypic coefficient of variability (PCV), Heritability %, Genetic Advance (GA)% were calculated. Correlation coefficient analysis in order to determine the genotypic and phenotypic correlation among the 11 traits was also conducted. A cluster analysis was done to determine the phylogenetic classification among the varieties under investigation using UPGMA and a dendrogram was constructed. The software Darwin 6.0 was used for the purpose.

III. Result & Discussion

The study evinced that in terms of Days to 50% flowering a diverse range of 70 to 100 days was observed among the varieties. The genotypes were mostly dwarf to semi dwarf in nature with an average height of 70 cm. Panicle exertion, a vital floral trait specially in case of WA CMS lines which exhibits partial exertion of panicles was found to be highest in IR58025A, having 81.78% exertion of panicles. But the variety COMS15A also showed a very promising panicle exertion of 79.82%. Pollen sterility % was found to be in a range of 94.2% to 99.84% with an average pollen sterility% of 98.03%. Appearance of few fertile pollen grains in a CMS line is quite possible since the trait is highly affected by environment. Similar scenario was observed earlier by Pardhe et al. (2011). Similar results of very high pollen sterility were also observed earlier by Pradhan & Jachuck (1993) and Kumar et al (1996). Stigma exertion % which is another vital floral trait was highest for PMS10A (50.25%) followed by DRR6A (48.77%). Thus these two varieties outperformed the check IR58025A having a stigma exertion of 42.77%. Outcrossing% which is the most vital trait for consideration was found to be highest in IR62829A (23.31%). Other varieties that also exhibited an outcrossing ability superior to that of the check IR58025A (18.31%) includes IR 68897 A (20.34%), IR75601A (20.1%), and PMS10A (19.24%), thus suggesting that these varieties may play a pivotal role in future hybrid rice breeding program especially under tropical conditions.

Analysis of variance shows a significant variation among the 20 genotypes at 0.01% level of significance. As per Sivashubramanian & Madhavamenon (1973), Johnson et al (1955a) moderate to high estimates of PCV (Phenotypic coefficient of variability) and GCV (Genotypic coefficient of variability) was observed in almost all the traits studied except for Panicle exertion%, Pollen sterility % and Test weight. A higher estimate of PCV than that of GCV was observed for almost all the traits suggesting that environment had some impact upon the traits under investigation. High heritability along with high estimates of genetic advance were observed in plant height and spikelets per panicle suggesting an additive gene interaction for these traits Johnson et al (1955a). Similarly in case of Days to 50% flowering, Panicle exertion%, outcrossing % and stigma exertion % , a high heritability combined with moderate estimates of Genetic advance (GA) was observed suggesting both additive and non additive gene interaction for these characters.

Correlation analysis (Table no: 4) showed that a positive correlation at 1% level of significance was present between Outcrossing% and panicle exertion% [where $R=0.695$ (genotypic), 0.714 (phenotypic)] and between Outcrossing% and stigma exertion% [where, $R=0.721$ (genotypic), 0.77 (phenotypic)]. Moreover, a positive correlation at a 5% level of significance was recorded between Outcrossing % and panicle length [where, $R=0.626$ (genotypic), 0.642 (phenotypic)] and spikelets per panicle at [$R=0.613$ (genotypic), 0.645 (phenotypic)]. A strong positive correlation at 5% level of significance was also observed between stigma exertion% and panicle exertion% at [$R=0.649$ (genotypic), 0.663 (phenotypic)]. Similarly pollen sterility% showed a significant positive correlation with spikelet fertility% [$R=0.712$ (genotypic) 0.756 (phenotypic)]. Outcrossing % is the most important trait under consideration when it comes to WA CMS lines in a hybrid rice breeding program and its interaction with stigma exertion rate was clearly evident. Similar results were also observed in the works of Tian et al (1990) and Dai et al (1999) Li (1995) Yang (1997) and Kato and Namai (1978a) So the correlation between outcrossing % and the two vital characters i.e. stigma exertion% and panicle exertion% are further elaborated in Fig.1 and Fig.2 which clearly indicates a similarity in the pattern with respect to the two traits having a strong correlation with outcrossing %, thus suggesting that selection in terms of outcrossing % coupled with these traits can be very useful while identifying WA CMS lines for future breeding program.

The dendrogram constructed from the cluster analysis suggests that the 20 varieties can be classified among three clusters with 1 variety remaining as an outlier (Table no.5). The varieties belonging to each cluster has a 70% similarity coefficient among them. Since the most important character under consideration is Outcrossing %, the genotypes belonging to Cluster 2 as shown in the Table: 6 has the highest average Outcrossing% of 19.44%. Among the genotypes belonging to this cluster, IR62829A had the highest Outcrossing rate of 23.31% followed by IR68897A having an Outcrossing% of 20.34%. Stigma exertion % having a direct impact upon the Outcrossing% is almost same in both cluster 2 and cluster 3 having an average stigma exertion % of 44.79% and 44.68% respectively. Pollen sterility % was also highest in case of Cluster 2 having an average pollen sterility % of 99.18%. Almost all the genotypes in cluster 2 performed at par with the popular check IR58025A variety in terms of pollen sterility %. While IR58025A had a pollen sterility of 99.84%, other candidates belonging to cluster 2 especially DRR6A and DRR5A performed at a same level with the check having a pollen sterility% of 99.12% and 99.59% respectively. Genotypes belonging to Cluster 2 also had slight advantage over the others in terms of other important characters like Days to 50% flowering, Panicle exertion rate and number of effective tillers having values of 79.25 days, 74.45% and 14.87 respectively. In case of cluster 3 the genotypes had a higher average value for number of spikelets per panicle of 147.22, which is higher than the candidates belonging to other two clusters.

IV. Conclusion

The experiment provided essential information regarding a diverse range of genotypes that can be utilized under tropical conditions for future hybrid rice breeding programs. Valuable information was obtained regarding the outcrossing potential of the elite genotypes studied in the experiment and best performing WA CMS lines under tropical climatic condition were identified which can be very helpful as an alternate for IR58025A and in turn help in enhancement of heterosis among newly developed hybrid combinations. Vital traits having a direct or indirect influence upon the outcrossing potential of the CMS lines were studied in details providing quintessential information for parental selection in future hybrid rice breeding programs.

Table 1: Mean values of 20 elite WA CMS lines

Genotypes	Days to 50% flowering	Plant height	Panicle length	Panicle exertion %	Number of effective tillers per plant	Pollen sterility %	Spikelets/p anicle	Spikelet fertility %	Outcrossing %	Stigma exertion rate	1000 seed weight
IR58025A	83.21	86.72	18	81.78	17.33	99.84	126.67	0.14	18.31	42.77	16.35
IR 68897 A	70.32	103.85	20.57	74.03	14.33	98.59	130.33	1.78	20.34	44.4	17.27
PMS 10 A	85.1	63.37	23.87	70.45	8	98.17	122.67	1.52	19.24	50.25	16.44
DRR 4A	80.21	61.89	22.58	68.47	10	98.67	171.67	1.47	17.38	41.16	17.77
DRR 5A	80.5	79.46	17.67	68.4	12.67	99.49	121.67	0.95	15.26	43.4	16.22
DRR 6A	78.69	88.47	20.32	78	12.67	99.12	135	0.12	17.31	48.77	15.13
COMS 15A	90.23	94.88	20.8	79.82	7.67	97.55	147.33	2.97	18.53	42.63	17.27
APMS 6A	84.38	88.82	15.7	63.35	9.67	96.7	117.33	0.33	15.38	33.26	15.3
PUSA 6A	79.58	83.67	15.46	57	14.67	97.78	124.67	1.89	10.93	16.93	14
IR62829A	77.24	81.73	23.01	73.05	15	98.8	123.67	0.43	23.31	45.4	15.23
PMS 17A	90	60.3	18.2	78.3	12	97	117	1.5	16.2	38	15
COMS 14A	85	52	17	70	11	98.1	120	0.8	15	34	14
PUSA3A	82	54.8	18.8	60	9	99.25	125	0.5	18.4	40.3	15.2
IR73318A	91	61.2	21	62	9	94.2	130	2	10.4	30.2	16
IR73323A	95	50	17.6	61	11	98.25	115	0.1	16.2	31.4	14
IR73328A	93	60	15.4	58	10	98.2	121	0.2	18.2	33.5	15
IR75601A	82	58	20.3	55	12	99.25	123	0.13	20.1	36.4	13.8
IR75608A	100	56	21	67.6	10	96.55	133	0.4	17	40	14
IR68888A	85	58.2	22	75	15	99.2	140	0.06	20	48	15.7
IR75594A	96	58	21.1	63.2	6	96	119	0.29	14	30	14.4
Mean	85.42	70.06	19.51	68.22	11.35	98.03	128.20	0.87	17.07	38.53	15.40
Minimum	70.32	50	15.4	55	6	94.2	115	0.06	10.4	16.93	13.8
Maximum	100	103.85	23.87	81.78	17.33	99.84	171.67	2.97	23.31	50.25	17.77
CD	3.35	5.44	3.24	7.62	4.91	1.8	5	3.22	5.12	5.66	1.5

Table 2: Analysis Of Variance (ANOVA)

SOV	Df	Days to 50% flowering	Plant height	Panicle length	Panicle exertion rate	Number of effective tiller per plant	Pollen sterility percentage	Spikelets per panicle	Spikelet fertility %	Outcrossing %	Stigma exertion rate	1000 seed weight
Variety	19	205.99**	499.48**	26.66**	174.19**	31.57**	2.69**	793.63**	2.59**	134.48**	277.44**	4.15**
Block	2	254.90	54.67	44.54	297.03	1.2	0.47	598.8	22.46	4.76	46.92	5.13
Error	38	15.23	11.34	4.03	21.22	9.23	1.25	9.57	6.33	10.06	9.70	12.10

*significant at 5% probability level, **significant at 1% probability level,

Table 3 GCV, PCV, Heritability and Genetic Advance

Characters	GCV	PCV	H%	GA	σ_2g	σ_2p
Days to 50% flowering	39.49	43.80	90	11.67	6.60	6.95
Plant height	15.32	15.84	93	24.56	162.71	174.06
Panicle length	13.87	17.18	65	3.68	7.54	11.57
Panicle exertion rate	9.96	11.95	69	10.19	50.66	72.88
Number of effective tiller per plant	22.36	33.48	44	2.50	7.44	16.68
Pollen sterility percentage	0.70	1.34	67	0.39	0.48	1.73
Spikelets per panicle	12.24	12.46	96	32.13	261.35	270.93
Spikelet fertility %	74.81	89.85	69	1.24	0.75	1.09
Outcrossing %	24.14	26.91	80	10.67	41.47	51.54
Stigma exertion rate	22.92	24.47	87	16.93	87.84	100.14
1000 seed wt	7.22	7.50	92	2.21	1.35	1.46

Table 4. The phenotypic and genotypic coefficient among the traits

		Days to 50% flowering	Plant height	Panicle length	Panicle exertion rate	effective tillers per plant	Pollen sterility %	Spikelets/p anicle	Spikelet fertility %	Outcrossing %	Stigma exertion rate%	1000 seed weight
Days to 50% flowering	G	1										
	P	1										
Plant height	G	-0.344	1									
	P	-0.389	1									
Panicle length	G	-0.075	-0.041	1								
	P	-0.083	-0.055	1								
Panicle exertion rate	G	-0.203	0.321	0.337	1							
	P	-0.312	0.353	0.385	1							
Number of effective tillers per plant	G	-0.512	0.382	0.141	0.294	1						
	P	-0.565	0.411	0.162	0.342	1						
Pollen sterility %	G	-0.201	0.175	-0.042	0.321	0.523	1					
	P	-0.213	0.185	-0.019	0.251	0.581	1					
Spikelets/panicle	G	-0.182	0.137	0.592	0.286	0.114	0.125	1				
	P	-0.176	0.155	0.611*	0.301	0.131	0.131	1				
Spikelet fertility %	G	-0.089	0.321	0.149	0.183	0.176	-0.712**	0.403	1			
	P	-0.126	0.354	0.162	0.211	0.201	-0.756**	0.436	1			
Outcrossing %	G	-0.335	0.158	0.626*	0.695**	0.284	0.395	0.613*	-0.254	1		
	P	-0.383	0.178	0.642*	0.714**	0.319	0.441	0.645*	-0.3	1		
Stigma exertion rate%	G	-0.411	0.206	0.609*	0.649*	0.138	0.398	0.564	-0.102	0.721**	1	
	P	-0.455	0.189	0.621*	0.663*	0.162	0.452	0.610*	-0.155	0.777**	1	
1000 seed weight	G	-0.142	0.511	0.393	0.522	0.055	0.118	-0.425	0.328	0.261	0.311	1
	P	-0.146	0.494	0.414	0.498	0.072	0.152	-0.44	0.351	0.287	0.301	1

*significant at 5% probability level, **significant at 1% probability level, P=Phenotypic correlation coefficient, G= Genotypic correlation coefficient

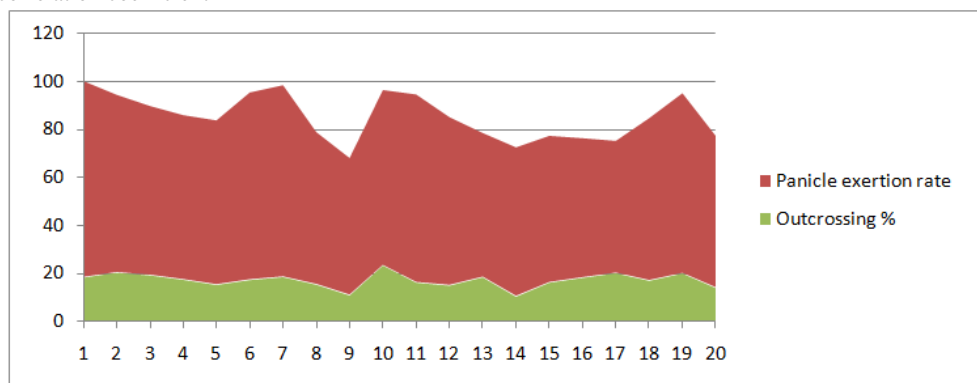


Fig.1. Graph showing a positive correlation between outcrossing% and panicle exertion rate

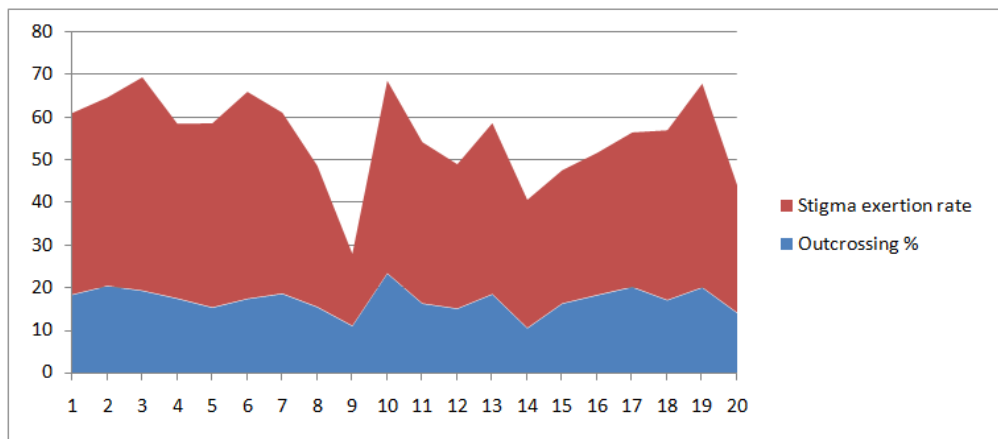


Fig.2. Graph showing a positive correlation between outcrossing% and stigma exertion %

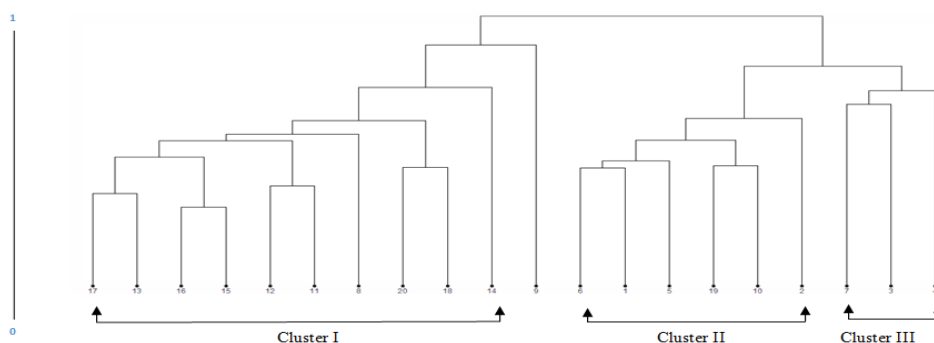


Fig: 3 Dendrogram showing the distribution of 20 genotypes in clusters

Table no: 5 Distribution of 20 genotypes in 4 clusters and 1 outliers

Cluster	Name of the Genotypes
1	(17) IR75601A, (13) PUSA 3A, (16) IR73328A, (15)IR 73323A, (12)COMS 14A, (11)PMS17A, (8)APMS 6A, (20)IR75594A, (18) IR75608A(14)IR 73318A
2	(6)DRR 6A, (1) IR58025A, (5) DRR5A, (19) IR 68888A, (10) IR 62829A, (2) IR 68897A
3	(7)COMS 15A, (3) PMS 10A, (4) DRR 4A
Outliers	
1	(9) PUSA 6A

Table: 6 Mean values of the genotypes of each cluster of 8 traits

Traits	No. of clusters	Cluster 1	Cluster 2	Cluster 3	Outliers
Days to 50% flowering		88.71	79.25	85.18	79.58
Plant height		60.35	81.99	73.38	83.67
Panicle length		18.34	20.25	22.41	15.46
Panicle exertion rate		63.43	74.45	72.91	57.00
Number of effective tillers per plant		9.96	14.87	8.56	14.67
Pollen sterility %		97.44	99.18	98.13	97.78
Spikelets/panicle		120.81	128.47	147.22	124.67
Spikelet fertility %		0.65	0.67	1.99	1.89
Outcrossing %		15.99	19.44	18.38	10.93
Stigma exertion rate		34.12	44.79	44.68	16.93
1000 grain weight		14.74	16.15	17.16	14.00

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