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Genetic Variability and Trait Association Analysis in F_3 Population of YH3 x AKDRMS 21-54 Cross.

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ABSTRACT

The present investigation was undertaken to study the variability, heritability, genetic advance, character associations and path coefficients of yield component traits in F_3 population of YH3 x AKDRMS 21-54 intra-specific cross of rice for the identification of effective selection criteria to improve grain yield improvement. High phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV) coupled with high heritability and genetic advance as per cent of mean were noticed for productive tillers per plant, filled grains per panicle, total grains per panicle and grain yield per plant indicating the effectiveness of direct phenotypic selection for improvement of these traits. Among these, productive tillers per plant and filled grains per panicle recorded positive direct effect coupled with significant and positive correlation with grain yield per plant. Hence, those traits form an identified as effective selection criterion for grain yield improvement in early generation of rice crop.

Keywords: *Correlation Analysis, F_3 generation, Genetic Advance, Heritability, Path Analysis, Rice and Variability.*

High yielding ability coupled with acceptable grain quality and resistance to biotic and abiotic stresses are important objectives of current rice breeding programs. Hybridization has been identified as an important plant breeding tool for combination of desired characters in addition to creation of desired variability. Selections in the F_2 or F_3 derived lines mainly rely on the assumption that performance at early generation is predictive based on homozygosity, particularly, in self-pollinated crops like rice (Mallimar *et al.*, 2015). Further, selection in segregating generations need to be focussed for obtaining a better yielding plant for which variability with respect to yield and yield related traits is of prime importance. However, direct phenotypic selection for grain yield, a complex trait, depends on number of characters, often polygenic in nature and highly influenced by environmental factors . Hence, identification of effective selection criteria for improvement of grain yield is a priority. In this context, studies on heritability and genetic advance of yield component traits assume importance. An analysis of the association of yield component traits with grain yield and their inter-associations is also important for the formulation of effective breeding strategy to improve grain yield. Further, to detect the traits, having high influence on grain yield, path analysis is commonly applied to elucidate information on the relative direct and indirect contribution of each component character towards yield and help the breeders in formulation of effective selection criteria for grain yield improvement.

In this context, hybridization programme was initiated using improved Sri Druthi (YH3) and Akshaydhan (AKDRMS 21-54) genotypes having

desirable characters to have a variety which is high yielding combined with bacterial leaf blight, blast and low soil phosphorus stress resistance in addition to other desirable economic characters for the states of Andhra Pradesh and Telangana. The present study was conducted to know the extent of genetic variability, inter-relationships and path coefficient for grain yield and yield contributing traits in the F_3 generation of YH3 x AKDRMS 21-54 intra-specific cross of rice.

MATERIAL AND METHODS

The present investigation was carried out at Agricultural College, Bapatla and ICAR- Indian Institute of Rice Research, Hyderabad. Genetically pure seeds of YH3 (an improved breeding line with the genetic background of the Sri Dhruti, possessing the major QTL conferring tolerance to low soil phosphorus) and AKDRMS 21-54 (a breeding line of the variety, Akshayadhan possessing the major bacterial blight resistance gene, *Xa21* and the major blast resistance gene, *Pi54)* were obtained from ICAR-IIRR, Rajendranagar, Hyderabad and the parents were raised in crossing block at Agricultural College Farm, Bapatla, Andhra Pradesh during *Kharif* 2019-20. YH3, used as female parent in the present study was developed through Marker Assisted Backcrossing by introgression of *Pup1*gene for low soil phosphorous tolerance, jointly by Professor Jayashankar Telangana State Agricultural University (PJTSAU), ICAR-IIRR and ANGRAU. Sri Druthi is widely cultivated in the Indian state of Andhra Pradesh and is preferred by rice millers due to its premium grain and cooking qualities. Hybridization of the parents was effected with the objective of developing breeding lines of Sri Druthi possessing resistance against bacterial blight (BB), Blast and tolerance to low soil phosphorous. Standard emasculation and pollination procedures were adopted and the crossing chamber facility available at Agricultural Research Station, Bapatla was utilized for the purpose. The crossed seeds were used to raise the F_1 generation during *Rabi* 2019-20 at Agricultural College Farm, Bapatla. Hybridity of the F_1s' was confirmed using gene-specific, PCR based markers (Table 1). Seed from the selected F_1 plants were harvested and forwarded to the F_2 generation. In F_2 generation, plants homozygous for *Xa21, Pi54* and *Pup1* gene-specific markers were selected during *Kharif 2020* and the seed from the identified F_2 plants were harvested individually and forwarded to the F_3 generation. 180 F_3 segregants along with the parents were sown in raised nursery bed and were transplanted in main field 20 days after sowing at a spacing of 20 x 15 cm during *Rabi* 2020-21 at Agricultural College Farm, Bapatla. All recommended agronomic practices and crop protection measures were adopted during the crop growth period for raising a healthy crop. Twelve traits *viz*., days to 50 per cent flowering (days), shoot length (cm), plant height (cm), productive tillers per plant, flag leaf length (cm), flag leaf width (cm), panicle length (cm), filled grains per panicle, total grains per panicle, spikelet fertility (%), test weight (g) and grain yield per plant (g) were recorded in every individual F_3 plant and the data obtained was subjected to statistical analysis.

Genetic variability parameters, *viz.*, Genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) were calculated using the formula given by Burton and Dewane (1953), heritability was calculated using the formula given by Allard *(*1960) and genetic advance as percentage of mean was calculated by adopting the formula given by Johnson *et al*. (1955). Correlation coefficients were calculated using the formula given by Singh and Choudhary (1977). The direct and indirect effects of different components on grain yield were estimated by path coefficient analysis

as suggested by Dewey and Lu (1959). Statistical analysis was carried out using the software Window Stat Version 8.5 and the R software version 1.4.1717 was used for illustrating association plot. Further, SPSS16.0 software was used to depict frequency distribution in the form of a histogram for the traits studied.

RESULTS AND DISCUSSION

The results on variability and other genetic parameters for grain yield and yield component traits studied in the present investigation are presented in Table 2 and Fig. 1-3. Grain yield per plant range was noticed 23.39 g to 59.40 g with a mean of 35.59 g per plant. Similar variation in grain yield per plant was reported earlier by Khandappagol *et al.* (2019) in their studies on segregating population of two crosses involving traditional varieties of rice. Further, test weight in the present study ranged from 18.81 g to 32.26 g. The results are also in agreement with the reports of Khandappagol *et al.* (2019). Flag leaf length and width ranges in the present study, were 18.81 cm to 50.09 cm with an average of 30.76 cm and 0.86 cm to 1.90 cm with a mean of 1.33 cm, respectively. Similar range for flag leaf length and width were reported earlier by Bakya *et al.* (2020). Panicle length ranges in the F_3 population studied 16.35 cm to 41.63 cm with a mean value of 26.07 cm. The results are in conformity with the reports of Priyanka *et al.* (2019).

The results on genotypic (GCV) and phenotypic (PCV) coefficients of variation are presented in Table 2 and Fig. 2. An analysis of these results revealed higher PCV value, compared to GCV value for all the traits studied indicating the effect of environment. Among the traits, test weight recorded greater difference between phenotypic and genotypic coefficients of variation compared to other traits indicating higher influence of environment on this trait, resulting in low heritability values for the trait. However, productive tillers per plant and grain yield per plant recorded minimum variation between GCV and PCV values indicating lesser influence of environment resulting in high heritability values ($\geq$ 95 per cent). These observations are in agreement with the inference of Priyanka *et al.* (2019). The results also revealed high genotypic and phenotypic coefficients of variation for productive tillers per plant, filled grains per panicle, total grains per panicle and grain yield per plant. These results are in agreement with the findings of Sameera *et al.* (2016) for productive tillers per plant; Meshram *et al.* (2020) for filled grains per panicle. Koli and Punia (2012) for total grains per panicle; and Swapnil *et al.* (2021) for grain yield per plant. In contrast, moderate genotypic and phenotypic coefficients of variation were recorded for days to 50 per cent flowering, shoot length, plant height, flag leaf length, flag leaf width and panicle length in the present study. These results are in agreement with the reports of Lakshmi *et al.* (2020) for days to 50 per cent flowering; Mallimar *et al.* (2015) for plant height, Gupta *et al.* (2020) for panicle length; Bakya *et al.* (2020) for flag leaf length and flag leaf width. Further, low genotypic and moderate phenotypic coefficient of variation were observed for spikelet fertility and test weight. Similar findings were repeated by Sanghera and Kashyap (2012) for spikelet fertility; and Harijan *et al.* (2021) for test weight.

High heritability (>60%) and high genetic advance as per cent of mean (>20%) were observed for days to 50 per cent flowering, shoot length, plant height, productive tillers per plant, flag leaf length, flag leaf width, panicle length, filled grains per panicle, total grains per panicle and grain yield per plant (Table 2 and Fig. 3). These results are in agreement with the observations of Kishore *et al.* (2015) for days to 50 per cent flowering; Gupta *et al.* (2020) for shoot length and panicle length; Chozin and Sumardi (2019)

for productive tillers per plant; Harijan *et al.* (2021) for flag leaf length; Bakya *et al.* (2020) for flag leaf width; Babu *et al.* (2017) for filled grains per panicle and total grains per panicle; and Krishna *et al.* (2020) for grain yield per plant. However, high heritability (>60%) coupled with moderate genetic advance as per cent of mean (10-20%) was observed for spikelet fertility. These findings are in agreement with the report of Kumar *et al.* (2020) for spikelet fertility. Moderate heritability coupled with moderate genetic advance as per cent of mean was observed for test weight, similar to results of Harijan *et al.* (2021).

High GCV and high PCV (>20%) coupled with high heritability (>60%) and high genetic advance as per cent of mean (>20%) were recorded for productive tillers per plant, filled grains per panicle, total grains per panicle and grain yield per plant, suggesting the pre-dominance of additive type of gene action for these traits. Hence, direct phenotypic selection would be effective for improvement of these traits, in early generations. Similar findings were reported earlier by Krishna *et al.* (2020) for filled grains per panicle; Swapnil *et al.* (2020) for total grains per panicle; and Gupta *et al.* (2020) for grain yield per plant.

The associations between yield and yield components are presented in Table 3 and Fig. 4. A perusal of these results revealed positive and significant association of grain yield with the yield component traits, namely, shoot length, plant height, productive tillers per plant, flag leaf width, panicle length, filled grains per panicle and total grains per panicle, indicating scope for their simultaneous improvement with grain yield per plant. These results are in agreement with the reports of Kohanaki *et al.* (2013) for plant height; Ramya *et al.* (2012) for productive tillers per plant; Bakya *et al.* (2020) for flag leaf width; Sowjanya and Hittalmani (2017) for panicle length; Priyanka *et al.* (2019) for filled grains per panicle; and Koli and Punia (2012) for total grains per panicle. Further, positive and significant associations were also noticed for plant height with shoot length, productive tillers per plant, flag leaf width, panicle length and test weight; productive tillers per plant with flag leaf width and panicle length; flag leaf width with panicle length, total grains per panicle and test weight; panicle length with total grains per panicle; and filled grains per panicle with total grains per panicle and spikelet fertility, indicating a scope for simultaneous improvement of these traits. These findings are in agreement with the reports of Ramya *et al.* (2012) for plant height with productive tillers per plant; Sameera *et al.* (2016) for plant height with panicle length; Kumar *et al.* (2020) for plant height with test weight; Bakya *et al.* (2020) for productive tillers per plant with flag leaf width; Sudeepthi *et al.* (2020) for productive tillers per plant with panicle length; Bakya *et al.* (2020) for flag leaf width with panicle length; Kohanaki *et al.* (2013) for panicle length with total grains per panicle; and filled grains per panicle with total grains per panicle; and Fathima *et al.* (2021) for filled grains per panicle with spikelet fertility.

Negative and significant associations were noticed for spikelet fertility with shoot length, plant height, flag leaf width and panicle length. These findings are in conformity with the reports of Sowjanya and Hittalmani (2017) for plant height with spikelet fertility. Such negative correlations are inferred to occur when one component gets advantage over the other, primarily due to competition for a common possibility, such as nutrient supply. Hence, balanced selection needs to be adopted while effecting simultaneous improvement for these traits (Sameera and Srinivas, 2016).

The results on path analysis of yield component traits on grain yield per plant are presented in Table 4 and Fig. 5. A perusal of the results revealed a residual effect of 0.369 indicating that variables

Table 1. Details of gene specific markers used for hybridity confirmation in the present study

Molecular Markers	Primer sequence	Chromosome location	Reference
pTA248	F: AGACGCGGGAAGGGTGGTTCCCGGA	11	Ronald *et al.* (1992)
	R: AGACGCGGGTAATCGAAAGATGAAA		
Pi 54 MAS	F: CAATCTCCAAAGTTTTCAGG	11	Ramkumar *et al.* (2011)
	R: GCTTCAATCACTGCTAGACC		
K20-2	F: CTGGACTTGACCCCAATGTA	12	Chin *et al.* (2010)
	R: TCTGATGGAGTGTTCGGAGT		

Table 2. Variability parameters in F_3 derivatives of YH3 x AKDRMS 21-54 intra-specific cross

S.No.	Character	Mean	Range		Coefficient of variation		Heritability (%)	Genetic advance as % of mean
			Minimum	Maximum	GCV (%)	PCV (%)		
1	Days to 50 per cent flowering	88.13	59.00	127.00	14.17	15.25	86.40	27.13
2	Shoot length (cm)	86.24	57.44	128.32	11.89	13.60	76.40	21.40
3	Plant height (cm)	111.12	73.47	168.07	11.80	13.47	76.60	21.27
4	Productive tillers per Plant	11.84	6.00	29.00	40.99	41.54	97.40	83.34
5	Flag leaf length (cm)	30.76	18.81	50.09	16.34	17.56	86.50	31.31
6	Flag leaf width (cm)	1.33	0.86	1.90	14.57	16.18	81.10	27.03
7	Panicle length (cm)	26.07	16.35	41.63	13.94	15.35	82.50	26.08
8	Filled grains per panicle	174.64	70.00	348.00	33.60	34.29	96.00	67.81
9	Total grains per panicle	208.99	123.00	358.00	26.00	26.77	94.40	52.03
10	Spikelet fertility (%)	83.39	58.12	99.01	9.68	11.54	70.30	16.71
11	Test weight (g)	24.84	18.81	32.26	7.76	10.17	58.20	12.19
12	Grain yield per plant (g)	35.59	23.39	59.40	34.94	35.56	96.60	70.72

studied in the present investigation explained about 63.10 per cent of variability for grain yield per plant and therefore other attributes, besides the characters studied are contributing for grain yield per plant. High positive direct effect of filled grains per panicle in addition to positive and significant association with grain yield per plant was observed in the present study. These findings are in agreement with the reports of Kishore *et al*. (2015). Direct effects equal to the correlation coefficients were also observed for panicle length and productive tillers per plant, indicating direct selection of the traits for effective gain yield improvement. The results are in conformity with the findings of Fathima *et al*. (2021) for productive tillers per plant. In contrast, negligible direct effects were observed for shoot and flag leaf length. These results are in agreement with the reports of Priyanka *et al*. (2019) for flag leaf length. The association was however, positive and significant with shoot length. Further, high negative direct effect coupled with significant positive correlation was observed for total grains per panicle. These findings are in agreement with the reports of Singh *et al.* (2020). Indirect effects are inferred to be the cause of correlation with grain yield per plant for these traits, indicating the need for consideration of the indirect causal factors also

Table 3. Correlation coefficients for grain yield and yield components in F_3 derivatives of YH3 x AKDRMS 21-54 intra-specific cross

Traits	Shoot length	Plant height	Productive tillers per Plant	Flag leaf length	Flag leaf width	Panicle length	Filled grains per panicle	Total grains per panicle	Spikelet fertility	Test weight	Grain yield per plant
Days to 50 per cent flowering	-0.0184	-0.0181	0.0825	0.005	-0.1078	-0.0809	-0.1024	-0.086	-0.0572	0.0018	-0.0214
Shoot length		0.9549**	0.1819**	0.0913	0.6127**	0.4785**	-0.0467	0.0514	-0.1743**	0.1144*	0.1650**
Plant height			0.1167*	0.0867	0.6298**	0.4602**	-0.0582	0.0395	-0.1803**	0.1167*	0.1368*
Productive tillers per Plant				-0.0586	0.3186**	0.4155**	0.2392**	0.3164**	-0.0837	-0.0179	0.4091**
Flag leaf length					0.0707	0.1428*	0.0105	0.0147	0.0196	-0.005	0.0294
Flag leaf width						0.6997**	0.101	0.2030**	-0.1391*	0.1181*	0.2301**
Panicle length							0.0119	0.1660**	-0.2568**	0.0715	0.3532**
Filled grains per panicle								0.8939**	0.4737**	-0.0424	0.2277**
Total grains per panicle									0.0447	-0.0157	0.2808**
Spikelet fertility										-0.0032	-0.0511
Test weight											-0.0577

Table 4. Direct and indirect effects for yield component traits in F_3 derivatives of YH3 x AKDRMS 21-54 intra-specific cross

Traits	Days to 50 per cent flowering	Shoot length	Plant height	Productive tillers per Plant	Flag leaf length	Flag leaf width	Panicle length	Filled grains per panicle	Total grains per panicle	Spikelet fertility	Test weight	Grain yield per plant
Days to 50 per cent flowering	-0.0126	0.0002	0.0002	-0.0010	-0.0001	0.0014	0.0010	0.0013	0.0011	0.0007	0.0000	-0.0214
Shoot length	-0.0011	0.0581	0.0555	0.0106	0.0053	0.0356	0.0278	-0.0027	0.0030	-0.0101	0.0066	0.1650**
Plant height	0.0001	-0.0031	-0.0033	-0.0004	-0.0003	-0.0021	-0.0015	0.0002	-0.0001	0.0006	-0.0004	0.1368*
Productive tillers per Plant	0.0219	0.0483	0.0310	0.2654	-0.0155	0.0846	0.1103	0.0635	0.0840	-0.0222	-0.0047	0.4091**
Flag leaf length	0.0001	0.0010	0.0010	-0.0006	0.0111	0.0008	0.0016	0.0001	0.0002	0.0002	-0.0001	0.0294
Flag leaf width	0.0109	-0.0620	-0.0637	-0.0322	-0.0072	-0.1012	-0.0708	-0.0102	-0.0205	0.0141	-0.0120	0.2301**
Panicle length	-0.0230	0.1361	0.1309	0.1182	0.0406	0.1990	0.2845	0.0034	0.0472	-0.0730	0.0204	0.3532**
Filled grains per panicle	-0.0736	-0.0336	-0.0418	0.1718	0.0076	0.0725	0.0085	0.7183	0.6422	0.3402	-0.0304	0.2277**
Total grains per panicle	0.0399	-0.0238	-0.0183	-0.1469	-0.0068	-0.0942	-0.0771	-0.4150	-0.4642	-0.0207	0.0073	0.2808**
Spikelet fertility	0.0161	0.0490	0.0507	0.0235	-0.0055	0.0391	0.0722	-0.1331	-0.0126	-0.2810	0.0009	-0.0511
Test weight	-0.0001	-0.0052	-0.0053	0.0008	0.0002	-0.0053	-0.0032	0.0019	0.0007	0.0001	-0.0452	-0.0577

Residual effect = 0.369; Diagonal and bold values indicate the direct effects

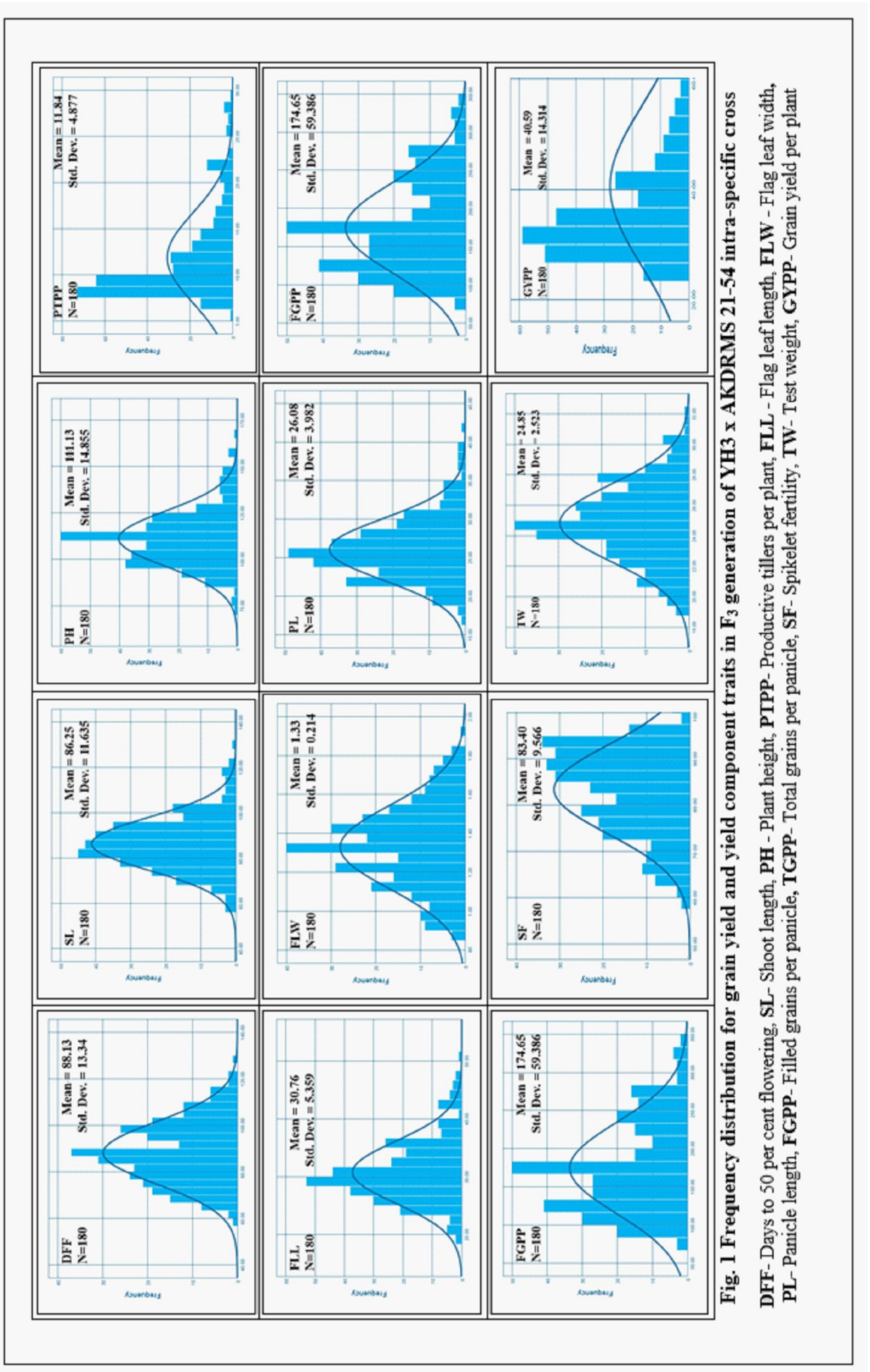

Fig. 1 Frequency distribution for grain yield and yield component traits in F_3 generation of YH3 x AKDRMS 21-54 intra-specific cross

DFF- Days to 50 per cent flowering, **SL**- Shoot length, **PH** - Plant height, **PTPP**- Productive tillers per plant, **FLL** - Flag leaf length, **FLW** - Flag leaf width, **PL**- Panicle length, **FGPP**- Filled grains per panicle, **TGPP**- Total grains per panicle, **SF**- Spikelet fertility, **TW**- Test weight, **GYPP**- Grain yield per plant

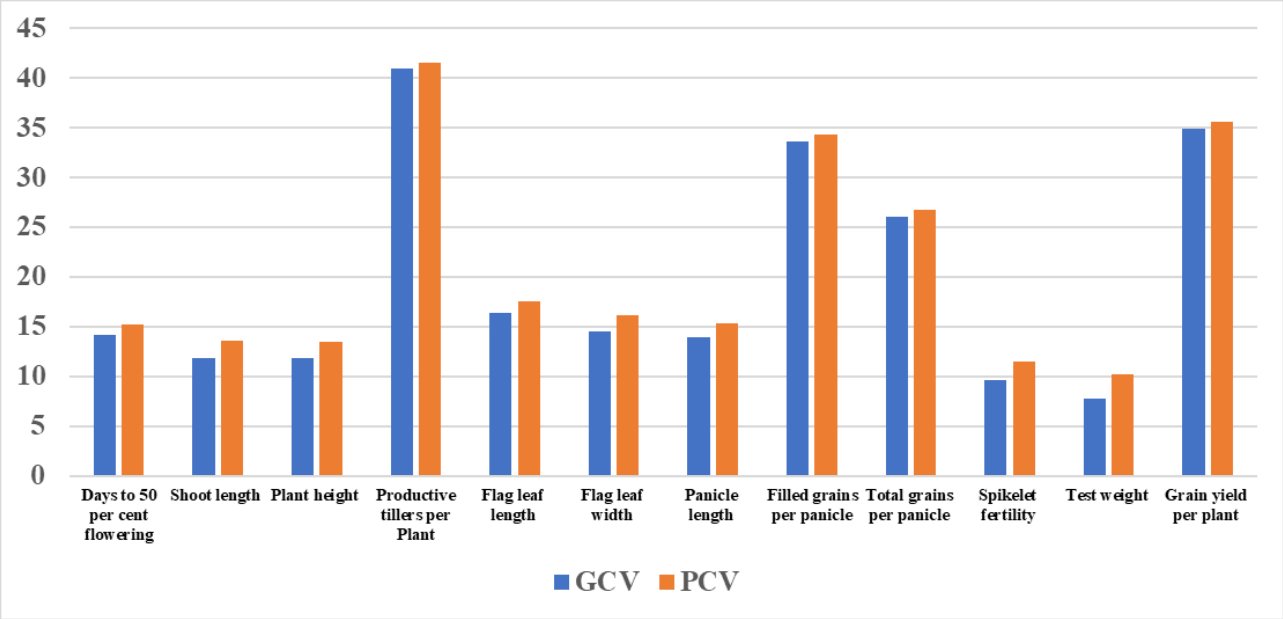

Fig 2. Genotypic and Phenotypic coefficients of variation for grain yield and yield components in F_3 derivatives of YH3 x AKDRMS 21-54 intra-specific cross

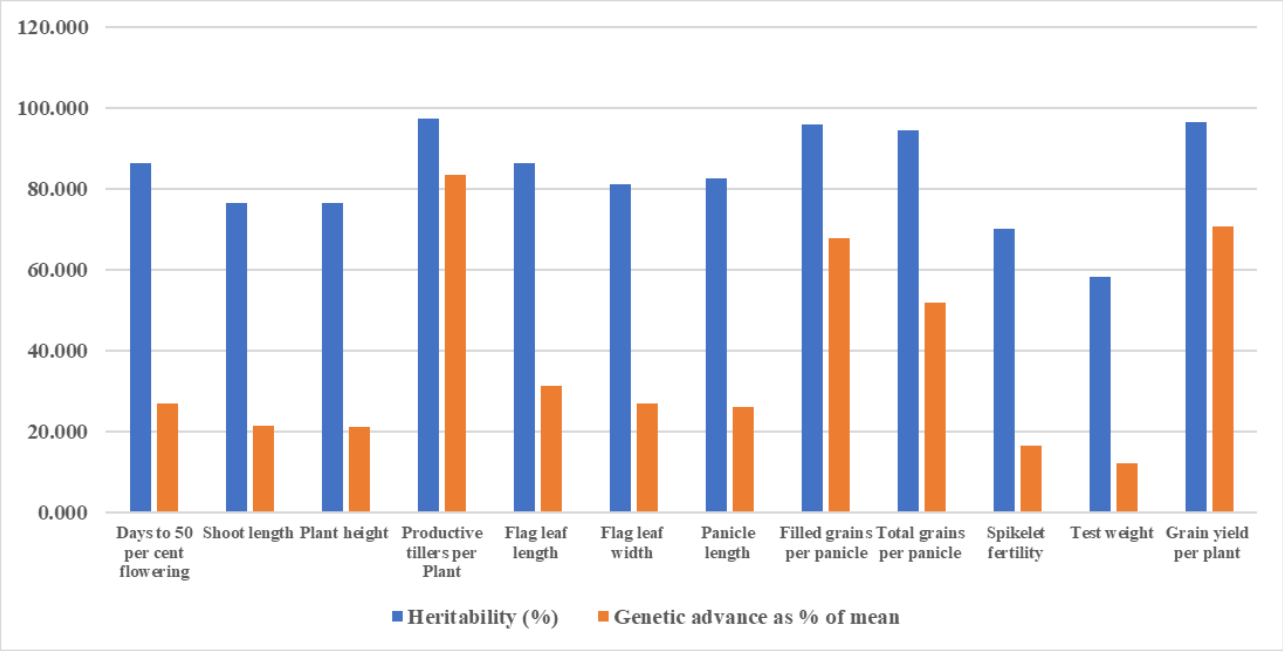

Fig 3. Heritability and genetic advance as per cent mean for grain yield and yield component traits in F_3 derivatives of YH3 x AKDRMS 21-54 intra-specific cross

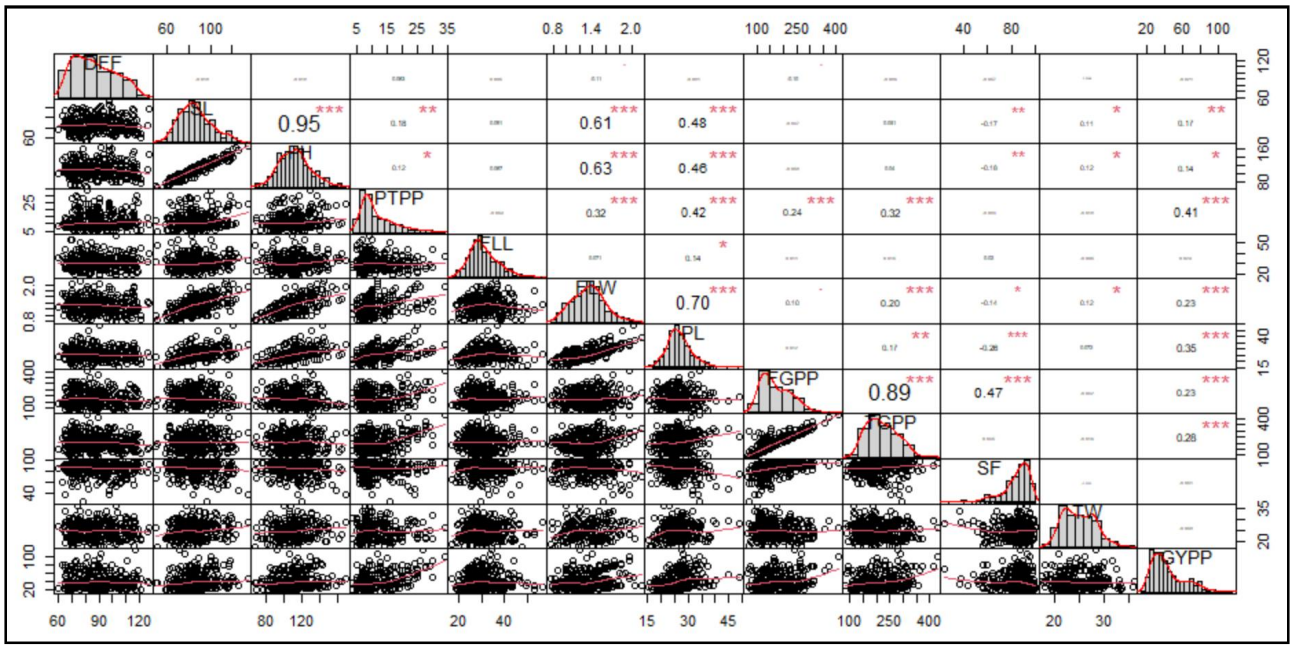

Fig 4. Correlation matrix of grain yield and yield components in F_3 derivatives of YH3 x AKDRMS 21-54 intra-specific cross

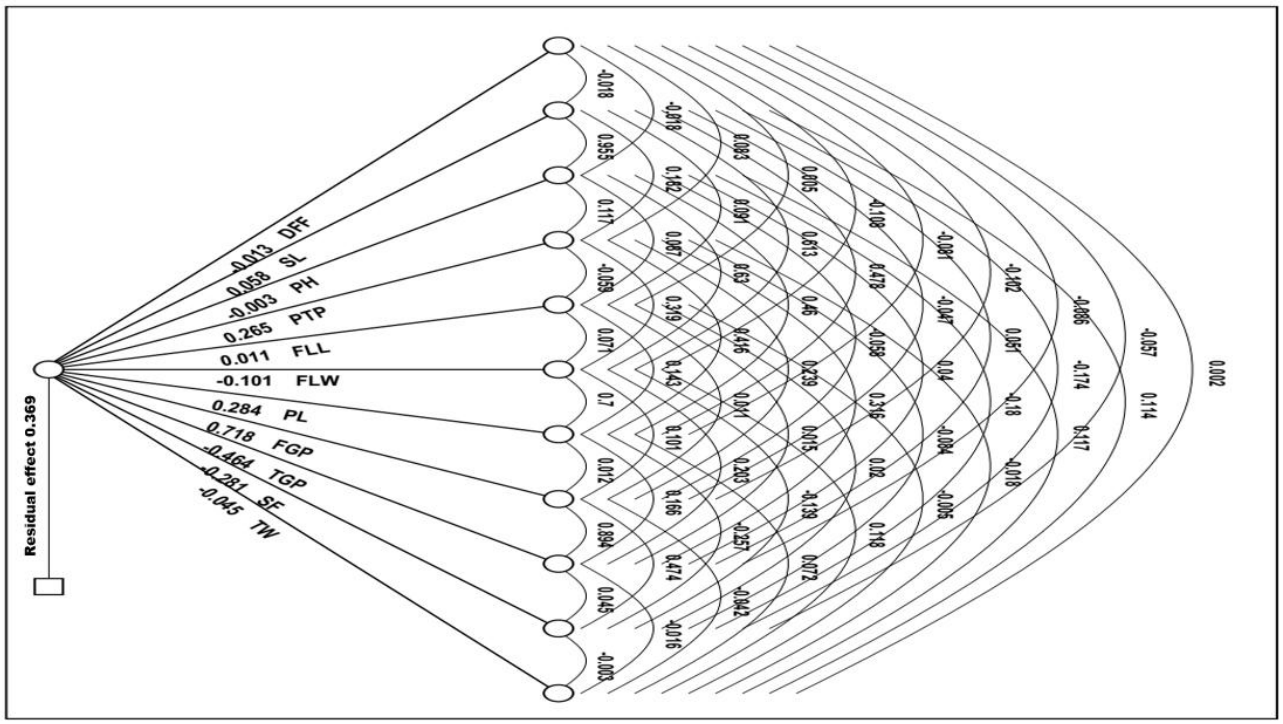

Fig 5. Path diagram of yield components for grain yield per plant in F_3 derivatives of YH3 x AKDRMS 21-54 intra-specific cross

simultaneously, while effecting selections aimed at improvement of grain yield. Low and negligible negative direct effects were noticed for flag leaf width, test weight, days to 50 per cent flowering and plant height along with non-significant to significant associations with grain yield per plant. The results are in agreement with the findings of Fathima *et al.* (2021) for test weight; Muthuramu and Ragavan (2020) for days to 50 per cent flowering and Sanghera and Kashyap (2012) for plant height. However, moderate negative direct effect was noticed for spikelet fertility. The traits had also recorded non-significant association with grain yield per plant.

CONCLUSION

High GCV, PCV, heritability and genetic advance as per cent were observed for productive tillers per plant, filled grains per panicle, total grains per panicle and grain yield per plant, indicating the effectiveness of direct phenotypic selection for improvement of these traits. Among these, productive tillers per plant and filled grains per panicle had recorded positive direct effect coupled with significant and positive correlation with grain yield per plant. Hence, the traits, productive tillers per plant and filled grains per panicle are identified as effective selection criterion for effecting grain yield improvement in early generation of rice crop.

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