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Investigating Phenotypic Correlation and Path Analysis in Rice (Oryza sativa L.) Under Irrigated and Rain-fed Conditions

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Abstract

To develop a breeding programme to improve drought tolerance of a crop, it is necessary to gain an understanding on how the crop reacts to drought. This is best done under field conditions in the area, where the crop is grown, since the seasonal timing of drought stress varies from one location to another. While selecting a suitable plant type, correlation studies would provide reliable information on nature, extent and direction of selection, especially when the breeder needs to combine high potentials with desirable agronomic traits and grain quality characters. Path coefficient analysis on the other hand is an efficient statistically technique specially designed to quantify the interrelationship of different components and their direct and indirect effects on grain yield. This approach is more important to comprehend genetic makeup of dependent trait when the determining component characters are correlated. The experimental material for the present study comprised of 25 entries (6 parents + 9 F1's + 9 F2's + 1 check), planted in a compact family block design with three replications. HUR 3022, HUR 105 and Sarjoo 52 were planted as lines and Nagina 22, Anjali and Birsa Gora were treated as testers. The experiment was conducted in two water regimes: irrigated and rainfed conditions, respectively. All experimental materials were tested under both the conditions. Recommended agronomic practices were followed to grow a healthy crop. Observations were recorded on 20 randomly selected plants per replication for eleven characters viz., seedling height (SH), plant height (PH), stomatal behavior (SB), leaf rolling (LR), stay green (SG), panicle weight (PW), percent filled grains (PFG), spikelet per panicle (SPP), thousand grain weight (TGW), yield per plant (YPP) and proline content (PC). The mean values recorded for eleven characters in F2 generation were used for statistical analysis. The results of this research showed that indirect se¬lections for increasing the number of SPP and decreasing SH and PH under both the conditions can be suitable to improve paddy yield of rice in breeding programs. The component traits such as, PC, SB, LR, SG, PFG, TGW and YPP singly or in combinations appear to be most important towards enhancing seed yield and also drought tolerance in transgressive segregants.

Introduction

Cereals have played a significant role in the evolution of human civilization. Rice (Oryza sativa L.) is a member of cereals, belonging to the order Poales of the grass family Poaceae (Graminae), grown all over the world. Rice (Oryza sativa L.) is the staple food of more than three billion people in the world, most of them living in Asia. Irrigated rice accounts for 55% of world area and about 75% of total rice production. Rain-fed lowland represents about 25% of total rice area, accounting for 17% of world rice production. Upland rice covers 13% of the world rice area and accounts for 4% of global rice production. Deepwater rice, although it has less area, meets the need of around 100 million people. In India, the total area under irrigated, rain-fed lowland and upland rice is 22.0, 14.4, and 6.3 million ha, respectively (Singh, 2009).

Studies on the plant response to water stress are becoming increasingly important, as most of climatic change scenarios suggest an increase in aridity in many areas of the globe (Petit et al., 1999). On a global basis, drought (assumed to be soil and/ or atmospheric water deficit) in conjunction with high temperature and radiation, possess the most important environmental constraints to plant survival and to crop productivity (Boyer, 1982). As irrigation water is not adequate as per crop requirement, the possible solutions to improve field productivity are i) environment control development i.e. improve plant living environment to fit the needs of crop, this includes technologies which reduce soil and water loss, decrease soil water evaporation, increase and maximize the use of soil water storage, collect non cultivate field run offs and use them as irrigation supplement. ii) Approach of biological water saving i.e. modify plant to adapt the dry environment; this includes genetic modification of plant, physiological regulation and application of crop complementary effort. It is stated that management practices can contribute to increase yield in moisture stress environments but major progress will be realized through genetic improvement (White et al., 1994; Singh, 1995; Yadav et al., 2003) and therefore through plant breeding and molecular breeding, it would be better to develop drought tolerant varieties than to irrigate rain-feds.

To develop a breeding programme to improve drought tolerance of a crop, it is necessary to gain an understanding on how the crop reacts to drought. This is best done under field conditions in the area, where the crop is grown, since the seasonal timing of drought stress varies from one location to another. Phenotype is the outcome of the interaction of the genotype with the environment. Rice's susceptibility to water stress is more pronounced at the reproductive stage and causes the greatest reduction in grain yield when stress coincides with the irreversible reproductive processes (Matsushima, 1966; Cruz and O'Toole, 1984). The genetic architecture of grain yield can be better resolved through components rather than yield per se, as the yield is the end product of multiplication interactions between various yield components (Grafius, 1959).

While selecting a suitable plant type, correlation studies would provide reliable information on nature, extent and direction of selection, especially when the breeder needs to combine high potentials with desirable agronomic traits and grain quality characters. Path coefficient analysis on the other hand is an efficient statistically technique specially designed to quantify the interrelationship of different components and their direct and indirect effects on grain yield. This approach is more important to comprehend genetic makeup of dependent trait when the determining component characters are correlated.

A simple correlation does not provide the true associations of character with each other as these attributes are related among themselves and considerably influence each other. Hence, these correlations are partitioned into direct and indirect effects to pin point the precise direct and indirect cause of these association. In the present investigation, phenotypic correlations of seed yield per plant with other characters were partitioned into their direct and indirect effects through path coefficient analysis.

Materials and Methods:

The present investigation was conducted during three kharif seasons i.e. 2010, 2011 and 2012 at Agricultural Farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi. The experimental material for the present study comprised of 25 entries (6 parents + 9 F1's + 9 F2's + 1 check), planted in a compact family block design with three replications. HUR 3022, HUR 105 and Sarjoo 52 were planted as lines and Nagina 22, Anjali and Birsa Gora were treated as testers. The experiment was conducted in two water regimes: irrigated and rainfed conditions, respectively. All experimental materials were tested under both the conditions. Recommended agronomic practices were followed to grow a healthy crop. While P and K were applied in full dose at the time of sowing, N was applied in three splits as top dressing. Insect and weed control management were applied periodically as required.

Observations were recorded on 20 randomly selected plants per replication for eleven characters viz., seedling height (SH), plant height (PH), stomatal behavior (SB), leaf rolling (LR), stay green (SG), panicle weight (PW), percent filled grains (PFG), spikelet per panicle (SPP), thousand grain weight (TGW), yield per plant (YPP) and proline content (PC). The mean values recorded for eleven characters in F2 generation were used for statistical analysis. The genotypic and phenotypic correlation coefficients were estimated and path coefficient analysis was done as per Dewey and Lu and Singh and Chaudhary.

Results and Discussion

Phenotypic correlation under irrigated and rainfed conditions:

SH was reported to show positive significant correlation with PH, PC and SG in kharif, 2012 (irrigated and rainfed). It also exhibited negative significant correlation with LR and TGW in kharif, 2012 (irrigated and rainfed condition). PH reported positive significant correlation with PC, SB and SG in kharif, 2012 (irrigated and rainfed). PH exhibited negative significant correlation with LR and TGW in kharif 2011 and 2012 (irrigated). It also showed negative significant correlation with PW, LR and TGW in kharif, 2012 (rainfed) at phenotypic level. PH reported positive significant correlation with PC and SB in the season kharif, 2011 and positive significant correlation with PC, SB and SG in kharif, 2012 (irrigated and rainfed). PH exhibited negative significant correlation with LR and TGW in kharif 2011 and 2012 (irrigated). It also showed negative significant correlation with PW, LR and TGW in kharif, 2012 (rainfed). PC exhibited positive significant correlation with SB and SG in kharif, 2011, 2012 (irrigated) and 2012 (rainfed). While its association with PW, PFG, LR, TGW and YPP was found to be negative but significant in kharif, 2011. In kharif, 2012 (irrigated), PC exhibited negative significant correlation with PW, SPP, LR, TGW and YPP whereas in kharif, 2012 (rainfed), it showed negative significant correlation with PW, PFG, SPP, LR, TGW and YPP. SB exhibited positive significant correlation with PW, SPP, PFG, TGW and YPP in kharif, 2011 and 2012 (rainfed) and PW, PFG, TGW and YPP in kharif, 2012 (irrigated). Whereas it exhibited negative significant correlation with LR and SG in kharif 2011 and 2012 (rainfed) and LR in kharif, 2012 (irrigated). Association of PW with SPP, PFG, LR, TGW and YPP was found to be positive and significant in kharif, 2011, 2012 (irrigated) and 2012 (rainfed). Whereas it exhibited negative significant correlation with stay green in kharif 2011, 2012 (irrigated) and 2012 (rainfed) season. SPP exhibited positive significant correlation with PFG, LR, TGW and YPP in kharif, 2011, 2012 (irrigated) whereas it reported positive significant correlation with PFG, TGW and

YPP in kharif, 2012 (rainfed). Whereas it exhibited negative significant correlation with SG in kharif 2011, 2012 (irrigated) and 2012 (rainfed). Association of PFG with TGW and YPP was found to be positive and significant in kharif, 2011, 2012 (irrigated) and 2012 (rainfed). Whereas it exhibited negative significant correlation with stay green in kharif 2011, 2012 (irrigated) and 2012 (rainfed). LR reported positive significant correlation with YPP kharif in 2012 (irrigated) and TGW in 2012 (rainfed) whereas it exhibited negative significant correlation with SG in kharif 2011, 2012 (irrigated) and 2012 (rainfed). SG was reported to have negative significant correlation with TGW and YPP in kharif 2011 and kharif, 2012 (rainfed). Whereas it exhibited negative significant correlation with YPP in kharif, 2012 (irrigated). TGW reported positive significant correlation with YPP in kharif, 2011, 2012 (irrigated) and 2012 (rainfed).

Phenotypic path coefficient analysis under irrigated and rainfed conditions:

SH exhibited substantial negative direct effect on YPP. It showed positive indirect effect on YPP via PW, SPP, PFG and LR. SH contributed considerable negative indirect effect on YPP via PH, PC, SB, SG and TGW, in kharif, 2011 and 2012 (irrigated). SH was reported to exhibit positive indirect effect on YPP via PW, SPP and LR and negative indirect effect on YPP via PH, PC, SB, PFG, SG and TGW, in kharif, 2012 (rainfed). PH exhibited positive direct effect on YPP in kharif, 2011 and 2012 (rainfed) and negative direct effect on YPP in kharif, 2012 (irrigated). Plant height made substantial positive indirect contribution on YPP via SH, PC, SB, PFG and SG and in kharif, 2011 and 2012 (rainfed). Negative indirect effect on YPP was contributed by PH via PW, SPP, LR and TGW in kharif, 2011 and 2012 (rainfed). PH exhibited positive indirect effect on YPP via PW, SPP, PFG, LR and TGW in kharif, 2012 (irrigated) and negative indirect effect on YPP was contributed via SH, PC, SB and SG in kharif, 2012 (irrigated). PC exerted negative direct effect on YPP in kharif, 2011 and 2012 (rainfed) and positive direct effect on YPP in kharif, 2012 (irrigated). PC exhibited positive indirect effect on YPP via PW, SPP, PFG and LR in kharif, 2011 and 2012 (rainfed) whereas negative indirect effect on PC was exhibited by SH, PH, SB, SG and TGW in kharif, 2012 (irrigated). SH, PH, SB and SG were reported to exert positive indirect effect on PC in kharif, 2012 (irrigated) whereas negative indirect effect on YPP was exhibited via PW, SPP, PFG, LR and TGW in kharif, 2012 (irrigated). SB exhibited negative direct effect on YPP in kharif, 2011 and 2012 (irrigated) and positive direct effect on YPP in kharif, 2012 (rainfed). SB showed positive indirect effect on YPP via LR and SG in kharif, 2011 and 2012 (irrigated). It also exhibited negative indirect effect on YPP via SH, PH, PC, PW, SPP, PFG and TGW in kharif 2012 (irrigated). SB showed positive indirect effect on YPP via SH, PH, PC, PW, SPP and PFG in kharif, 2012 (rainfed), whereas it exhibited negative indirect effect on YPP via LR, SG and TGW in kharif, 2012 (rainfed). PW exhibited high positive direct effect on YPP in kharif, 2011 and 2012 (irrigated) while negative direct effect on YPP was reported in kharif, 2012 (rainfed). PW showed positive indirect effect on YPP via SB, SPP, PFG, LR and TGW in kharif, 2011 and 2012 (irrigated). PW was reported to have negative indirect effect on YPP via SH, PH, PC and SG in kharif, 2011 and 2012 (irrigated). PW showed positive indirect effect on YPP via SH, PH, PC, SG and TGW in kharif, 2012 (rainfed) whereas it exhibited negative indirect effect on YPP via SB, SPP, PFG and LR in kharif, 2012 (rainfed). SPP exhibited negative direct effect on YPP in kharif, 2011 and high positive direct effect on YPP in kharif, 2012 (irrigated) and 2012 (rainfed). SPP also showed positive indirect effect via SH, PH, PC and SG in kharif, 2011 whereas it exhibited negative indirect effect on YPP via SB, PW, PFG, LR and TGW in kharif, 2011. SPP contributed considerable positive indirect effect via SB, PW, PFG, LR and TGW whereas negative indirect effect on YPP was contributed via SH, PH, PC and SG in kharif, 2012 (irrigated) and 2012 (rainfed). PFG was reported to excise high positive direct effect on YPP in kharif, 2011, 2012 (irrigated) and 2012 (rainfed). PFG was reported to have positive indirect effect via PH, SB, PW, SPP and TGW in kharif, 2011. Positive indirect effect via PH, SB, PW and SPP for YPP was exhibited in kharif, 2012 (irrigated) whereas SH, PH, SB, PW, SPP and TGW also showed positive indirect effect in kharif, 2012 (rainfed). PFG exerted negative indirect effect on YPP via SH, PC, LR and SG in kharif, 2011. It also reported negative indirect effect on YPP via SH, PC, LR, SG and TGW in kharif, 2012 (irrigated) whereas in kharif, 2012 (rainfed), PFG showed negative indirect effect on YPP via PC, LR and SG. LR exerted negative direct effect on YPP in kharif, 2010 and 2011 (irrigated) and positive direct effect in kharif, 2012 (rainfed). LR was reported to exert positive indirect effect on YPP via SH, PH, PC, SB, PFG and SG in kharif, 2011 and 2012 (irrigated) whereas in kharif 2012 (rainfed) positive indirect effect was excised via PW and SPP. LR exhibited negative indirect effect on YPP via PW, SPP and TGW in kharif, 2011 and 2012 (irrigated) whereas it showed negative indirect effect on YPP via

SH, PH, PC, SB, PFB, SG and TGW in kharif, 2012 (rainfed). SG exerted positive direct effect on YPP in kharif, 2011 and 2012 (irrigated) and negative direct effect on YPP in kharif, 2012 (rainfed). SG excised positive indirect effect on YPP via SH, PH and PC in kharif, 2011 and 2012 (irrigated) whereas in kharif 2012 (rainfed), SG exerted positive indirect effect via SB, PW, SPP, PFG and LR. It was reported that SG showed negative indirect effect on YPP via SB, PW, SPP, PFG, LR and TGW in kharif, 2011 and 2012 (irrigated). SG exhibited negative indirect effect on YPP via SH, PH, PC and TGW in kharif, 2012 (rainfed). TGW exhibited positive direct effect on YPP in kharif, 2011, 2012 (irrigated) and 2012 (rainfed). TGW exhibited positive indirect effect on YPP via SH, SB, PW and PFG in kharif, 2011 and 2012 (irrigated) whereas in kharif, 2012 (rainfed), TGW showed positive indirect effect on YPP via PW and SPP. TGW exerted negative indirect effect on YPP via PH, PC, SPP, LR and SG in kharif, 2011 and 2012 (irrigated). Whereas in kharif, 2012 (rainfed), TGW showed negative indirect effect on YPP via SH, PH, PC, SB, PFG, LR and SG.

Conclusion

The results of this research showed that indirect selections for increasing the number of SPP and decreasing SH and PH under both the conditions can be suitable to improve paddy yield of rice in breeding programs. The component traits such as, PC, SB, LR, SG, PFG, TGW and YPP singly or in combinations appear to be most important towards enhancing seed yield and also drought tolerance in transgressive segregants.

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TABLES

Table 1a: ESTIMATES OF PHENOTYPIC CORRELATION CO EFFICIENT (rg) FOR YIELD AND TEN COMPONENT CHARACTERS IN RICE IN KHARIF, 2011, 2012 (IRRIGATED) and 2012 (RAINFED)

TRAITS	SEASON	S. H	P. H	PC	SB	PW	SPP	PFG	LR	SG	TGW
S. H	**2011**	**1**	0.7894 ***	0.5824 ***	0.1576	-0.4187 **	-0.5442 ***	-0.2811	-0.5449 ***	0.5692 ***	0.1215
	2012(I)	1	0.8145 ***	0.6894 ***	0.1073	-0.3877 **	-0.4237 **	-0.3076 *	-0.5650 ***	0.5913 ***	-0.0463
	2012(RF)	1	0.7837 ***	0.6003 ***	0.122	-0.4119 **	-0.4732 **	-0.1432	-0.5456 ***	0.6304 ***	-0.111
P. H	**2011**	0.7894 ***	**1**	0.6945 ***	0.1574	-0.4240 **	-0.4170 **	-0.4446 **	-0.5392 ***	0.6160 ***	0.0124
	2012(I)	0.8145 ***	1	0.7556 ***	0.0656	-0.3757 *	-0.3646 *	-0.4998 ***	-0.4757 ***	0.5973 ***	-0.1273
	2012(RF)	0.7837 ***	1	0.8428 ***	0.0675	-0.5942 ***	-0.5878 ***	-0.4665 **	-0.4651 **	0.6745 ***	-0.2406
PC	**2011**	0.5824 ***	0.6945 ***	**1**	0.3445 *	-0.4624 **	-0.3429 *	-0.6046 ***	-0.6608 ***	0.7611***	0.0235
	2012(I)	0.6894 ***	0.7556 ***	1	0.3275 *	-0.5508 ***	-0.6018 ***	-0.5309 ***	-0.7008 ***	0.7894 ***	-0.0402
	2012(RF)	0.6003 ***	0.8428 ***	1	0.2854	-0.7969 ***	-0.8017 ***	-0.6374 ***	-0.5981 ***	0.8417 ***	-0.1966
SB	**2011**	0.1576	0.1574	0.3445 *	**1**	-0.5502 ***	-0.2431	-0.1198	-0.6862 ***	0.6529 ***	0.0608
	2012(I)	0.1073	0.0656	0.3275 *	1	-0.3887 **	-0.5521 ***	-0.0885	-0.6448 ***	0.6287 ***	-0.0145
	2012(RF)	0.122	0.0675	0.2854	1	-0.4631 **	-0.5191 ***	-0.1058	-0.6410 ***	0.5651 ***	0.2632
PW	**2011**	-0.4187 **	-0.4240 **	-0.4624 **	-0.5502 ***	**1**	0.7560 ***	0.4856 ***	0.6387 ***	-0.7558 ***	0.1773
	2012(I)	-0.3877 **	-0.3757 *	-0.5508 ***	-0.3887 **	1	0.9442 ***	0.6251 ***	0.5809 ***	-0.7213 ***	0.3905 **
	2012(RF)	-0.4119 **	-0.5942 ***	-0.7969 ***	-0.4631 **	1	0.9859 ***	0.6307 ***	0.7208 ***	-0.9076 ***	0.0494
SPP	**2011**	-0.5442 ***	-0.4170 **	-0.3429 *	-0.2431	0.7560 ***	**1**	0.2932	0.4948 ***	-0.4865 ***	-0.0209
	2012(I)	-0.4237 **	-0.3646 *	-0.6018 ***	-0.5521 ***	0.9442 ***	1	0.5397 ***	0.7280 ***	-0.7923 ***	0.2897
	2012(RF)	-0.4732 **	-0.5878 ***	-0.8017 ***	-0.5191 ***	0.9859 ***	1	0.5676 ***	0.7987 ***	-0.9521 ***	0.0189
PFG	**2011**	-0.2811	-0.4446 **	-0.6046 ***	-0.1198	0.4856 ***	0.2932	**1**	0.1496	-0.5858 ***	0.2842
	2012(I)	-0.3076 *	-0.4998 ***	-0.5309 ***	-0.0885	0.6251 ***	0.5397 ***	1	0.1252	-0.4723 **	0.3925 **
	2012(RF)	-0.1432	-0.4665 **	-0.6374 ***	-0.1058	0.6307 ***	0.5676 ***	1	0.0377	-0.4525 **	0.3083 *

Table 1b: ESTIMATES OF PHENOTYPIC CORRELATION CO EFFICIENT (rg) FOR YIELD AND TEN COMPONENT CHARACTERS IN RICE IN KHARIF, 2011, 2012 (IRRIGATED) and 2012 (RAINFED)

TRAITS	SEASON	S. H	P. H	PC	SB	PW	SPP	PFG	LR	SG	TGW
LR	**2011**	-0.5449 ***	-0.5392 ***	-0.6608 ***	-0.6862 ***	0.6387 ***	0.4948 ***	0.1496	1	-0.8324 ***	-0.1562
	2012(I)	-0.5650 ***	-0.4757 ***	-0.7008 ***	-0.6448 ***	0.5809 ***	0.7280 ***	0.1252	1	-0.8682 ***	-0.0737
	2012(RF)	-0.5456 ***	-0.4651 **	-0.5981 ***	-0.6410 ***	0.7208 ***	0.7987 ***	0.0377	1	-0.8922 ***	-0.2451
SG	**2011**	0.5692 ***	0.6160 ***	0.7611***	0.6529 ***	-0.7558 ***	-0.4865 ***	-0.5858 ***	-0.8324 ***	1	-0.0496
	2012(I)	0.5913 ***	0.5973 ***	0.7894 ***	0.6287 ***	-0.7213 ***	-0.7923 ***	-0.4723 **	-0.8682 ***	1	-0.1009
	2012(RF)	0.6304 ***	0.6745 ***	0.8417 ***	0.5651 ***	-0.9076 ***	-0.9521 ***	-0.4525 **	-0.8922 ***	1	0.0122
TGW	**2011**	0.1215	0.0124	0.0235	0.0608	0.1773	-0.0209	0.2842	-0.1562	-0.0496	1
	2012(I)	-0.0463	-0.1273	-0.0402	-0.0145	0.3905 **	0.2897	0.3925 **	-0.0737	-0.1009	1
	2012(RF)	-0.111	-0.2406	-0.1966	0.2632	0.0494	0.0189	0.3083 *	-0.2451	0.0122	1
YPP	**2011**	-0.5051	-0.5136	-0.6369	-0.3002	0.6775	0.4312	0.708	0.3539	-0.6571	0.2532
	2012(I)	-0.37	-0.3501	-0.4502	-0.3915	0.8496	0.834	0.5841	0.4725	-0.6039	0.3525
	2012(RF)	0.0502	-0.2623	-0.4424	0.0349	0.2654	0.2242	0.6042	-0.1376	-0.1546	0.4964

Table 2a: ESTIMATES OF PHENOTYPIC PATH ANALYSIS FOR YIELD IN RICE IN KHARIF, 2011, 2012 (IRRIGATED) AND 2012 (RAINFED)

TRAITS	SEASON	S. H	P. H	PC	SB	PW	SPP	PFG	LR	SG	TGW
S. H	**2011**	-0.3861	-0.3048	-0.2249	-0.0609	0.1617	0.2101	0.1085	0.2104	-0.2198	-0.0469
	2012(I)	-0.1116	-0.0909	-0.077	-0.012	0.0433	0.0473	0.0343	0.0631	-0.066	0.0052
	2012(RF)	0.3243	0.2541	0.1946	0.0396	-0.1336	-0.1535	-0.0464	-0.1769	0.2044	-0.036
P. H	**2011**	0.0978	0.1239	0.0861	0.0195	-0.0525	-0.0517	-0.0551	-0.0668	0.0763	0.0015
	2012(I)	-0.1051	-0.1291	-0.0975	-0.0085	0.0485	0.0471	0.0645	0.0614	-0.0771	0.0164
	2012(RF)	0.0484	0.0618	0.0521	0.0042	-0.0367	-0.0363	-0.0288	-0.0288	0.0417	-0.0149
PC	**2011**	-0.2973	-0.3546	-0.5105	-0.1759	0.236	0.1751	0.3087	0.3374	-0.3886	-0.012
	2012(I)	0.0941	0.1032	0.1365	0.0447	-0.0752	-0.0822	-0.0725	-0.0957	0.1078	-0.0055
	2012(RF)	-0.4895	-0.6872	-0.8154	-0.2327	0.6498	0.6537	0.5197	0.4877	-0.6863	0.1603
SB	**2011**	-0.0136	-0.0136	-0.0298	-0.0864	0.0475	0.021	0.0103	0.0593	-0.0564	-0.0052
	2012(I)	-0.0161	-0.0098	-0.049	-0.1497	0.0582	0.0827	0.0132	0.0966	-0.0941	0.0022
	2012(RF)	-0.011	-0.0061	-0.0258	-0.0904	0.0419	0.0469	0.0096	0.0579	-0.0511	-0.0238
PW	**2011**	-0.3199	-0.324	-0.3533	-0.4205	0.7642	0.5777	0.3711	0.4881	-0.5776	0.1354
	2012(I)	-0.1642	-0.1591	-0.2333	-0.1646	0.4236	0.4	0.2648	0.2461	-0.3056	0.1654
	2012(RF)	0.3853	0.5559	0.7455	0.4333	-0.9355	-0.9224	-0.59	-0.6744	0.8491	-0.0462
SPP	**2011**	0.1366	0.1047	0.0861	0.061	-0.1898	-0.2511	-0.0736	-0.1243	0.1222	0.0053
	2012(I)	-0.2344	-0.2017	-0.3329	-0.3054	0.5223	0.5531	0.2985	0.4027	-0.4383	0.1602
	2012(RF)	-0.4849	-0.6023	-0.8214	-0.5319	1.0102	1.0246	0.5815	0.8184	-0.9756	0.0193
PFG	**2011**	-0.0112	-0.0178	-0.0242	-0.0048	0.0194	0.0117	0.0399	0.006	-0.0234	0.0114
	2012(I)	-0.0232	-0.0376	-0.04	-0.0067	0.0471	0.0406	0.0753	0.0094	-0.0356	0.0296
	2012(RF)	-0.0263	-0.0856	-0.117	-0.0194	0.1157	0.1041	0.1835	0.0069	-0.083	0.0566

Table 2b: ESTIMATES OF PHENOTYPIC PATH ANALYSIS FOR YIELD IN RICE IN KHARIF, 2011, 2012 (IRRIGATED) AND 2012 (RAINFED)

TRAITS	SEASON	S. H	P. H	PC	SB	PW	SPP	PFG	LR	SG	TGW
LR	**2011**	0.3625	0.3587	0.4396	0.4565	-0.4249	-0.3292	-0.0995	-0.6652	0.5537	0.1039
	2012(I)	0.1149	0.0967	0.1424	0.1311	-0.1181	-0.148	-0.0255	-0.2033	0.1765	0.015
	2012(RF)	0.1956	0.1668	0.2144	0.2298	-0.2584	-0.2864	-0.0135	-0.3585	0.3199	0.0879
SG	**2011**	-0.0802	-0.0868	-0.1073	-0.092	0.1065	0.0686	0.0826	0.1173	-0.141	0.007
	2012(I)	0.0746	0.0753	0.0995	0.0793	-0.091	-0.0999	-0.0596	-0.1095	0.1261	-0.0127
	2012(RF)	0.1405	0.1503	0.1875	0.1259	-0.2022	-0.2121	-0.1008	-0.1988	0.2228	0.0027
TGW	**2011**	0.0064	0.0007	0.0012	0.0032	0.0094	-0.0011	0.015	-0.0083	-0.0026	0.0529
	2012(I)	0.0011	0.003	0.0009	0.0003	-0.0091	-0.0067	-0.0091	0.0017	0.0023	-0.0232
	2012(RF)	-0.0322	-0.0699	-0.0571	0.0764	0.0143	0.0055	0.0895	-0.0712	0.0036	0.2904
YPP	**2011**	-0.5051	-0.5136	-0.6369	-0.3002	0.6775	0.4312	0.708	0.3539	-0.6571	0.2532
	2012(I)	-0.37	-0.3501	-0.4502	-0.3915	0.8496	0.834	0.5841	0.4725	-0.6039	0.3525
	2012(RF)	0.0502	-0.2623	-0.4424	0.0349	0.2654	0.2242	0.6042	-0.1376	-0.1546	0.4964