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Research Article

CHARACTER ASSOCIATION STUDIES OF F_5 FAMILIES IN RICE (*Oryza sativa* L.)

TEJASWINI K.L.Y.[1]*, RAVI KUMAR B.N.V.S.R.[2], LAL AHAMAD MOHAMMAD[1] AND KRISHNAM RAJU S.[2]

[1]Agricultural College, Bapatla, 522101, Acharya N.G. Ranga Agricultural University, Rajendranagar, Hyderabad, 500 030
[2]APRRI and Regional Agricultural Research Station, Maruteru, 534 122, Acharya N.G. Ranga Agricultural University, Rajendranagar, Hyderabad, 500 030
*Corresponding Author: Email-tejaswini.kraleti@gmail.com

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Abstract- Present study was conducted during *kharif*, 2015 at APRRI & RARS, Maruteru with an objective to establish the nature of relation between grain yield and yield components by partitioning the correlation coefficients between grain yield and its components into direct and indirect effects by using simple correlation and path analysis on 114 F5 families from six crosses along with their seven parents. Data was recorded on ten characters which showed significant differences among themselves. The study of character association and path coefficient analysis indicated that panicle length had positive direct effect coupled with positive significant correlation with grain yield per plant and hence direct selection can be made based on this trait for improving yield.

Keywords- Correlation, path analysis, F5 families.

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Introduction

Rice is the staple food crop for 3.5 billions worldwide. China and India alone account for >50% of the rice grown and consumed. Rice provides up to 50% dietary caloric supply and a substantial part of the protein intake for about 520 million people living in poverty in Asia and therefore critical for global food security. It is also the primary source of income and employment for more than 200 million households across countries in the developing world. Rice is therefore on the frontline in the fight against world hunger and poverty. It is also a symbol of both cultural identity and global unity. For all of these reasons, it is apt to say that "Rice is Life" [5]. The demand for rice production is increasing day by day because of expansion of rice consuming people. Globally, it is planted on about 158 million hectares with an annual production of 478 million tons. India ranks first in area (43.85 million hectares) and second in the production (104.78 million tonnes) with a productivity of 2185 kg ha^{-1}. To achieve this target, it is necessary to enhance the production and productivity of existing rice cultivars through pyramiding of high yield alleles into agronomically desirable genotypes. Therefore, keeping in view of the future demand of rice, there is a continuous need to evolve new varieties with higher yields through various genetic approaches and selection of genotypes in early generations would become essential. As yield is a complex character, which is highly influenced by environment, direct selection for yield results in limited success in yield improvement. Hence, indirect approach has to be practiced by selecting yield component characters as they show association among themselves and also with yield and this way is more effective if the components are positively correlated with yield [13].

Correlation is the measure of mutual relationship between two variables and measures the degree of closeness and the linear relationship between them. Path analysis facilitates the partitioning of correlation coefficients into direct and indirect effects of various characters on yield. For selection to be more affective, information regarding mutual relationship among characters and their direct and indirect effects towards grain yield is essential. Correlation and Path analysis establish the extent association between yield and its components and also bring out relative importance of their direct and indirect effects, thus giving an obvious understanding of their association with grain yield. Ultimately, this kind of analysis could help the breeder to design his selection strategies to improve grain yield [11]. Hence, in the present study, an attempt was made to understand the association and path analysis of component characters for grain yield one hundred and fourteen F_5 rice families obtained from six crosses and their seven parents.

Material and Methods

The experimental material consisted of one hundred and fourteen F_5 families belonging to six crosses of rice with seven parents obtained from Andhra Pradesh Rice Research Institute and Regional Agricultural Research Station, Maruteru and were sown in randomized block design with two replications during *kharif,* 2015. Thirty days old seedlings were transplanted with a spacing of 20 cm and 15 cm between rows and plants, respectively. The crop was maintained healthy by following all other agronomic and plant protection practices applicable for commercial rice crop. Observations were recorded on five randomly selected plants for eight characters *viz.,* plant height, number of panicles per plant, panicle length, grain yield per plant, test weight, kernel length, kernel breadth and L/B ratio while for other two characters *viz.,* days to 50 per cent flowering, days to maturity, observations were recorded on plot basis. The mean values over two replications were used for statistical analysis and analysis was done as per [8,3,2].

Results and Discussions

The analysis of variance revealed significant differences among the genotypes for all the characters [Table-1] indicating that there is an inherent genetic difference among the genotypes.

The study of character association [Table-2] revealed that the character panicle length showed significant positive association with grain yield per plant indicating that direct selection can be practiced for this character. Other traits *viz.,* number of panicles per plant, test weight, kernel length and kernel breadth reported negative non significant correlation with grain yield while days to 50% flowering, days to maturity, plant height and L/B ratio recorded positive non significant correlation with grain yield indicating that these traits have little influence on yield.

Table-1 *Analysis of variance (mean sum of squares) for 10 characters for 121 genotypes of rice (Oryza sativa L.) during kharif, 2015.*

Source of variations	d. f.	Days to 50% flowering	Days to maturity	Plant height	Number of panicles per plant	Panicle length	Grain yield per plant	Test weight	Kernel length	Kernel breadth	Kernel L/B ratio
Mean sum of squares											
Replications	1	0.04	0.264	0.051	0.810	3.499	3.380	0.001	0.013	0.000	0.051
Genotypes	120	65.833**	66.903**	122.849**	4.795**	8.045**	52.314**	52.299**	0.336**	0.098**	0.216**
Error	120	2.071	0.981	4.117	0.510	1.250	1.706	1.160	0.025	0.196	0.038

*Significant at 5% level

**Significant at 1% level

Table-2 *Phenotypic and genotypic correlation coefficient of 121 lines (114 families and 7 parents) of rice (Oryza sativa L.)during kharif, 2015.*

S. No	Characters		Days to 50% flowering	Days to maturity	Plant height	Number of panicles per plant	Panicle length	Test weight	Kernel length	Kernel breadth	L/B ratio
1.	Days to 50% flowering	r_p	**1.0000**								
		r_g	**1.0000**								
2.	Days to maturity	r_p	0.9294**	**1.0000**							
		r_g	0.9602**	**1.0000**							
3.	Plant height	r_p	0.1920**	0.2161**	**1.0000**						
		r_g	0.2139**	0.2309**	**1.0000**						
4.	Number of panicles per plant	r_p	0.3248**	0.3565**	0.4577**	**1.0000**					
		r_g	0.3811**	0.3956**	0.4890**	**1.0000**					
5.	Panicle length	r_p	-0.0293	-0.0708	0.3670**	0.1449*	**1.0000**				
		r_g	-0.0641	-0.0902	0.4296**	0.1642*	**1.0000**				
6.	Test weight	r_p	0.2425**	0.2301**	0.0031	0.0657	-0.2633**	**1.0000**			
		r_g	0.2519**	0.2382**	-0.0045	0.0769	-0.3254**	**1.0000**			
7.	Kernel length	r_p	0.1655**	0.1890**	0.1743**	0.1822**	0.0085	0.2252**	**1.0000**		
		r_g	0.2002**	0.2147**	0.1916**	0.2170**	-0.0117	0.2383**	**1.0000**		
8.	Kernel breadth	r_p	0.0891	0.1018	0.0069	-0.0871	-0.2794**	0.4000**	-0.0360	**1.0000**	
		r_g	0.0929	0.1116	0.0170	-0.1380	-0.3990**	0.5120**	-0.0414	**1.0000**	
9.	L/B ratio	r_p	-0.0355	-0.0486	0.0824	0.1631*	0.2648**	-0.2066**	0.5326**	-0.8083**	**1.0000**
		r_g	-0.0320	-0.0443	0.0841	0.2003**	0.3281**	-0.2653**	0.5847**	-0.8287**	**1.0000**
10.	Grain yield per plant	r_p	0.0830	0.0380	0.0523	-0.0193	0.3157**	-0.1071	-0.0152	-0.0204	0.0234
		r_g	0.0794	0.0499	0.0475	-0.0286	0.3543**	-0.1138	-0.0176	-0.0280	0.0297

Days to 50% flowering showed positive significant association with days to maturity (0.9294**/0.9602), plant height (0.1920**/0.2139**), number of panicles per plant (0.3248**/0.3811), test weight (0.2425**/0.2519) and kernel length (0.1655**/0.2002**) while with kernel breadth (0.0891/0.0929) and grain yield (0.0830/0.0794) it showed positive non-significant association at both phenotypic and genotypic levels. Negative non-significant association was observed with panicle length (-0.0293/-0.0641) and L/B ratio (-0.0355/-0.0320) at both phenotypic and genotypic levels. Days to maturity showed significant positive association with plant height (0.2161**/0.2309**), number of panicles per plant (0.3565**/0.3956**), test weight (0.2301**/0.2382**), kernel length (0.1890**/ 0.2147**) at both genotypic and phenotypic levels where as with kernel breadth (0.1018/0.1116) and grain yield per plant, it showed positive non-significant association at both levels. At phenotypic and genotypic level, panicle length (-0.0708/-0.0902) and L/B ratio (-0.0486/-0.0443) showed negative non-significant association with days to maturity. Non-significant association of days to 50% flowering and days to maturity with grain yield indicates that this trait has little influence in improving the yield. Plant height showed positive significant association with number of panicles per plant (0.4577**/0.4890**), panicle length (0.3670**/0.4296**) and kernel length (0.1743**/0.1916**) at both genotypic and phenotypic levels. Positive non-significant association was observed for test weight (0.0031) at phenotypic level and for kernel breadth (0.0069/0.0170), L/B ratio (0.0824/00841) and grain yield (0.0523/0.0475) at both genotypic and phenotypic levels. This shows that increase in plant height will leads to increase in number of panicles per plant, panicle length and kernel length while in our present investigation plant height has little influence on improving grain yield per plant.

Number of panicles per plant showed positive significant correlation with panicle length (0.1449*/0.1642*), kernel length (0.1822**/0.2170**) and L/B ratio (0.1631*/0.2003**) at both genotypic and phenotypic levels while it showed positive non-significant association with test weight (0.0657/0.0769) at both the levels. Kernel breadth (-0.1380*) showed negative significant association at genotypic level where as grain yield per plant (-0.0193/-0.0286) showed negative non-significant correlation with number of panicles per plant at both genotypic and phenotypic levels. This result indicates that increase in number of panicles per plant will result in increase of panicle length, kernel length and L/B ratio while kernel breadth will be reduced. Panicle length showed significant positive association with grain yield per plant (0.3157**/0.3543**) and L/B ratio (0.2648**/ 0.3281**) while with test weight (-0.2633**/-0.3254**) and kernel breadth (-0.2794**/-0.3990**) it showed significant negative association at both the levels. *This* showed that increase in panicle length will increase grain yield and L/B ratio. Hence selection of plants with higher panicle length will improve yield.

Test weight recorded positive significant correlation with kernel length (0.2252**/0.2383**) and kernel breadth (0.4**/0.5120**) whereas with L/B ratio it recorded significant negative correlation (-0.2066**/-0.2653**) at both genotypic and phenotypic levels. Negative non-significant association was recorded with grain yield per plant (-0.1071/-0.1138) at both the levels. These results showed that increase in test weight will increase kernel length and kernel breadth while L/B ratio will be reduced where as its influence on grain yield is not significant. Kernel length showed positive significant association with L/B ratio (0.5326**/0.5847**) while negative non-significant association with kernel breadth (-0.0360/-0.0414) and grain yield per plant (-0.0152/-0.0176) at both the levels. These results indicate that increase in kernel length will increase L/B ratio while it recorded non-significant association with grain yield. Kernel breadth showed significant negative correlation with kernel L/B ratio (-0.8083**/-0.8287**) and negative non-significant association with grain yield per plant (-0.0204/-0.0280) at both the levels. This shows that increase in kernel breadth results in reduction of kernel length and L/B ratio but it has no significant impact on grain yield. L/B ratio recorded positive non-significant association with grain yield per plant (0.0234/0.0297). This shows that L/B ratio has no direct role in improving grain yield per plant [2,7,8,14].

The above interrelationship explained in [Fig-1 & 2] amongst the traits indicated that Panicle length had positive significant correlation with grain yield per plant and hence direct selection for such trait will be effective in improving the yield. The strong positive association among the traits indicated that simultaneous selection for these characters would result in improvement of high yielding varieties. Although days to 50% flowering, days to maturity, plant height and L/B ratio did not exhibit positive significant association with grain yield, their role in contributing towards grain yield could not be overlooked as these component traits exhibited positively significant association with important yield attributes. Thus, these traits may be assumed to indirectly contribute via other traits in governing grain yield. In this regard it is important to partition out the observed phenotypic association into direct and indirect effects of the component traits towards grain yield.

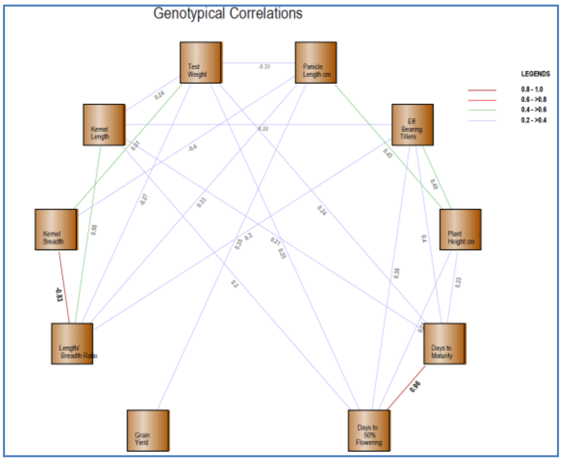

Fig-1 Genotypic correlations

A character contributing to grain yield may contribute directly or indirectly. The estimates of direct and indirect effect are presented in [Table-3]. In the present investigation, panicle length had the highest positive direct effect coupled with positive significant correlation with grain yield per plant. Therefore, simultaneous improvement of grain yield is possible through selection of this trait. Days to 50% flowering and L/B ratio also recorded direct positive effects but have positive non-significant correlation. Hence indirect factors are to be considered for improving the yield.

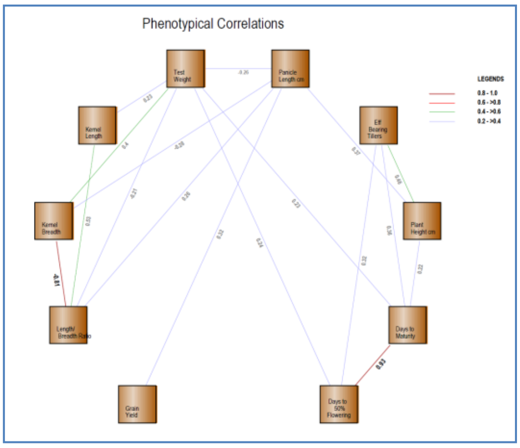

Fig-2 Phenotypic correlations

The direct contribution of Days to 50% flowering on yield was positive (0.2658/0.2303) at phenotypic and genotypic levels while it showed positive non-significant correlation (0.0830/0.0794) with the grain yield per plant at both the levels. It manifested positive indirect effects *via* days to maturity (0.4715) and number of panicles per plant (0.0130) at genotypic level only while for kernel breadth (0.0126/0.5519) at both genotypic and phenotypic levels. Negative indirect effects at both the levels were recorded *via* plant height (-0.0138/-0.0540), panicle length (-0.0103/-0.0256), test weight (-0.0204/-0.1037), kernel length (-0.0030/-0.7790) and L/B ratio (-0.0020/-0.2250). Days to maturity manifested positive direct effect on yield (0.4910) at genotypic level only while it showed positive non-significant correlation (0.0380/0.0499) with the grain yield per plant at both the levels where as it reported positive indirect effects via days to 50% flowering (0.2471/0.2211) and kernel breadth (0.0144/0.6631) at both the levels and via number of panicles per plant (0.0135) at genotypic level only. It recorded negative indirect effect via plant height (-0.0155/-0.0583), panicle length (-0.0249/-0.0360), test weight (-0.0194/-0.0981), kernel length (-0.0034/-0.8353) and L/B ratio (-0.0027/-0.3114) at both genotypic and phenotypic levels.

Table-3 *Path coefficients of yield and yield components of rice (Oryza sativa L.)during kharif, 2015*.

S. No.	Characters		Days to 50% flowering	Days to maturity	Plant height (cm)	Number of panicles per plant	Panicle length (cm)	Test weight (g)	Kernel length (mm)	Kernel breadth (mm)	L/B ratio
1.	Days to 50% flowering	P	**0.2658**	0.2471	0.0510	0.0864	-0.0078	0.0645	0.0440	0.0237	-0.0094
		G	**0.2303**	0.2211	0.0493	0.0878	-0.0148	0.0580	0.0461	0.0214	-0.0074
2.	Days to maturity	P	-0.1252	**-0.1347**	-0.0291	-0.0480	0.0095	-0.0310	-0.0255	-0.0137	0.0065
		G	0.4715	**0.4910**	0.1134	0.1942	-0.0443	0.1169	0.1054	0.0548	-0.0217
3.	Plant height (cm)	P	-0.0138	-0.0155	**0.0719**	-0.0329	-0.0264	-0.0002	-0.0125	-0.0005	-0.0059
		G	-0.0540	-0.0583	**-0.2523**	-0.1234	-0.1084	0.0011	-0.0483	-0.0043	-0.0212
4.	Number of panicles per plant	P	-0.0207	-0.0227	-0.0291	**-0.0637**	-0.0092	-0.0042	-0.0116	0.0055	-0.0104
		G	0.0130	0.0135	0.0167	**0.0342**	0.0056	0.0026	0.0074	-0.0047	0.0069
5.	Panicle length (cm)	P	-0.0103	-0.0249	0.1293	0.0511	**0.3523**	-0.0927	0.0030	-0.0984	0.0933
		G	-0.0256	-0.0360	0.1716	0.0656	**0.3994**	-0.1300	-0.0047	-0.1593	0.1310
6.	Test weight (g)	P	-0.0204	-0.0194	-0.0003	-0.0055	0.0222	**-0.0843**	-0.0190	-0.0337	0.0174
		G	-0.1037	-0.0981	0.0018	-0.0317	0.1340	**-0.4117**	-0.0981	-0.2108	0.1092
7.	Kernel length (mm)	P	-0.0030	-0.0034	-0.0032	-0.0033	-0.0002	-0.0041	**-0.0181**	0.0007	-0.0097
		G	-0.7790	-0.8353	-0.7455	-0.8441	0.0457	-0.9271	**-3.8904**	0.1611	-2.2749
8.	Kernel breadth (mm)	P	0.0126	0.0144	0.0010	-0.0123	-0.0394	0.0564	-0.0051	**0.1410**	-0.1140
		G	0.5519	0.6631	0.1011	-0.8197	-2.3699	3.0410	-0.2460	**5.9399**	4.9225
9.	L/B ratio	P	-0.0020	-0.0027	0.0046	0.0091	0.0147	-0.0115	0.0296	-0.0450	**0.0556**
		G	-0.2250	-0.3114	0.5914	1.4085	2.3069	-1.8648	4.1110	-5.8261	**7.0303**
10.	Grain yield per plant (g)	P	0.0830	0.0380	0.0523	-0.0193	0.3157	-0.1071	-0.0152	-0.0204	0.0234
		G	0.0794	0.0499	0.0475	-0.0286	0.3543	-0.1138	-0.0176	-0.0280	0.0297

Bold are direct effects. Residual effect(P): R= 0.9309
P: Phenotypic path coefficient (G): R= 0.8191; G: Genotypic path coefficient

The direct contribution of plant height on yield was positive (0.4910) at phenotypic level only while it showed positive non-significant correlation (0.0523/0.0475) with the grain yield per plant at both the levels. Plant height recorded positive indirect effects via days to 50% flowering (0.0510/0.0493), panicle length (0.1293/0.1716), kernel breadth (0.0010/0.1011) and L/B ratio (0.0046/0.5914) at both the levels and via number of panicles per plant (0.0167), days to maturity (0.1134) and test weight (0.0018) at genotypic level only. These results suggest that indirect casual factors are to be considered for improvement of yield when the traits days to 50% flowering, days to maturity and plant height are considered.

The direct contribution of number of panicles per plant on yield was positive (0.0342) at phenotypic level only while it showed negative non-significant correlation (-0.0193/-0.0286) with the grain yield per plant at both the levels. Here, correlation coefficient is negative and non-significant while direct effect was positive. Hence, a restricted simultaneous selection model is to be followed i.e., restrictions are to be imposed to nullify the undesirable indirect effects in order to make use of the direct effect. Number of panicles per plant recorded positive indirect effects via days to 50% flowering (0.0864/0.0878), panicle length (0.0511/0.0656) and L/B ratio (0.0091/1.4085) at both the levels and via days to maturity (0.1942) at genotypic level only. While it recorded negative indirect effect via plant height (-0.0329/-0.1234), test weight (-0.0055/-0.0317), kernel length (-0.0033/-0.8441) and kernel breadth (-0.0123/-0.8917) at both the levels.

The direct contribution of panicle length on yield was positive (0.3523/0.3994) at phenotypic and genotypic levels while it showed significant positive correlation (0.3157**/0.3543**) with the grain yield per plant at both the levels. Here as the correlation coefficient between a causal factor and the effect is almost equal to its direct effect, correlation explains the true relationship and a direct selection through this trait will be effective. Panicle length manifested positive indirect effects *via* days to maturity (0.0095) at phenotypic level and number of panicles per plant (0.0056) at genotypic level only while for test weight (0.0222/0.1340) and L/B ratio (0.0147/2.3069) at both genotypic and phenotypic levels. Negative indirect effects at both the levels were recorded *via* days to 50% flowering (-0.0078/-0.0148), plant height (-0.0264/-0.1084) and kernel breadth (-0.0394/-2.3699).

The direct contribution of test weight on yield was negative (-0.0843/-0.4117) at phenotypic and genotypic levels while it showed negative non-significant correlation (-1.8648/-0.1071) with the grain yield per plant at both the levels. Test weight manifested positive indirect effects *via* days to maturity (0.1169), plant height (0.0011) and number of panicles per plant (0.0026) at genotypic level only while for days to 50% flowering (0.0645/0.0580) and kernel breadth (0.0564/3.0410) at both genotypic and phenotypic levels. Negative indirect effects at both the levels were recorded *via* panicle length (-0.0927/-0.1300), kernel length (-0.0041/-0.9271) and L/B ratio (-0.0115/-1.8648). The direct contribution of kernel length on yield was negative (-0.0181/-3.8904) at phenotypic and genotypic levels while it showed negative non-significant correlation (-0.0152/-0.0176) with the grain yield per plant at both the levels. As both correlation coefficient and direct effect was negative at both the levels, for test weight and kernel length, selection should be dropped based on this character. The trait kernel length manifested positive indirect effects *via* panicle length (0.0030) at phenotypic level whereas days to maturity (0.1054) and number of panicles per plant (0.0074) at genotypic level only while for days to 50% flowering (0.0440/0.0461) and L/B ratio (0.0296/4.1110) at both genotypic and phenotypic levels. Negative indirect effects at both the levels were recorded *via* plant height (-0.0125/ -0.0483), test weight (-0.0190/-0.0981) and kernel breadth (-0.0051/-0.2460).

The direct contribution of kernel breadth on yield was positive (0.1410/5.9399) at phenotypic and genotypic levels while it showed negative non-significant correlation (-0.0204/-0.0280) with the grain yield per plant at both the levels. Here as the correlation coefficient was negative but the direct effect was positive and high, a restricted simultaneous selection model is to be followed *i.e.*, restrictions are to be imposed to nullify the undesirable indirect effects in order to make use of the direct effect. Kernel breadth manifested positive indirect effects *via* number of panicles per plant (0.0055) at phenotypic level whereas days to maturity (0.0548) at genotypic level only while for days to 50% flowering (0.0237/0.0214) and kernel length (0.0007/0.1611) at both genotypic and phenotypic levels. Negative indirect effects at both the levels were recorded *via* plant height (-0.0005/-0.0043), panicle length (-0.0984/-0.1593), test weight (-0.0337/-0.2108) and L/B ratio (-0.0450/-5.8261). The direct contribution of L/B ratio on yield was positive (0.0556/7.0303) at phenotypic and genotypic levels while it showed positive non-significant correlation (0.0234/0.0297) with the grain yield per plant at both the levels. These results suggested that indirect casual factors are to be considered for improvement of yield. The trait L/B ratio manifested positive indirect effects *via* days to maturity (0.0030) at phenotypic level where as with number of panicles per plant (0.0069) and kernel breadth (4.9225) at genotypic level only while for panicle length (0.0933/0.1310) and test weight (0.0174/0.1092) at both genotypic and phenotypic levels. Negative indirect effects at both the levels were recorded *via* days to 50% flowering (-0.0094/-0.0074), plant height (-0.0059/-0.0212) and kernel length (-0.0097/-2.2749) [1,5,7,11,12,13].

Residual effect was high (81.9%) indicating that some other factors which were not been considered in the study, need to be included in the analysis to explain total variation in yield [Fig-3].

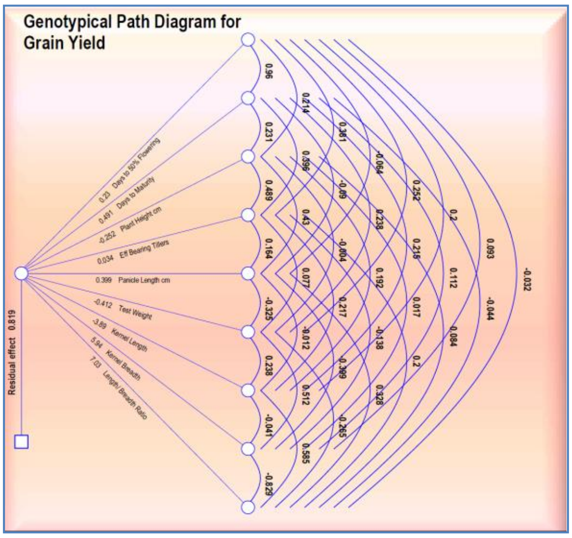

Fig-3 Genotypical path diagram for grain yield per plant

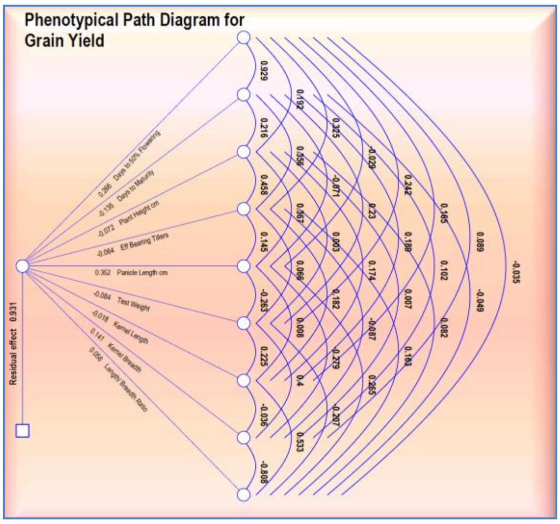

Fig-4 Phenotypical path diagram for grain yield per plant

Application of research: Character association and Path analysis studies gives the degree of relationship among the characters and their direct and indirect effects towards grain yield. In my present study, of character association and path coefficient analysis indicated that panicle length had positive direct effect [Fig-3&4] coupled with positive significant correlation with grain yield per plant and hence direct selection can be made based on this trait for improving yield.

Research Category: Character association and Path analysis

Abbreviations:
APRRI: Andhra Pradesh Rice Research Institute
RARS: Regional Agriculture Research Station
L/B: Length to Breadth Ratio
cm: centimeters
viz.: namely

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Principle Investigator: Dr B.N.V.S.R. Ravi Kumar, Scientist, Plant Breeding, APRRI & RARS, Maruteru, West Godavari District, Andhra Pradesh, India
University: Acharya N.G. Ranga Agricultural University, Rajendranagar, Hyderabad, 500 030
Research project name or number: MSc Thesis, Entitled Character Association and Screening for Sheath Blight and Bacterial Leaf Blight of F5 Families in Rice (*Oryza sativa* L.)

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