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Association Analysis for Yield and its Attributing Components in Rice (*Oriza sativa* L) under Two Environments

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Abstract

To enhance the yield potential of existing varieties along with creation of new varieties with stable and high yield potential is the basic aim of plant breeders. Keeping these points in view, his experiment was carried out to study the comparative performance and association of yield attributing characters with grain yield including path analysis in seventy three diverse rice genotypes at two research farms with different sodicity levels. The correlation coefficient analysis revealed the positively and significantly associated with productive tillers plant^{-1}, fertile spikelet panicle^{-1}, spikelet fertility %, biological yield plant^{-1} and 1000 grain weight while Path analysis showed biological yield plant^{-1}, harvest index, chlorophyll content and 1000- grains weight had positive and high direct effect on grain yield respectively at both sodicity levels. Hence direct selection of any traits namely biological yield plant^{-1}, harvest index, chlorophyll content and 1000 grain weight can be effective for future breeding programs to improve yield trait. Improvement in these traits will result in simultaneous improvement of yield.

Key words : Correlation, Path Analysis, Rice (*Oryza sativa* L.), Yield, Yield Attributing Traits.

Rice (*Oryza sativa* L.) is a *Kharif* crop, belongs to Kingdom: Plantae, Division: Magnoliophyta, Class: Liliopsida, Order: Cyperales, Family Poaceae (Gramineae), Genus: Oryza, Species: sativa, Sub-species: Indica with Chromosome no. 2n=24 and basic chromosome number is 5 and haploid chromosome number is 12. The genus Oryza has 24 species out of which, twenty two are wild and two species Oryza sativa and *Oryza glaberrima* are cultivated. All varieties found in Asia, America and Europe belong to *Oryza sativa* and varieties found in West Africa belong to *Oryza glaberrima*. Further, *Oryza sativa* rice varieties of the world are commonly grouped into three sub species *viz*., Indica, Japonica and Javanica. It has been estimated that the world will have to produce 60% more rice by 2030 than what it produced in 1995. Therefore, to increase production of rice plays a very important role in food security and poverty alleviation. Theoretically, rice still has great yield potential to be tapped and there are many ways to raise rice yield, such as building of irrigation works, improvement of soil conditions, cultural techniques and breeding of high yielding varieties. rice production should necessarily increase to meet the rising demand and the crop improvement programmes should be well ahead of the expected 1 billion increase estimated for 2050 (UN, 2015). Inland salinity areas in Uttar Pradesh are primarily found in the Raibareilly, Azamgarh, Sultanpur, Ayodhya, Lucknow, Unnao, and Pratapgarh districts. India is the world's second-biggest rice producer and the world's largest rice exporter. Rice contains 7-8% of proteins, 80% of Carbohydrates, 3% of Fiber, 3% of Fat. The correlation studies estimates the degree and direction of relationship between two or more variables and provides information about yield contributing characters. The present study was aimed at understanding the

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interrelationship among different traits for the selection of desirable genotypes of rice and understanding the direct and indirect effects concerning yield and its attributing characters. (Singh, S. K. 2020) In breeding it can be used to identify the component characters that can be used for selection for improvement of yield and can also aid in selecting elite genotypes from diverse populations (Johnson *et al,* 1955). Path coefficient analysis was developed by Wright in 1921 and was used for plant selection for first time by Dewey and Lu. It splits the correlation coefficient into direct and indirect effects. Information on relation among characters, direct and indirect effects caused by each of attributes towards yield in rice gives an added advantage for the selection and hence in breeding program. Grain yield is a complex trait which is a result of interaction between various genetic and environmental fluctuation (Wattoo *et al*., 2010). According to Wattoo *et al*. (2010), grain yield is a complex trait that depends upon different yield attributing traits.Path coefficient analyses evaluate the direct and indirect contribution of each trait to yield could be estimated picking up appropriate traits for indirect selection (Rasel *et al*., 2018) Path analysis helps to give idea about direct and in direct effects of yield components. While correlation studies gives the relationship among plant characters, their degree of linear relationship, path coefficient analysis more clarifies in partitioning the two traits into component that measures the direct and indirect effects. In the light of above scenario, this experiment was conducted to study the correlation and path coefficient analysis of yield and yield attributing characters for rice yield improvement through stability analysis under two sodicity levels.

Materials and Method

During *Kharif* 2019-20, two sets of tests were carried out at Kumarganj, Ayodhya's Student Instructional Farm (pH-8.4) with EC range (0.25-0.4), organic carbon 0.29 percent and Main Experiment Station (pH -9.5) with EC range (3.1-3.3), organic carbon 0.21 percent. All seventy-three genotypes, as well as three controls (Sarjoo-52, Pusa-44, and NDU-3), were sown in a Randomized Complete Block Design (RCBD) with three replications and a 5 m row length (inter-and intra-row spacing 20 cm and 15 cm, respectively). The study's experimental materials included seventy-three diverse genotypes obtained from various agro-climatic zones. These genotypes were obtained from the rice division of Acharya Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya's Department of Genetics and Plant Breeding. On the basis of five randomly selected competitive plants in each plot, the following observations were made: days to 50% flowering, productive tiller plant^{-1}, panicle length, fertile spikelet panicle^{-1}, spikelet fertility, biological yield plant^{-1} (g), harvest-index (percent), L/B ratio, 1000-grain weight, and grain yield plant^{-1} (g). The fertilizers were applied @120 kg nitrogen, 60 kg phosphorus and 60 kg potash ha^{-1} through urea, DAP and murate of potash, respectively. Statistical analysis of all characters was done following Dewey and Lu (1959) for path analysis and Singh and Chaudhary (1995) for correlation coefficient analysis among characters were calculated by following the standard procedures with the help of MSTATC, Statistica 2 and Genres software's.

Results and Discussion

Correlation coefficients : Tables 1 and 2 present the genotypic and phenotypic correlations for yield and yield components. These results exposed phenotypic and genotypic correlations to be of parallel direction and significance. However, genotypic correlations had found a higher extent compared to

Table 1. Genotypic (above diagonal) and Phenotypic (below diagonal) correlations at student instructional farm (E1) 2019-20

Characters	Days to 50% flowe-ring	Produ-ctive tiller plant-1	Panicle length (cm)	Fertile spikelet panicle-1	Spikelet fertility %	Biolo-gical yield plant-1 (g)	Harv-est index %	L/B ratio	Chloro-phyll content	1000-grain weight (g)	Grains yield plant-1 (g)
Days to 50% flowering	1.000	0.094	-0.094	-0.022	0.050	0.295**	-0.222**	0.101	-0.079	0.114	0.163*
Productive tiller plant^{-1}	0.105	1.000	0.204**	0.287**	-0.112	0.158*	0.132*	-0.048	-0.182**	0.421**	0.269**
Panicle length (cm)	-0.148*	0.113	1.000	0.353**	0.094	0.007	0.005	0.077	-0.195**	0.066	0.000
Fertile spikelet panicle^{-1}	0.018	0.260**	0.113**	1.000	0.178**	0.315**	-0.053	0.012	-0.351**	0.163*	0.312**
Spikelet fertility %	0.009	-0.084	-0.043	0.077	1.000	0.163*	0.206**	-0.026	0.099	0.304**	0.269**
Biological yield plant^{-1} (g)	0.275**	0.157*	0.026	0.321**	0.091	1.000	-0.485**	-0.255**	-0.387**	0.223**	0.775**
Harvest index %	-0.262**	0.105	-0.003	-0.086	0.241**	-0.485**	1.000	0.013	0.298**	0.224**	0.090
L/B ratio	0.160*	-0.032	0.031	0.020	-0.044	-0.242**	-0.018	1.000	-0.060	-0.195**	-0.274**
Chlorophyll content	-0.099	-0.193**	-0.156*	-0.340**	0.103	-0.380**	0.285**	-0.071	1.000	-0.025	-0.278**
1000-grain weight (g)	-0.080	0.249**	0.141*	0.160*	0.109	0.192**	0.181**	-0.213**	0.025	1.000	0.442**
Grains yield plant^{-1} (g)	0.190**	0.288**	-0.078	0.286**	0.265**	0.722**	0.094	-0.243**	-0.289**	0.227**	1.000

*, ** Significant at 5% and 1% probability levels, respectively.

Table 2. Genotypic (above diagonal) and Phenotypic (below diagonal) correlations at Main experiment station (E2)-2019-20

Characters	Days to 50% flowe-ring	Produ-ctive tiller plant-1	Panicle length (cm)	Fertile spikelet panicle-1	Spikelet fertility %	Biolo-gical yield plant-1 (g)	Harv-est index %	L/B ratio	Chloro-phyll content	1000-grain weight (g)	Grains yield plant-1 (g)
Days to 50% flowering	1.000	0.042	0.036	-0.010	0.054	0.336**	-0.251**	-0.049	-0.085	-0.011	0.222**
Productive tiller plant^{-1}	0.057	1.000	0.385**	0.316**	0.023	0.128	0.170*	-0.047	-0.044	0.230**	0.245**
Panicle length (cm)	0.005	0.300**	1.000	0.342**	-0.086	0.123	0.005	0.117	-0.044	0.257**	0.057
Fertile spikelet panicle^{-1}	-0.007	0.300**	0.327**	1.000	0.211**	0.329**	-0.015	-0.013	-0.351**	0.179**	0.347**
Spikelet fertility %	0.046	-0.005	0.007	0.105	1.000	0.130	0.221**	-0.007	0.114	0.264**	0.207**
Biological yield plant^{-1} (g)	0.266**	0.127	0.072	0..310**	0.034	1.000	-0.411**	-0.260**	-0.377**	0.252**	0.825**
Harvest index %	-0.168*	0.161*	0.044	0.027	0.173**	-0.413**	1.000	0.049	0.323**	0.240**	0.087
L/B ratio	-0.053	-0.070	0.113	-0.053	0.069	-0.247**	-0.028	1.000	0.062	-0.177**	-0.251**
Chlorophyll content	-0.048	-0.026	-0.114	-0.321**	0.000	-0.332**	0.271**	0.021	1.000	0.033	-0.263**
1000-grain weight (g)	-0.051	0.181**	0.149*	0.149*	-0.028	0.243**	0.191**	-0.232**	0.105	1.000	0.454**
Grains yield plant^{-1} (g)	0.200**	0.241**	0.063	0.339**	0.201**	0.755**	0.114	-0.227**	-0.278	0.256**	1.000

*, ** Significant at 5% and 1% probability levels, respectively

phenotypic correlations indicating the masking effect of environment. Similar results were stated by Madhavilatha *et al*. (2005).The grain yield plant^{-1} exhibited highly significant and positive correlation with Biological yield plant^{-1} (0.722) followed by Productive tillers plant^{-1} (0.288), fertile spikelet panicle^{-1} (0.286), Spikelet fertility (%) (0.265) and 1000-grains weight (0.227); while negative and significant correlation was observed with L/B ratio and chlorophyll content at Student Instructional Farm and at Main Experiment Station result revealed that grain yield plant^{-1} exhibited highly significant and positive correlation with Biological yield plant^{-1} (0.755) followed by fertile spikelet panicle^{-1} (0.339), 1000- grain weight(0.256), Productive tillers plant^{-1} (0.241) and Spikelet fertility (%) (0.201); while negative and significant correlation was observed with L/B ratio and chlorophyll content in Table 1 and 2. The strong positive association of grain yield with the Characters mentioned above has also being reported in rice by earlier workers viz., Verma and Srivastava (2004), Sahanabnath and Kole (2021), Bhor *et al*., (2020), Dey *et al*; (2019), Hossain *et al*., (2015), Kole *et al*., (2008) found same result for starch content in maize and Qamar *et al*. 2005; Ram Krishan *et al*. 2006. Days to 50% flowering was showed positive and significant correlation with plant biological yield plant^{-1} and L/B ratio, while it expressed negative and significant with panicle length and highly significant with harvest index. Productive tillers plant^{-1} demonstrated positive and highly significant association with fertile spikelet panicle^{-1} and 1000- grain weight and panicle length highly significant with fertile spikelet panicle^{-1} and significant with 1000- grain weight while negative and Significant with chlorophyll content at Student Instructional Farm. The similar findings were obtained by Sahanabnath and Kole (2021). Fertile spikelet panicle^{-1} was showed positive and highly significant correlation with biological yield plant^{-1} and positive and significant with 1000- grain weight; while highlysignificant and negative with chlorophyll content. Spikelet fertility showed positive and highly significant correlation with harvest index and biological yield plant^{-1} positive and highly significant association with 1000-grain weight while it had negative and highly significant association with harvest index, L/B ratio and chlorophyll content.Harvest index was showed positive and highly significant correlation with chlorophyll content and 1000-grain weight And L/B ratio was showed negative and highly significant correlation with 1000-grain weight at both Farm. At Main Experiment Station Days to 50% flowering was showed positive and significant correlation with biological yield plant^{-1}. Productive tillers plant^{-1} demonstrated positive and highly significant association with panicle length, fertile spikelet panicle^{-1} and 1000- grain weight and only significant association with harvest index. Panicle length highly significant with fertile spikelet panicle^{-1} and significant with 1000-grain weight. Similar trends of results were also reported by Dhurai *et al*. (2016), Namita *et al*. (2016), and Sathisha *et al*. (2015) Nikhil *et al*. (2014), Rabara *et al*. (2014).

Path-coefficient Analysis : As simple correlation does not provide the true contribution of the characters towards the yield, these genotypic correlations were partitioned into direct and indirect effects through path coefficient analysis. It allows separating the direct effect and their indirect effects through other attributes by apportioning the Correlations (Wright, 1921) for better interpretation of cause and effect relationship. At phenotypic level, Biological yield plant^{-1} (g) (0.8939) and harvest index (0.5566) exerted very high positive direct effect on grain yield plant^{-1} (g). Spikelet fertility (0.0878), productive tillers plant^{-1} (0.0703), days to 50% flowering (0.0622) and fertile spikelet panicle^{-1} (0.0157) also exerted

Table 3. Phenotypic path with grain yield plant^{-1} on Student Instructional Farm (E1) 2019-20

Characters	Days to 50% flowe-ring	Produ-ctive tiller plant-1	Panicle length (cm)	Fertile spikelet panicle-1	Spikelet fertility %	Biolo-gical yield plant-1 (g)	Harv-est index %	L/B ratio	Chloro-phyll content	1000-grain weight (g)	Grains yield plant-1 (g)
Days to 50% flowering	0.0622	0.0074	0.0147	0.0003	0.0008	0.2455	-0.1461	-0.0036	0.0124	0.0049	0.190**
Productive tiller plant^{-1}	0.0065	0.0703	-0.0112	0.0041	-0.0074	0.1407	0.0586	0.0007	0.0242	-0.0153	0.288**
Panicle length (cm)	-0.0092	0.0080	-0.0992	0.0052	-0.0038	0.0229	-0.0017	-0.0007	0.0196	-0.0086	-0.078
Fertile spikelet panicle^{-1}	0.0011	0.0183	-0.0327	0.0157	0.0068	0.2873	-0.0480	-0.0004	0.0426	-0.0098	0.286**
Spikelet fertility %	0.0006	-0.0059	0.0043	0.0012	0.0878	0.0817	0.1342	0.0010	-0.0129	-0.0067	0.265**
Biological yield plant-1 (g)	0.0171	0.0111	-0.0025	0.0051	0.0080	0.8939	-0.2700	0.0054	0.0476	-0.0118	0.722**
Harvest index %	-0.0163	0.0074	0.0003	-0.0014	0.0212	-0.4336	0.5566	0.0004	-0.0357	-0.0111	0.094
L/B ratio	0.0100	-0.0023	-0.0031	0.0003	-0.0039	-0.2161	-0.0103	-0.0223	0.0089	0.0130	-0.243**
Chlrophyll content	-0.0061	-0.0136	0.0155	-0.0054	0.0090	-0.3400	0.1588	0.0016	-0.1252	-0.0015	-0.289**
1000-grain weight (g)	-0.0050	0.0175	-0.0140	0.0025	0.0095	0.1714	0.1006	0.0048	-0.0031	-0.0613	0.227**

Residual effect = 0.178. *, ** Significant at 5% and 1% probability levels, respectively

Table 4. Phenotypic path with grain yield plant^{-1} on Main Experiment Station (E2)-2019-20

Characters	Days to 50% flowe-ring	Produ-ctive tiller plant-1	Panicle length (cm)	Fertile spikelet panicle-1	Spikelet fertility %	Biolo-gical yield plant-1 (g)	Harv-est index %	L/B ratio	Chloro-phyll content	1000-grain weight (g)	Grains yield plant-1 (g)
Days to 50% flowering	0.0286	0.0027	-0.0002	-0.0001	0.0045	0.2413	-0.0826	-0.0015	0.0080	0.0020	0.200**
Productive tiller plant-1	0.0016	0.0463	-0.0134	0.0061	-0.0005	0.1149	0.0794	-0.0020	0.0044	-0.0070	0.241**
Panicle length (cm)	0.0002	0.0139	-0.0446	0.0066	0.0006	0.0654	0.0216	0.0032	0.0190	-0.0058	0.063
Fertile spikelet panicle-1	-0.0002	0.0139	-0.0146	0.0203	0.0100	0.2809	0.0132	-0.0015	0.0534	-0.0058	0.339**
Spikelet fertility %	0.0013	-0.0003	-0.0003	0.0021	0.0957	0.0305	0.0853	0.0019	-0.0001	0.0011	0.201**
Biological yield plant-1 (g)	0.0076	0.0059	-0.0032	0.0063	0.0032	0.9065	-0.2037	-0.0069	0.0553	-0.0094	0.755**
Harvest index %	-0.0048	0.0075	-0.0020	0.0005	0.0166	-0.3747	0.4928	-0.0008	-0.0450	-0.0074	0.114
L/B ratio	-0.0015	-0.0032	-0.0050	-0.0011	0.0066	-0.2238	-0.0138	0.0281	-0.0035	0.0090	-0.227**
Chlrophyll content	-0.0014	-0.0012	0.0051	-0.0065	0.0000	-0.3013	0.1335	0.0006	-0.1663	-0.0041	-0.278**
1000-grain weight (g)	-0.0015	0.0084	-0.0066	0.0030	-0.0027	0.2200	0.0940	-0.0065	-0.0174	-0.0387	0.256**

Residual effect = 0.176. *, ** Significant at 5% and 1% probability levels, respectively

Fig. 1. Student Instructional Farm (E1)

Fig. 2. Main Experiment Station (E2)

moderate direct effect on Grain yield plant^{-1}. The direct effects of other four characters were too low to be considered of any consequence. Biological yield plant^{-1} exhibited high order of positive indirect effects on grain yield plant^{-1} via, Days to 50% flowering (0.0171) and Productive tillers plant^{-1} (0.0111). In contrasts high order of negative indirect effects were extended by panicle length (-0.0025). Harvest-index exhibited high order of positive indirect effect on grain yield plant^{-1} via, spikelet fertility (0.0212) and productive tillers plant^{-1} (0.0074) while negative indirect effects were extended by biological yield plant^{-1} (-0.4336), days to 50% flowering (-0.0163). The remaining estimates of indirect effects in this analysis were negligible at Student Instructional Farm and at Main Experiment Station same result found with little bit difference in data of phenotypic path. The estimate of residual effect was (0.178) indicated that most of the yield contributing characters were taken into account in the present study at Student Instructional Farm and Main Experiment Station in Table 3 and 4. These results are in conformity to that of Sarawgi *et al*. (1997) and Mishra and Verma (2002), Verma and Srivastava (2004),. Supported related findings were carried out by Bhandru *et al*. (2010), Fiyaz *et al*. (2011) Akhtar *et al*. (2011), Kishore *et al*., (2018) Dey *et al*., (2019), Akter *et al*., (2019), Sudeepthi *et al*. (2020), Aparna and Indradeo (2020), Critical analysis of results obtained from character association and path analysis indicated that biological yield hill^{-1} and harvest index possessed both positive association and high positive direct effects. Hence, selection for these traits could bring improvement in yield and yield components.

Conclusion

From results it had been seen that biological yield plant^{-1}, chlorophyll content, productive tillers plant^{-1} and 1000 grain weight had both positive correlation as well as positive direct effect on grain yield. Hence direct selection of these traits can be done in breeding programs of rice. Improvement in these traits will result in simultaneous improvement in grain yield.

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