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Phenotypic stability and its inheritance for yield and yield components in hybrid rice

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Abstract
The present investigation was conducted to evaluate 68 hybrid rice materials, their parents involving four cytoplasmic male sterile lines and 17 restorer lines along with four checks for their phenotypic stability and its inheritance across two different agro-climatic zones of Andhra Pradesh, South India. Substantial portion of genotypes and environment interactions was due to the linear component for panicle weight, flag leaf length, flag leaf width, productive tillers per plant, filled grains per panicle, 1000 grain-weight and grain yield per plant indicated that significant variability among the experimentation could be predicated. Based on the positive values of environmental indices, Jagtial rabi season was found to be most favourable location for seed yield per plant. In the present study three CMS lines IR-79156A, DRR-14A and IR-68897A and testers R-43, R-465, R-47, R-49, R-56, IR-64, IR-66, DRR-714-1-2-R and IR-10198 were identified as stable parents -over four environments for yield and its important components can be used for developing stable hybrids. Considering the yield and its component traits, high yielding hybrids viz., DRR-14A x R-43, IR-80555A x R-54, IR-68897A x R-43, IR-68897A x R-48, IR-68897A x R-56 were stable and appear to be promising in both *kharif* and *rabi* season of Telangana region, recommended for multilocation trials. The pattern of inheritance of stability is different for different characters and also for different genotypes for the same character. Outcome of this study is stable hybrids that involved stable parents but stable parents need not necessarily generate stable hybrids.

Keywords: inheritance, components, hybrid rice, Phenotypic

Introduction
Rice is the staple crop and important cereal crop of India, being a thermo and photosensitive in nature, due to its buffering capacity it is being cultivated round the year in different agro-climatic zones of the country. However, the hybrids and breeding materials are likely to interact differently with different environments. The presently cultivated varieties and hybrids though having high seed yield potential, they are erratic in their performance even under less varied conditions of cultivation. Lack of hybrids suitable to specific locations and seasons accounts for the decline in the area and productivity in rice, apart from the biotic and abiotic stresses. This warrants the attention of the plant breeders to evolve superior hybrids that would sustain well in the strainful situation. Therefore, assessment of its adaptability is of important concern. Productivity of a population is the function of its adaptation, whereas stability is the statistical measure of genotype x environment interaction (Kandil *et al.*, 1990) [17].
However, little information is available on the stability of rice hybrids. Young and Virmani (1990) [37] also observed varying magnitude of heterosis over environments and stressed the need to evaluate hybrids across environments to identify stable hybrids with high yield that shows least interaction with environment. In Andhra Pradesh rice is a predominant crop grown under varied climatic conditions with staggered sowings during kharif and rabi seasons. This stresses the need for identification of stable hybrids, which show least genotype x environmental interaction so that these hybrids can be commercialized under different climatic conditions. The objective of the present study was: (1). Determine the most stable lines and hybrids (2). Study the Inheritance pattern of the stability.

Materials and Methods
The sum of 68 F_1 hybrids along with 21 parents (4 CMS B lines, 17 restorers) and four checks (two hybrids *viz.*, DRRH-2 and PSD-3 and two varieties *viz.*, MTU-1010 and JGL-1798) were transplanted in randomized block design in two replications with a spacing of 20 x15 cm during *kharif*, 2013 and 15x15 cm during *rabi*, 2013-14 at Regional Agricultural Research station, Jagtial for Northern Telangana Agro climatic zone and Agricultural Research Station, Kampasagar Southern Telangana Agro climatic zone. All necessary recommended packages of practices of ANGRAU were followed to raise a healthy crop and each entry was planted in two rows of 1.8 m length. At flowering and maturity stages, observations recorded on twelve

characters. Data obtained from the four environments were subjected to pooled analysis of variance as per Panse and Sukhatme (1985) [23]. Following the methodology of Eberhart and Russell's model (1966) [9], three parameters namely; (i) overall mean of each genotype over a range of environments, (ii) the regression of each genotype on the environmental index and (iii) a function of the squared deviation from the regression were estimated. Eberhart and Russell (1966) [9] used to study the stability of genotypes under different environments.

Results and Discussions

In the present investigation, 93 genotypes including 68 hybrids, 21 parents and four checks were subjected to pooled analysis of variance for twelve characters (table 1). The analysis of variance of stability revealed that the genotypes and environments were significant for all the traits studied except for flag leaf length, productive tillers per plant, filled grains per panicle and productivity per day for genotype, indicating the diversity among the genotypes and environments studied. The genotypes and environment interactions were significant for traits like panicle weight, flag leaf length, flag leaf width, productive tillers per plant, filled grains per panicle, 1000 grain- weight and grain yield per plant. Significance of genotype x environment interactions implies differential behavior of genotypes under the four environments as also revealed by Shanmuganathan and Ibrahim (2005) [29], Deshpande and Dalvi (2006) [5] and Sridhar *et al*, (2011) [31]. The stability analysis not carried out for the remaining six traits, since, GE interactions were found to be non-significant.

Partitioning the sum of squares into varieties, environments + (Genotype x Environment) and pooled error revealed that mean squares due to environments + (Genotypes x Environment) were significant for all the eleven characters, reemphasizing the existence of GE interactions for these traits. These findings are in conformity with Young and Virmani (1990) [37] and Deshpande *et al*, (2003) [6]. Sum of squares due to E x (GxE) was further partitioned into that of environment (linear), genotype x environment (linear) and pooled deviation. Significant variation due to environment (linear) was observed for all the characters except flag leaf length and filled grains per panicle, revealing the linear contribution of environmental effects and additive environment variance on these characters. Similar results were reported earlier by Deshpande *et al.,* (2003) [7], Vidhu Francis *et al., (*2005) [33] and Ramya and Senthil Kumar (2008) [25] for majority of the traits. The linear component of GE interaction was significant for all the characters except for days to 50 per cent flowering and plant height, suggesting that the genotypes differ for their linear response to environments as also revealed by Lohithaswa *et al.,* (1999) [20], Shadakshari *et* Kumar *al.,* (2001), Narayana Swamy and Dushyantha (2003), and Ramya and Senthil Kumar (2008) [25] for majority of characters. However, Ramya and Senthil Kumar (2008) [25] reported contradictory results for days to 50 per cent flowering and plant height. The mean sum of squares for pooled deviation was significant for all the characters except for flag leaf length indicating the non-linear response and unpredictable nature of genotypes by significantly differing the stability. Significant non-linear responses were also observed earlier by Hegde and Vidyachandra (1998) [15], Lohithaswa *et al.,* (1999) [20], Deshpande *et al.,* (2002) [7], while both significant and non-significant linear responses were reported by Young and Virmani (1990) [37], Deshpande *et al.,* (2003) [6], Lavanya *et al.,*(2005), Babu *et al.,* (2005) [1] and Ramya and Senthil Kumar (2008) [25].

Environmental index reveals the favorability of an environment at a particular location. Breeze (1969) [4] pointed out that the estimates of environmental index can provide the basis for identifying the favourable environments for the expression of maximum potential of the genotype. Based on the positive values of environmental indices (table 3), Jagtial (*Kharif*) was found to be the most favourable location for filled grains per panicle, 1000 grain weight and panicle weight and Kampasagar (*Kharif*) was most favourable for flag leaf length, flag leaf width and productive tillers per plant. Jagtial rabi season was found to be most feavourable location for seed yield per plant. The results are in broad agreement with the results reported by Lohithaswa *et al.,* (1999) [20], Narasimha Reddy (2005) [22] and Saidaiah *et al.,* (2011) [27]. Since certain genotypes are searching for favourable environments to express their fullest potential of yield and yield attributes, hence an appropriate genotype has to be bred for each season.

Table 1: ANOVA for yield and yield components for stability in rice

Source	df	Days to 50% flowering	Plant height (cm)	Panicle length (cm)	Panicle weight (g)	Flag Leaf length (cm)	Flag Leaf width (cm)	Productive tillers per Plant	Spikelet Fertility (%)	Filled grains per Panicle	Grain yield per Plant (g)	1000 Grain weight (g)	Productivity per Day (kg/ha)
Genotypes	92	57.51**	112.42**	7.70**	0.38**	12.07	0.06**	1.28	160.92**	85.79	18.20**	1.06**	113.35
Envi + (GenX Envi)	279	27.28**	275.78**	9.82**	0.76**	21.74**	0.03**	3.05**	57.28	532.63**	21.46**	10.35**	107.66
Environments	3	549.94**	21574.23**	637.17**	47.69**	27.36**	0.05**	3.76**	641.34**	1035.53**	806.60**	0.63**	1860.37**
Genotype X Environment	276	21.60	44.28	3.00	0.25**	1392.50**	2.63**	135.12**	50.93	58236.89**	12.93*	5.47**	88.61
Environments (linear)	1	1649.82**	64722.68**	1911.50**	143.08**	12.53	0.02**	2.33*	1924.02**	413.78	2419.79**	0.58**	5581.10**
Geno X Envi (linear)	92	25.51	50.88	3.66*	0.38**	4177.51**	7.90**	405.37**	51.43	174710.69**	15.77*	16.42**	89.84
Pooled Deviation	186	19.43**	40.53**	2.65**	0.18**	13.22	0.03**	3.55**	50.14**	560.99**	11.38**	1.32**	87.04**
Pooled Error	368	2.85	1.59	1.23	0.02**	12.05**	0.01**	1.71**	3.17	336.51**	1.25	0.21**	11.75

Table 2: Environmental indices for yield and yield components in rice over seasons and locations

Characters		Seasons and locations			
		Kharif		Rabi	
		Jagtial	Kampasagar	Jagtial	Kampasagar
Panicle weight (gm)	Ij	0.814	0.389	-0.573	-0.630
Flag leaf length (cm)	Ij	2.166	2.510	-5.729	1.052
Flag leaf width (cm)	Ij	0.134	0.149	-0.190	-0.093
Productive tillers per plant	Ij	0.640	1.333	-0.651	-1.322
Un productive tillers per plant	Ij	-1.514	-1.423	0.535	2.402
Filled grains per panicle	Ij	30.816	9.830	-18.54	-22.104
1000 Grain weight (g)	Ij	0.236	0.182	-0.217	-0.201
Yield/ Plant (gm)	Ij	2.214	-6.425	3.681	0.530

Table 3: Percent of stability of parents, hybrids in checks

Characters	No. of parents	Parents (%)	Crosses	Crosses (%)
Panicle weight (gm)	8	38.10	19	27.94
Flag leaf length (cm)	9	42.86	41	60.29
Flag leaf width (cm)	16	76.19	59	86.76
Productive tillers per plant	13	61.90	46	67.65
Filled grains per panicle	5	23.81	24	35.29
1000 Grain weight (g)	10	47.62	48	70.59
Yield/ Plant (gm)	9	42.86	33	48.53

Stability performance of rice hybrids

Both linear regression (bi) and deviation from regression (S^2di) components of genotype x environment interaction should be considered along with mean in judging the phenotypic stability of a genotype (Eberhart and Russel, 1966). Linear regression (bi) is a measure of response or sensitivity to environmental changes of a variety while deviation from regression measures the stability of genotypes with the lowest standard deviation near to zero being the most stable and vice versa. Genotype with high mean performance, regression coefficient (bi) approaching one and low deviation (S^2di) was considered to be an average stable genotype which would be expected to perform uniformly well over variable environments, whereas bi being less than unity indicates a genotype to be above average stable response and which will be specially adapted to low yielding or unfavourable environments and if bi value more than unity indicates a genotype with below average stable response, such a genotype would perform better in high yielding or favourable environments, however its performance will be lower in stress environments compared to its genetic potentiality. Taking these parameters into consideration, the results obtained are discussed character wise (table 5).

Panicle weight is positively associated with grain yield and is known to contribute grain yield via more number of filled grains per panicle. The results indicated that the GE interaction was mainly due to both linear and non-linear components. Similar result was reported by Saidaiah *et al.*, (2011) [27] and significance of non-linear component was reported by Hedge and Vidyachandra (1998) [15] and Narasimha Reddy (2005) [22].

Among the parents, the lines IR-68897A (2.83g) and IR 79156A (2.74g) and the testers R-47 (3.08g), IR-66 (2.94g), R-54 (2.85g), R-44 (2.76g), R-51 (2.47g) and DRR-714-1-2-R (2.70g) are widely adaptable with average stability. The hybrids IR-79156A x R-52 (3.28g), IR-68897A x IR-64 (3.11g), IR-79156A x R-48 (3.12g), IR-80555A x IR-10198 (3.03g) and IR-79156A x IR-13419 (3.03g) were recorded more than 3.0g of panicle weight and possessed the average stability and are widely adaptable. Four hybrids, IR-80555A x R-52 (2.57g), IR-79156A x R-51 (3.65g), IR-68897A x R-56 (3.36g) and IR-79156A x IR-64 (3.24g) are adoptable to favourable environments and one hybrid DRR-14A x R-42 possessed less than average stability and specially adapted to unfavourable environment.

For flag leaf length both linear and non- linear components of GE interaction were found significant (Saidaiah *et al.*, (2011) [27] The line IR-79156A and the testers, IR-13419 (29.71 cm), R-54 (29.65 cm), JGL-11118 (28.10 cm) and R-56 (28.08 cm) recorded significantly at par to the best check JGL-1798 (32.10 cm) and are rated as widely adaptable with average stability. Among the hybrids, twelve hybrids *viz.*, IR-79156A x DRR-714-1-2-R (31.78 cm), IR-79156A x R-43 (31.10 cm), IR-79156A x R-42 (30.73 cm), IR-79156A x IR-64 (30.47 cm), IR-79156A x JGL-11118 (30.05 cm), IR-79156A x R-52 (29.74 cm), IR-79156A x R-44 (29.13 cm), IR-79156A x IR-13419 (28.71 cm), IR-68897A x IR-64 (28.45 cm), DRR-14A x R-44 (28.21 cm), IR-80555A x R-44 (28.13 cm) and IR-79156A x R-49 (27.92 cm) with significantly at par to the best check JGL-1798 and possessed average stability and are widely adaptable. Three hybrids IR-79156A x IR-66 (29.44 cm), IR-80555A x R-51 (25.93 cm) and DRR-14A x R-56 (25.63 cm) had higher flag leaf length and are adaptable for favourable environments. Six hybrids *viz.*, IR-79156A x R-46 (31.06 cm), IR-80555A x R-48 (28.92 cm), DRR-14A x R-46 (27.28 cm), DRR-14A x R-52 (26.38 cm), IR-68897A x R-49 (26.18 cm) and DRR-14A x R-54 (25.09 cm) registered higher flag leaf length and are adaptable to poor environments with more than the average stability. Among the parents, one line IR-68897A and four testers R-47, R-51, R-56 and IR-64 and as many as 36 hybrids significantly at par to the best check JGL-1798 (1.36 cm) and are considered to be stable, which can be recommended for wider environments.

For flag leaf width seven hybrids *viz.*, IR-80555A x R-56 (1.30 cm), DRR-14A x IR-10198 (1.29 cm), IR-80555A x R-48 (1.24 cm), IR-79156A x R-47 (1.16 cm), IR-79156A x IR-66 (1.16 cm) and IR-68897A x R-46 (1.06 cm) with higher flag leaf width are considered to be adaptable to favourable environments. Three cross combinations *viz.*, IR-79156A x IR-13419 (1.24 cm), IR-79156A x R-44 (1.19 cm) and IR-68897A x R-49 (1.17 cm) had higher flag leaf width and are adaptable to poor environments with more than the average stability.

Productive tillers known directly to have contributed towards grain yield can be exploited. The more number of productive tillers the more will be the yield and vice versa. In the present study, both linear and non- linear components of GE interactions were found to be significant for number of productive tillers per plant. Significance of linear component was reported by Shanmuganathan and Ibrahim (2005) [29], while significance of non- linear component was reported by Babu *et al.*, (2005) [1]. Among the parents, the lines DRR-14A and IR-80555A and testers R-44, R-46, R-47, R-49, R-54, IR-64, IR-66, IR-13419, IR-10198 and JGL-11118 had nearly equal number of productive tillers per plant as in checks and are adaptable to wider environments possessing the average stability. Among the hybrids, 27 hybrids statistically at par to the best hybrid IR-80555A x IR-13419 and are considered as ideal and highly adaptable hybrids having average stability and expected to perform well in all the environments. Hybrids *viz.*, IR-80555A x IR-66 (10.59), DRR-14A x R-56 (9.82), DRR-14A x R-47 (9.25), IR-79156A x R-49 (8.28), DRR-14A x R-49 (8.06) and IR-79156A x R-48 (7.69) registered more number of productive tillers per plant and are adapted to favourable environments with less than the average stability. Two hybrids DRR-14A x R-51 (8.58) and IR-79156A x DRR-714-1-2-R (8.69) possessed more than average stability hence specially adapted for poor environments.

Both linear and non-linear components of GE interactions were found to be significant for number of filled grains per panicle. Babu *et al.*, (2005) [1] and Ramya and Senthil Kumar (2008) [25] reported similar results. Significance of non-linear components was reported by Lohithaswa *et al.*, (1999) [20]. Among the testers, R-43 (101.97 grains), R-46 (102.6 grains), R-56 (101.1 grains), IR-64 (100.38 grains) and IR-10198 (92.4 grains) possessed higher number of grains and exhibited average stability and hence adaptable to wider environments. Among the hybrids, IR-80555A x R-51 (132.10 grains) and IR-68897A x JGL-11118 (113.53 grains) recorded maximum filled grains per panicle and statistically at par to the best check DRRH-2 (128.49 grains) and seventeen more hybrids are widely adaptable to different environments with the average stability. Two hybrids IR-79156A x R-49 (102.25 grains) and IR-79156A x R-56 (112.18 grains) had more number of filled grains per panicle and are considered for favourable environments. Three hybrids *viz.*, DRR-14A x R-48 (93.19 grains), DRR-14A x R-49 (93.18 grains) and IR-80555A x IR-13419 (94.48 grains) are adaptable to poor environments.

More of the grain weight of genotype serves as an indicator to the final product i.e. the grain yield. For 1000 grain- weight, both linear and non-linear components of GE interaction were significant in the present study. Significance of linear component was reported by Subrahmanya Hegde and Vidyachandra (1998) [15] and significance of non-linear component was reported by Lohithaswa *et al.*, (1999) [20]. Contradictoringly non-significance of both linear and non-linear GE interactions was reported by Vidhu Francis *et al.*, (2005) [33]. Among the parents, lines IR-80555A (20.42 g), IR-79156A x (20.49g), IR-68897A (20.77g) and testers R-44 (21.81g), R-47 (24.26g), R-49 (21.53g), R-56 (22.77g) and DRR-714-1-2-R (22.84g) and as many as 38 hybrids were found to be adaptable to wider environments. Thirteen hybrids are considered to favourable environments and three hybrids *viz.*, DRR-14A x R-42 (23.26g), DRR-14A x IR-13419 (18.80g) and IR-68897A x R-43 (23.14g) are suitable to poor environments.

Single plant yield is the most important trait in the development of rice hybrids. A perusal of stability parameters for single plant yield indicated that both linear and non-linear components of GE interaction were significant in the present study. Similar results were reported by Panwar *et al.*, (2008), Krishnappa *et al.*, (2009), Saidaiah *et al.*, (2011) [27] and Sridhar *et al* (2011) [31]. While contradicting these results indicated only significance of non- linear component was reported by Arumugan *et al.*,(2007). Among the parents, lines DRR-14 (17.9g), IR-68897A (22.6g) and IR-79156A (20.7g) and testers R-43 (20.0g), R-46 (19.4g), R-56(19.1g), IR-64 (18.1g), IR-10198 (14.9g), DRR-714-1-2-R (15.3g) and Hybrids viz., DRR-14A x R-43 (18.3g), DRR-14A x IR-64 (17.3g), DRR-14A x IR-13419 (15.6g), IR-80555A x R-54 (19.4g), IR-80555A x IR-13419 (17.5g), IR-80555A x IR-10198 (17.6g), IR-79156A x R-52 (16.4g), IR-79156A x R-54 (17.6g), IR-68897A x R-43 (17.7g), IR-68897A x R-48 (22.1g), and IR-68897A x R-56 (18.1g) were highly adaptable having average stability and predictable performance under all enivronments. Other Hybrids, IR-79156A x R-51 (18.2g), IR-79156A x R-47 (17.9g) and IR-79156A x IR- 13419 (21.2g) which showed above average response were stable under favourable environments. The hybrid, IR- 79156A x IR-64 (20.7g) which recoreded below average response and stable under unfavourable environments.

Any generalization regarding the stability of a genotype for all the traits is quite difficult as many hybrids had average stability to the environments for yield and its component characters. Eberhart and Russell (1966) [9] suggested that, if the traits associated with high yield show stability, the selection of genotype only for yield could be effective. A non-significant correlation between the deviation from regression (S^2di) and mean performance or regression coefficient (bi) indicated that these stability parameters might be under the control of different genes located on different chromosomes (Reddy and Chudary, 1991; Singh *et al.*, 1955) [26]. Earlier Grafius (1956) and Bradshaw (1965) also reported that plasticity in one or more component characters might be involved in the final character. It is inferred that alleles that confer broader adaptation might be involved to achieve yield and stability across environments. It is also clear that most of the high yielding hybrids exhibited stability for yield components panicle weight, flag leaf length, filled grains per panicle, productive tillers per plant, 1000 grain- weight and seed yield per plant over all the environments. This might be due to plasticity in their traits and phenotypic stability could be the result of their high plasticity due to its heterogenous composition.

Table 4: Stable parents for various characters in rice

S. No	parents	Characters
1	IR-68897A	Panicle weight, flag leaf width, 1000 grain weight and grain yield
2	IR-79156A	Panicle weight, flag leaf length, 1000 grain weight and grain yield
3	IR-80555A	Productive tillers per plant, flag leaf width, 1000 grain weight
4	DRR-14A	Productive tillers per plant and grain yield
5	R-43	Filled grains per panicle and grain yield
6	R-46	Productive tillers per plant and grain yield
7	R-47	Panicle weight, flag leaf width, productive tillers per plant and 1000 grain weight
8	IR-66	Panicle weight, flag leaf width and productive tillers per plant
9	IR-64	Filled grains per panicle, productive tillers per plant, flag leaf width, 1000 grain weight and grain yield
10	IR-10198	Filled grains per panicle, productive tillers per plant, flag leaf length and grain yield
11	R-49	Productive tillers per plant and 1000 grain weight
12	R-56	Flag leaf length, flag leaf width, filled grains per panicle, 1000 grain weight and grain yield
13	DRR-714-1-2-R	Panicle weight, Flag leaf width, 1000 grain weight and grain yield

Table 6: Stable hybrids for various characters in rice

Character	High yielding and stable under four different environments (bi =1, S^2di=0)	High yielding and suitable to favourable environments (bi >1, S^2di=0)	High yielding and suitable to unfavourable environments (bi <1, S^2di=0)
Panicle weight	Hybrids: IR-79156A x R-52, IR-68897A x IR-64, IR-79156A x R-48, IR-80555A x IR-10198, IR- 79156A x IR-13419 Parents: IR-68897A,IR-79156A,R-47, IR-66, R-54, R-44,R-51, DRR-714-1-2-R	Hybrids:IR-79156A x R-51, IR-68897A x R-56, IR-79156A x IR-64	Hybrids:DRR-14A x R-42
Flag leaf length	Hybrids:IR-79156A x DRR-714-1-2-R, IR-79156A x R-43, IR-79156A x R-42, IR-79156A x IR-64, IR-79156A x JGL-11118, IR-79156A x R-52, IR-79156A x R-44, IR-79156A x IR-13419, IR-68897A x IR-64,DRR-14A x R-44, IR-80555A x R-44 and IR-79156A x R-49 Parents: IR 79156A, IR-13419, R-54, JGL-11118, R-56, R-44, IR-10198	Hybrids:IR-79156A x IR-66, IR-80555A x R-51, DRR-14A x R-56	Hybrids:IR-79156A x R-46, IR-80555A x R-48, DRR-14A x R-46, DRR-14A x R-52, IR-68897A x R-49 Parents: IR-68897A, R-54
Flag leaf width	Hybrids:DRR-14A x R-47, DRR-14A x R-54, DRR-14A x IR-13419, DRR-14A x DRR-714-1-2-R, IR-80555A x R-44, IR-80555A x DRR-714-1-2-R, IR-79156A x R-48, IR-79156A x R-51, IR-79156A x R-52, Parents: IR-68897A, IR-80555 A, R-47, R-51, R-52, R-54, R-56, IR-64, IR-66, DRR-714-1-2-R	Hybrids:IR-80555A x R-56, DRR-14AxIR-10198, IR-80555A x R-48,IR-79156A x R-47, IR-79156A x IR-66, IR-68897A x R-46 Parents: R-42,R-49	Hybrids:IR-79156AxIR-13419, IR-79156A x R-44,IR-68897A x R-49 Parents: R-43, R-44, IR-10198
Productive tillers per plant	Hybrids:DRR-14A x R-42, DRR-14A x R-48, IR-80555A x R-42, IR-80555A x R-46, IR-80555A x R-52, IR-80555A x R-56, IR-80555A x IR- 64, IR-80555A x DRR-714-1-2-R, IR-79156A x R-47, IR-79156A x IR-64, IR-79156A x IR-13419 Parents: DRR-14A, IR-80555 A, R-44, R-46, R-47, R-49, R-49, IR-64, IR-66, IR-13419, IR-10198, JGL-11118	Hybrids:IR-80555A x IR-66, DRR-14A x R-56, DRR-14A x R-47,IR-79156A x R-49,DRR-14A x R-49,IR-79156A x R-48	Hybrids:DRR-14A x R-51, IR-79156A x DRR-714-1-2-R Parents: R-56
Filled grain per panicle	Hybrids:IR-80555A x R-51, IR-68897A x JGL-11118, DRR-14A x R-54, DRR-14A x IR-64, IR-80555A x R-43, IR-80555A x R-48, IR-80555A x R-52, IR-80555A x IR-64, IR-80555A x DRR-714-1-2-R Parents: R-43,R-46,R-56,IR-64,IR-10198	Hybrids:IR-79156A x R- 49, IR-79156A x R-56	Hybrids:DRR-14A x R-48, DRR-14A x R-49, IR-80555A x IR-13419
1000-grain weight	Hybrids:DRR-14A x R-49, DRR-14A x IR-10198, IR-80555A x R-43,IR-80555A x R-49,IR-79156A x R-47, IR-79156A x R-49,IR-79156A x IR-10198, IR-68897A x R-52, IR-68897A x R-54,IR-68897A x IR-13419 Parents: IR-68897A, IR-80555 A, IR-79156A,R-44, R-47, R-49, R-56, DRR-714-1-2-R,	Parents: IR-64, IR-10198	Hybrids:DRR-14A x R-42, DRR-14A x IR-13419, IR-68897A x R-43
Grain yield per plant	Hybrids:DRR-14A x R-43, DRR-14A x IR-64, DRR-14A x IR-13419, IR-80555A x R-54, IR-80555A x IR-13419, IR-80555A x IR-10198, IR-79156A x R-52, IR-79156A x R-54, IR-68897A x R-43, IR-68897A x R-48, IR-68897A x R-56 Parents: DRR-14A, IR-68897A, IR-79156A, R-43, R-46, R-56, IR-64, IR-10198, DRR-714-1-2-R	Hybrids:IR-79156A x R-51, IR-79156A x R-47, IR-79156A x IR- 13419	Hybrids: IR- 79156A x IR-64

Inheritance pattern of the stability

Hybrids were less predictable than parents except for panicle weight (table 4), while both hybrids and parents were less predictable for filled grains per panicle and panicle weight. This is in agreement with Babu *et al.*, (2005) [1], Deshpande and Dalvi (2006) [5] and Saidaiah *et al.*, (2011) [27], who reported that hybrids were less predictable than parents for most of the yield contributing traits.

The stability of hybrids may be governed by set of genes for stability present in parents. It is revealed from (table 6) stable hybrids, IR- 79156A x JGL -11118, IR- 79156A x R-44 and IR- 79156A x IR-13419 (flag leaf length), IR-80555A x DRR-714-1-2-R (Flag leaf width), IR-80555A x R-46, IR-80555A x IR-64 (Productive tillers per plant), IR-80555A x R-49, IR-79156 A x R-47 and IR-79156 A x R-49 (1000 grain weight) and DRR-14A x R-43, IR-68897A x R-43 and IR-68897A x R-56 (grain yield per plant) derived from stable parents. This indicates that sets of genes for stability were inherited from its parents. On other hand below average (bi>1, S^2di=0) stable cross combinations, for the traits panicle weight (IR-79156A x R-51), flag leaf width (IR – 80555A x R-56, IR-79156A X R-47 and IR-79156A X IR-66), and productive tillers per plant (IR-80555A x IR-66, DRR-14A x R-47 and DRR-14A x R-49) derived from both stable parents. Hybrid IR-79156A x IR-64 suitable for unfavourable environments (bi<1, S^2di=0) involved both stable parents for seed yield per plant. However, three hybrids IR-68896A x IR-64 (flag leaf length), IR-80555A x R-44 (Flag leaf length) and IR-80555A x R-56 (productive tillers per plant) derived from one stable and unstable parents. Most stable hybrids comprised one stable parent. Similarly, hybrid suitable for favourable and unfavourable environments involved unstable parents. On the basis of these results, it can be concluded that the genes for stability, if present below the thresh hold level, may produce the stable genotypes, which is true in most cases. The patteren of inheritance of stability is different for different characters and also for different genotypes for the same character (Vikas and Singh, (2006)). Lavanya *et al.* (2005), Deshpande and Dalvi (2006) [5], and Saidaiah *et al.*,(2011) [27] also confirmed the earlier reports that stable hybrids involved stable parents but stable parents need not necessarily generate stable hybrids.

Conclusions

In the present study, it can be conclude that three CMS lines IR-79156A, DRR- 14A and IR-68897A and testers R-43, R-465, R-47, R-49, R-56, IR-64, IR-66, DRR-714-1-2-R and IR-10198 were identified as stable parents over four environments for yield and its important components can be used for developing stable hybrids (table 5). Even though many number of hybrids were identified as stable, considering the yield and its component traits, high yielding hybrids viz., DRR-14A x R-43, IR-80555A x R-54, IR-68897A x R-43, IR-68897A x R-48, IR-68897A x R-56 were the stable hybrids. It is proved beyond doubt that, these cross combinations appear to be promising in both *kharif* and *rabi* season of Telangana region and exhibiting higher yields. It should be tested for stability in yield performance in different locations before it is released as a commercial hybrid.

From the study of inheritance pattern, the stability of hybrids may be governed by set of genes for stability present in parents. Most stable hybrids comprised one stable parent. Similarly, hybrid suitable for favourable and unfavourable environments involved unstable parents. The patteren of inheritance of stability is different for different characters and also for different genotypes for the same character. Outcome of this study is stable hybrids that involved stable parents but stable parents need not necessarily generate stable hybrids.

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