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Studies on Correlation and Path Analysis for Yield and Morpho-Physiological Traits in Elite Rice (*Oryza sativa* L.) Genotypes under Dry DSR System

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ABSTRACT

An experiment was conducted at the Agricultural College, Aswaraopet, Bhadradri Kothagudem district, Telangana, India during July to December 2021 by using thirty elite rice genotypes comprising of different durations *i.e.* short, medium and long to study the nature of relationship between grain yield and morpho-physiological traits by partitioning the correlation co-efficients between grain yield and morpho-physiological traits into direct and indirect effects. Observations were recorded on seven yield, six physiological and three root characters. The correlation studies revealed that, grain yield plant^{-1} had shown a significant positive association with yield contributing traits like 1000 grain weight, spikelet fertility, specific leaf area and root biomass, indicating the importance of these traits in yield improvement. Among all other yield attributing characters, spikelet fertility showed the highest significant positive correlation with yield whereas days to 50% flowering and number of productive tillers plant^{-1} exhibited non-significant positive association with grain yield plant^{-1}. Path coefficient analysis revealed that the highest positive direct effect on grain yield was exhibited by spikelet fertility and 1000 grain weight. A high magnitude of negative direct effects on yield was shown by field emergence at 14 DAS. Thus, from the studies on correlation and path analysis, it could be concluded that the traits *viz.*, spikelet fertility, 1000 grain weight, specific leaf area and root biomass could be used as selection parameters for improving grain yield under dry DSR system.

KEYWORDS: Correlation, path analysis, dry DSR, morpho-physiological traits, rice, yield

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1. INTRODUCTION

Rice (*Oryza sativa* L.) is one of the most important staple food crop for more than half of the world's population and is the primary staple food crop in Asia. It is mostly grown in Asia, Latin America and Africa which represent a semitropical climate with alternating wet and dry seasons (Rao et al., 2016). Globally it is grown in an area of 158 mha with the production of 700 mt. with an area, production and productivity of 46.4 mha, 124.36 mt, and 2790 kg ha^{-1} respectively, India is one of the largest producers of rice. In Telangana, rice is grown in an area of 3.96 mha producing 20.21 mt with the productivity of 5160 kg ha^{-1} (Anonymous, 2022).

Currently no varieties are available that are amenable for alternate tillage and establishment techniques, especially in unpuddled or zero tillage soil conditions with direct seeding in Asia (Fukai, 2002, Lafitte et al., 2002, Watanabe et al., 1997) due to more focus of breeding efforts on developing varieties suitable for transplanting system. Direct dry seeding rice requires specially bred cultivars with good mechanical strength in the coleoptiles to facilitate early seedling emergence, early seedling vigour for weed competitiveness (Dixit et al., 2015, Jannik et al., 2000, Sandhu et al., 2015, Sandhu et al., 2021, Zhao et al., 2006), efficient root system for anchorage and tapping soil moisture from lower layers during peak evaporative demands (Clark et al., 2000, Pantuwan et al., 2002) along with yield stability, ability to germinate under anaerobic conditions (Ghosal et al., 2019), tolerance to early submergence (Ismail et al., 2009), early heading and short intermediate height (Fukai, 2002), lodging resistance (Yadav et al., 2017, Sandhu et al., 2019b, Subedi et al., 2019), high specific leaf area during vegetative growth and low specific leaf area with high chlorophyll content during reproductive phase (Jones et al., 1997a, Jones et al., 1997b, Kumar and Jagdish, 2011) in addition to short and medium duration. In the present context of rice cultivation shifting from the traditional transplanting system to alternate rice establishment techniques like drum seeding and direct seeding with aview of conserving natural resources, energy and increasing cost of cultivation. Hence, there is an urgent need to develop high yielding varieties suitable for alternate rice establishment techniques. The characters such as grain yield are complex in general that depends on various contributing traits (Donde et al., 2020, Ikeda et al., 2013, Zhou et al., 2018, Shaobing et al., 2008) and hence, the knowledge of correlation among yield and morpho-physiological traits, in addition to identification of direct and indirect effects of morpho-physiological traits on yield would help in developing varieties with high yields. The joint variation of two or more variables will be studied by correlation analysis and used to determine the association between different variables contributing to yield (Kothari and Garg, 2020). The association between the traits as stipulated by the correlation coefficient is considered as an important criterion for selection of superior genotypes and shall be used for yield advancement through the improvement of yield attributing traits. Path coefficient measures the direct influence of one variable on other and separate the correlation coefficient into direct and indirect effects and visualize the relationship among variables in more meaningful manner (Ratna et al., 2015). The elucidation of information on morpho-physiological traits that are associated positively with yield and the direct and indirect effects of different characters on yield will help the breeders select for high yielding genotypes under dry-DSR and hence, an attempt was made in this article to identify the characters that need to be selected for improvement of yield under dry-DSR.

2. MATERIALS AND METHODS

The material for the present study comprised of thirty short, medium and long duration elite rice genotypes Table 1. All 30 genotypes were sown at Agricultural College, Aswaraopet, Telangana, India during *kharif* season (July–December) of 2021 under the dry DSR system to understand the relationship between yield and its' component morpho-physiological traits. All the thirty genotypes were sown through the dibbling method in a randomized block design that was replicated thrice, with a spacing of 20 cm between rows and 10 cm between plants. Pre-emergence herbicide Pendimethalin 30% EC @ 2.5 L ha^{-1} was applied within 48 hours after sowing followed by application of Post-emergence herbicide Bispyribac sodium @ 250 ml ha^{-1} to control weeds, which is a major problem in dry DSR. To ensure a uniform plant population

Table 1: List of genotypes

Sl. No.	Maturity	Genotypes
I	Long duration	MTU 1061, WGL 44, BPT 5204
II	Medium duration	WGL 32100, WGL 14, JGL 11470, JGL 27356, RNR 11718, WGL 915, RNR 28361, Sugandha Samba, Krishna, JGL 28545, Bhadrakali, WGL 697 and WGL 739
III	Short duration	JGL 18047, JGL 24423, RNR 15048, WGL 962 and Tellahamsa
IV	Pre-released cultures / recently released	PR 126, PR 124, PR 127, PR 129, PR 121, PR 114, PR 128, RNR 21278 and RNR 29325

replication^{-1}, all appropriate precautions were taken and the crop was raised by following all the packages of practices. Observations were recorded on seven yield, six physiological and three root characters *viz.*, field emergence at 7 and 14 DAS, plant stand m^{-2}, days to 50% flowering, number of productive tillers plant^{-1}, plant height (cm), culm strength, panicle length (cm), spikelet fertility (%), 1000-grain weight (g), grain yield plant^{-1} (g), specific leaf area (cm^2), root length (cm), root biomass (g), total biomass (g) and harvest index by randomly choosing five plants from each entry in each replication and the data were subjected to correlation and path coefficient analysis as suggested by Singh and Chaudhary (1995) and Dewey and Lu (1959) respectively.

3. RESULTS AND DISCUSSION

Selection solely based on correlation without taking into account how the individual characters interact can occasionally be deceptive. Numerous investigations were carried out with an eye towards the significance of character relationship between grain yield plant^{-1} and its contributing traits. Studies on association between yield and its component traits would help the breeders improve complex traits like yield and selection based on only yield is ineffective. Hence, knowledge of the magnitude and direction of association between yield and its contributing characters is very important in identifying key parameters for enhancing yield through suitable breeding programme.

3.1. *Correlation analysis*

Significant phenotypic correlations without significant genotypic correlations are of no value as genotypic correlation expresses the existence of real association and phenotypic correlations occurs by chance. If the genotypic correlation is significant but phenotypic is not, it means that the existing real association is masked by environmental effect. The results on correlation between yield and morpho-physiological characters are presented in Table 2.

The results of the present study on genotypic and phenotypic correlations indicated that grain yield plant^{-1} had a significant positive relationship with 1000 grain weight (0.3005**/0.2971**), spikelet fertility (0.4409**/0.4114**), specific leaf area (0.3188**/0.2751**) and root biomass (0.2633**/0.0826) whereas days to 50% flowering (0.1217/0.1170), number of productive tillers plant^{-1} (0.0995/0.0591), plant height (0.1762/0.1750), panicle length (0.0510/0.0857), harvest index(0.1248/0.0857), plant stand m^{-2} (0.1622/0.1506) and total biomass (0.0206/0.0266) registered a non-significant positive association with yield. The highest significant genotypic positive association with yield was exhibited by spikelet fertility (0.4409**). Significant positive correlation for root weight was reported earlier by Babu et al. (2001), Yogameenakshi and Vivekanandan (2004), Kanbar et al. (2009) and Vengatesh and Govindarasu (2018); for total

Table 2: Phenotypic (P) and Genotypic (G) correlation coefficient analysis of yield and morpho-physiological traits

		DFF	PH	NPT	PL	HI	GW	FD-7	FD-14
DFF	G	1.0000	-0.0808	-0.0374	-0.0395	-0.0249	-0.1502	-0.2100*	-0.2406*
	P	1.0000	0.0809	0.0281	0.0303	0.0200	0.1392	0.1842	0.2133*
PH	G		1.0000	0.0001	0.1031	-0.3096**	0.1469	0.3113	0.3086**
	P		1.000	0.0065	0.0998	-0.2286*	0.1442	0.2494*	0.2579 *
NPT	G			1.000	0.0249	-0.0495	-0.4308	-0.3805	-0.3425**
	P			1.000	0.0077	-0.0761	-0.2995**	-0.2740**	-0.2914**
PL	G				1.000	0.0221	-0.1422	-0.1126	-0.1247
	P				1.000	0.0037	-0.1293	-0.0903	-0.1068
HI	G					1.0000	0.1474	-0.1329	-0.1291
	P					1.0000	0.0652	-0.0581	-0.0508
GW	G						1.0000	0.1285	0.1354
	P						1.0000	0.1272	0.1231
FD-7	G							1.0000	0.9980
	P							1.0000	0.9908 **
FD-14	G								1.0000
	P								1.0000
PS	G								
	P								

Table 2: Continue...

		PS	CS	SF	SLA	RL	TB	RB	GY
DFF	G	0.2094*	0.2471*	0.1163	-0.0439	0.1586	-0.1803	-0.1902	0.1217
	P	0.1805	0.2269 *	0.1225	-0.011	0.1586	-0.1803	-0.1902	0.117
PH	G	-0.0883	0.1665	0.3407**	-0.0627	-0.085	0.0414	0.0035	0.1762
	P	-0.0754	0.1668	0.3229 **	0.063	-0.0836	0.0392	0.0011	0.175
NPT	G	-0.1528	-0.0458	0.2943**	0.1923	0.2759**	0.3014**	0.2275*	0.0995
	P	-0.1005	-0.0191	0.2495 *	0.0826	0.1841	0.2144 *	0.1729	0.0591
PL	G	0.0366	-0.0947	-0.0494	0.0879	-0.0861	-0.1249	-0.1826	0.051
	P	0.0383	-0.0945	-0.0541	0.0796	-0.0789	-0.1186	-0.1800	0.0857
HI	G	-0.0931	-0.2922*	-0.4189**	0.0227	-0.3700**	-0.2372*	-0.3642**	0.1248
	P	-0.0665	-0.2182*	-0.2470*	0.0286	-0.2767**	-0.1588	-0.2453 *	0.0857
GW	G	0.1387	-0.0547	-0.0629	0.1498	-0.1441	-0.215	-0.2716**	0.3005**
	P	0.1223	-0.049	-0.0538	0.1166	-0.1407	-0.2079*	-0.2663 *	0.2971**
FD-7	G	-0.0934	0.1741	-0.0352	-0.2886**	0.3750**	-0.112	-0.0545	-0.2500**
	P	-0.0678	0.1467	-0.0205	-0.1671	0.3017**	-0.0945	-0.039	-0.2033*
FD-14	G	-0.1068	0.1774	-0.0315	-0.2839**	0.3614	-0.0919	-0.0398	-0.2512*
	P	-0.0782	0.1509	-0.0171	-0.1625	0.3023**	-0.0812	-0.0292	-0.2142*
PS	G	1.000	0.0503	-0.2095**	0.6233**	0.0203	-0.1549	-0.116	0.1622
	P	1.000	0.0384	-0.1727	0.5094 **	0.022	-0.1482	-0.1052	0.1506
CS	G	1.0000	0.0812	0.0192	0.3785**	0.0931	0.0488	-0.1054	
	P	1.0000	0.0763	-0.0087	0.3688**	0.0945	0.0493	-0.105	
SF	G		1.0000	-0.021	0.1601	0.3208**	0.3044**	0.4409**	
	P		1.0000	-0.003	0.1432	0.2992**	0.2882 **	0.4114**	
SLA	G			1.0000	-0.1036	0.0047	-0.0301	0.3188**	
	P			1.0000	-0.0808	-0.0055	-0.0205	0.2751**	
RL	G				1.0000	-0.0224	0.0229	-0.2342*	
	P				1.0000	-0.0233	0.0206	-0.2342*	
TB	G					1.0000	-0.0233	0.0206	
	P					1.0000	-0.0233	0.0206	
RB	G						1.0000	0.2633**	
	P						1.0000	0.0826	

*: Significant at (p=0.05) level; **: Significant at (p=0.01) level; P: Represents phenotypic correlation coefficient; G: Represents genotypic correlation coefficient; FD 7: Field emergence at 7 DAS, FD-14: Field emergence at 14 DAS: PS: Plant stand m^{-2}, DFF: Days to 50% flowering; NPT: Number of productive tillers plant^{-1}; PH: Plant height (cm); CS: Culm strength; PL: Panicle length (cm); SF: Spikelet fertility (%), GW-1000: Grain weight (g); GY: Grain yield plant^{-1} (g); SLA: Specific leaf area (cm^2); RL: Root length (cm); RB: Root biomass (g); TB: Total biomass (g); HI: Harvest index

leaf area by Mohankumar et al. (2011). Mohankumar et al. (2011), Murthy et al. (2011), Kanbar et al. (2011), Wei et al. (2011), Babu et al. (2012), Malarvizhi et al. (2012), Sathya and Jebaraj (2012) reported positive association of panicle length and 1000 grain weight with yield.

3.2. Path analysis

The path coefficient analysis allows the separation of direct and indirect effects through other features by partitioning the correlations whereas correlation simply depicts the relationship between two variables (Wright, 1921). The direct and indirect effects of morpho-physiological traits on yield were presented in Table 3 and Figure 1.

Spikelet fertility registered highest genotypic direct effect on yield (0.3902) followed by specific leaf area (0.3448), total biomass (0.3247), field emergence at 7 DAS (0.3152), harvest index (0.2880), 1000 grain weight (0.1996), root length (0.1725), plant height (0.1566), days to 50% flowering (0.0902) and panicle length (0.0623). Similar results were also reported earlier by Nayak et al. (2016), Islam et al. (2019) for 1000 grain weight, Chandra and Nilanjaya (2017), Satish Chandra et al. (2009) for days to fifty percent flowering, Afrin et al. (2017) for plant height, Petchiammal and Kumar (2007) and Mustafa and Elsheikh (2007), Patel et al. (2014) for panicle length, plant height and days to fifty percent flowering. High negative direct effects were shown by field emergence at 14 DAS (-0.6044) followed by number of productive tillers plant^{-1} (-0.3834) and culm strength (-0.1967) due to their negative indirect effects exhibited through other traits (Vengatesh and Govindarasu, 2018).

Studies on correlation and path coefficient analysis, emphasized the need for selection based on plant type with greater spikelet fertility, specific leaf area, root biomass, 1000 grain weight, plant height, harvest index, total biomass, root length, 50% flowering and panicle length since, these traits were found to be the important direct contributors for grain yield.

Table 3: Phenotypic (P) and genotypic (G) path coefficients of yield and morpho-physiological traits in rice (*Oryza sativa* L.)

		DFF	PH	NPT	PL	HI	GW	FD-7
DFF	G	0.0902	-0.0073	-0.0034	-0.0036	-0.0022	-0.0136	-0.0189
	P	0.1041	-0.0084	-0.0029	-0.0032	-0.0021	-0.0145	-0.0192
PH	G	-0.0127	0.1566	0.000	0.0161	-0.0485	0.023	0.0487
	P	-0.0043	0.0533	0.0003	0.0053	-0.0122	0.0077	0.0133
NPT	G	0.0143	0.0000	-0.3834	-0.0095	0.019	0.1652	0.1459
	P	0.0039	-0.0009	-0.1396	-0.0011	0.0106	0.0418	0.0383
PL	G	-0.0025	0.0064	0.0015	0.0623	0.0014	-0.0089	-0.0070
	P	-0.0017	0.0057	0.0004	0.0569	0.0002	-0.0074	-0.0051
HI	G	-0.0072	-0.0892	-0.0143	0.0064	0.288	0.0425	-0.0383
	P	-0.0021	-0.0243	-0.0081	0.0004	0.1061	0.0069	-0.0062
GW	G	-0.0300	0.0293	-0.0860	-0.0284	0.0294	0.1996	0.0257
	P	-0.0415	0.0430	-0.0893	-0.0386	0.0195	0.2983	0.0379
FD-7	G	-0.0662	0.0981	-0.1200	-0.0355	-0.0419	0.0405	0.3152
	P	-0.1842	0.2242	-0.2464	-0.0812	-0.0522	0.1143	0.8991
FD-14	G	-0.2406	-0.1865	0.207	0.0754	0.078	-0.0819	-0.6064
	P	-0.2133	-0.2743	0.3099	0.1136	0.054	-0.1309	-1.0538
PS	G	0.0139	-0.0059	-0.0102	0.0024	-0.0062	0.0092	-0.0062
	P	0.0241	-0.01	-0.0134	0.0051	-0.0089	0.0163	-0.009
CS	G	-0.0486	-0.0327	0.009	0.0186	0.0575	0.0108	-0.0342
	P	-0.0331	-0.0243	0.0028	0.0138	0.0318	0.0071	-0.0214
SF	G	0.0454	0.1329	0.1148	-0.0193	-0.1634	-0.0246	-0.0137
	P	0.0422	0.1112	0.0859	-0.0186	-0.0851	-0.0185	-0.0071
SLA	G	-0.0152	-0.0216	0.0663	0.0303	0.0078	0.0516	-0.0995
	P	-0.0023	-0.013	0.017	0.0164	0.0059	0.024	-0.0344
RL	G	0.0274	-0.0147	0.0476	-0.0148	-0.0638	-0.0249	0.0647
	P	-0.0083	0.0043	-0.0095	0.0041	0.0143	0.0073	-0.0156
TB	G	-0.0585	0.0134	0.0979	-0.0406	-0.077	-0.0698	-0.0364
	P	0.0505	-0.0003	-0.0464	0.0483	0.0658	0.0715	0.0105
RB	G	0.0186	-0.0003	-0.0223	0.0179	0.0356	0.0266	0.0053
	P	0.0505	-0.0003	-0.0464	0.0483	0.0658	0.0715	0.0105
DFF	G	-0.0217	0.0189	0.0223	0.0105	-0.004	0.0143	
	P	-0.0222	0.0188	0.0236	0.0127	-0.0011	0.0167	

Table 3: Continue...

		FD-14	PS	CS	SF	SLA	RL
PH	G	0.0483	-0.0138	0.0261	0.0534	-0.0098	-0.0133
	P	0.0138	-0.004	0.0089	0.0172	-0.0034	-0.0045
NPT	G	0.1313	0.0586	0.0176	-0.1128	-0.0737	-0.1058
	P	0.0407	0.0140	0.0027	-0.0348	-0.0115	-0.0257
PL	G	-0.0078	0.0023	-0.0059	-0.0031	0.0055	-0.0054
	P	-0.0061	0.0022	-0.0054	-0.0031	0.0045	-0.0045
HI	G	-0.0372	-0.0268	-0.0842	-0.1207	0.0065	-0.1066
	P	-0.0054	-0.0071	-0.0231	-0.0262	0.003	-0.0294
GW	G	0.027	0.0277	-0.0109	-0.1207	0.0065	-0.1066
	P	0.0367	0.0365	-0.0146	-0.0160	0.0348	-0.042
FD-7	G	0.3162	-0.0294	0.0549	0.0111	-0.091	0.1182
	P	0.8908	-0.061	0.1319	-0.0205	-0.1502	0.2712
FD-14	G	-0.6044	0.0645	-0.1072	0.019	0.1716	-0.2184
	P	-0.9036	0.0832	-0.1605	-0.0171	0.1729	-0.3215
PS	G	-0.0071	0.0665	0.0033	-0.0139	0.0415	0.0014
	P	-0.0104	0.1333	0.0051	-0.023	0.0679	0.0029
CS	G	-0.0349	-0.0099	-0.1967	-0.016	-0.0038	-0.0744
	P	-0.022	-0.0056	-0.1458	-0.0111	0.0013	-0.0538
SF	G	-0.0123	-0.0818	0.0317	0.3902	-0.0082	0.0625
	P	-0.0059	-0.0595	0.0263	0.3445	-0.00 11	0.0493
SLA	G	-0.0979	0.2149	0.0066	-0.0072	0.3448	-0.0357
	P	-0.0335	0.1049	-0.0018	-0.0006	0.206	-0.0166
RL	G	0.0624	0.0035	0.0653	0.0276	-0.0179	0.1725
	P	-0.0156	-0.0011	-0.019	-0.0074	0.0042	-0.0516
TB	G	-0.0298	-0.0503	0.0302	0.1042	0.0015	-0.0073
	P	0.0078	-0.0662	0.0422	0.1336	-0.0024	-0.0104
RB	G	0.0039	0.0014	-0.0048	-0.0298	0.0029	-0.0022
	P	0.0078	0.0282	-0.0132	-0.0774	0.0055	-0.0055

* Significant at (p=0.05) level; ** Significant at (p=0.01) level; Genotypic Residual effect=0.5256; Phenotypic Residual effect=0.5973; Bold Values are direct effects

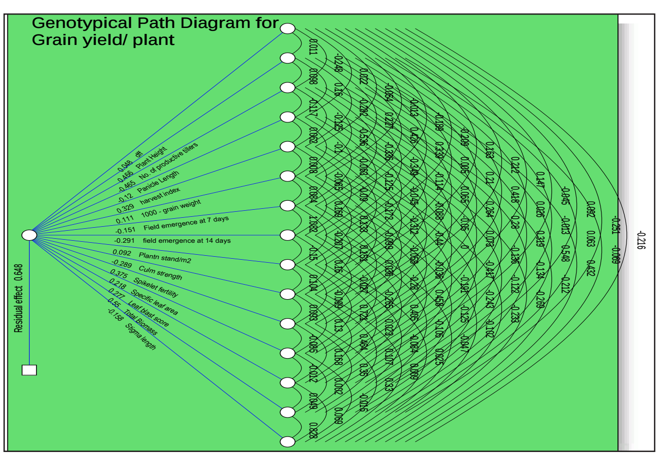

Figure 1: Genotypic path diagram for yield

4. CONCLUSION

The traits like spikelet fertility, specific leaf area, 1000 grain weight and root biomass were found to be the key parameters for selection of genotypes suitable for dry DSR with higher yield followed by the characters days to 50% flowering, number of productive tillers plant^{-1}, plant height, panicle length, harvest index, plant stand m^{-2} and hence, it is suggested to focus much on above characters while developing varieties amenable for dry DSR system.

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