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Path coefficient and genetic divergence analysis for germplasm selection in aerobic rice (*Oryza sativa* L.)

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Abstract
In temperate areas, rice production may benefit from rising temperatures. However, in the majority of the world's rice areas, crop production will suffer as a consequence of climate change unless measures for improved crop adaptation to rising temperature, submergence, salinization or drought are taken. Because of increasing water scarcity, there is a need to develop alternative systems that require less water. The above challenges can be met by exploiting genetic resources with conventional and biotechnological approaches to produce highly productive and well-adapted varieties. To mitigate threats to productivity posed by intensification, diversification, water shortages and climate changes will require innovative approaches to develop resource management and germplasm options

Keywords: germplasm lines, grain yield, path coefficient

Introduction
Rice is cultivated world-wide over an area about 164.72 million hectares with an annual production and productivity of about 745.71 million tones and 4527.10 kg per hectare, respectively (Anonymous 2013)[3].India has the largest area of 44.00 million hectares constituting 28.01% of the land under rice in the world and ranks second in total production with 148.37 million tonnes, next only to China (193.00 million tonnes) with an average productivity of 3.37 tonnes per hectare (Anonymous, 2009a)[1]. More than 80 % of our countrymen depend fully or partially on rice as their main cereal food and staple diet. Uttar Pradesh is an important rice growing state in the country. The area and production of rice in this state is about 5.34 million hectares and 9.55 million tonnes, respectively, with the productivity of 1.79 tonnes per hectare (Anonymous, 2009 b) [2].
Global climate change is one of the humankind's most important challenges. There is a growing consensus that Earth's temperature is increasing, largely as a result of carbon dioxide and other greenhouse gas (GHG) emissions. In temperate areas, rice production may benefit from rising temperatures. However, in the majority of the world's rice areas, crop production will suffer as a consequence of climate change unless measures for improved crop adaptation to rising temperature, submergence, salinization or drought are taken. Traditional lowland rice with continuous flooding in Asia has relatively high water inputs. Now the scenario has been changed because of increasing water scarcity, there is a need to develop alternative systems that require less water. The above challenges can be met by exploiting genetic resources with conventional and biotechnological approaches to produce highly productive and well-adapted varieties. To mitigate threats to productivity posed by intensification, diversification, water shortages and climate changes will require innovative approaches to develop resource management and germplasm options. Rice is grown under many different conditions. In Asia, more than 80% of the developed freshwater resources are used for irrigation purposes and about half of which is used for rice production.

Materials and Methods
The present investigation was carried out at the Crop Research Farm, Masodha, N.D. University of Agriculture and Technology, Narendra Nagar (Kumarganj), Faizabad. The germplasm along with check varieties were evaluated during *Kharif*, 2013. Geographically this place is located in between 26.47^0N latitude, 82.12^0E longitude and at an altitude of 113 meters above from mean sea level. This area falls in sub-tropical climatic zone. The climate of district Faizabad is semi-arid with hot summer and cold winter. The germplasm evaluation

experiment involved evaluation of 56 germplasm lines along with three checks *viz*., Shusksamrat, NDR 2064 and NDR 359. The 56 germplasm lines along with three checks were evaluated in augmented design during *Kharif*, 2013. The experimental field was sub-divided in to 4 blocks of 17 plots each. The three checks were allocated randomly to three plots in each block, while remaining 14 plots in a block were used for accommodating the unreplicated test genotypes.

Result and Discussion

The direct and indirect effects of eleven characters on grain yield per plant estimated by path coefficient analysis using simple correlations are given in Table 1.

The highest positive direct effect on grain yield per plant was exerted by biological yield per plant (1.228) followed by harvest-index (1.113). The direct effects of remaining eleven characters were too low to be considered important. Biological yield per plant exhibited high order of positive indirect effects on grain yield per plant via. plant height (0.352) and panicle bearings tillers per plant (0.264). In contrast high order of negative indirect effects were extended by biological yield per plant on grain yield per plant via. harvest-index (-0.842), flag leaf area (-0.205),days to 50% flowering (-0.170), spikelets per panicle (-0.131) and panicle length (-0.125). Harvest–index exhibited high order positive indirect effects on grain yield per plant via1000-grain weight (0.537), days to 50% flowering (0.245), flag leaf area (0.226) and spikelet per panicle (0.182), while it executed high negative indirect effect on grain yield per plant via., biological yield per plant (-0.764), panicle bearing tillers per plant (-0.315), plant height (-0.235) and days to maturity (-0.158).The rest of the estimates of indirect effects obtained in the path analysis were negligible. The estimate of residual factors (0.1151) obtained in path analysis was low.

Table 1: Direct and indirect effects of 13 characters on grain yield per plant in aerobic rice

Character	Days to 50% Flowering	Daysto Maturity	Plant Height (cm)	Panical Length (cm)	Panicle Bearing Tillers/ Plant	Spikelet/ Panicle (%)	Flag Leaf Area(cm2)	Spikelet Fertility (%)	1000-grain Weight (cm)	Biological Yield/ Plant (gm)	Harvest Index (%)	Grian yield/plant
Days to 50% Flowering	0.032	-0.008	0.001	-0.003	0.003	0.001	0.006	0.002	0.004	-0.005	0.007	0.112
Maturity Days	-0.001	0.004	0.000	0.000	-0.001	-0.001	-0.001	0.000	-0.001	0.000	-0.001	-0.243
Plant Height (cm)	0.001	0.002	0.043	-0.004	0.000	0.000	-0.003	0.001	-0.011	0.012	-0.009	0.148
Panical Length (cm)	0.004	0.000	0.004	-0.041	0.014	-0.010	-0.001	0.010	0.007	0.004	-0.003	-0.093
Panicle Bearing Tillers/ Plant	0.002	-0.007	0.000	-0.008	0.022	-0.005	-0.001	0.003	-0.001	0.005	-0.006	-0.017
Spikelet/Panicle (%)	-0.002	0.005	0.000	-0.011	0.009	-0.047	0.003	0.041	0.007	0.005	-0.008	0.066
Flag Leaf Area(cm2)	0.001	-0.001	0.000	0.000	0.000	0.000	0.003	0.001	0.001	-0.001	0.001	0.002
Spikelet Fertility (%)	-0.006	-0.010	-0.002	0.024	-0.011	0.085	-0.039	-0.098	-0.022	0.005	-0.002	-.0.069
1000-grain Weight (cm)	0.006	-0.008	-0.014	-0.009	-0.002	-0.008	0.013	0.012	0.056	-0.003	0.027	0.510
Biological Yield/ Plant (gm)	-0.170	-0.063	0.352	-0.125	0.264	-0.131	-0.205	-0.060	-0.066	1.228	-0.842	0.487
harvest Index (%)	0.245	-0.158	-0.235	0.084	-0.315	0.182	0.226	0.018	0.537	-0.764	1.113	0.277

Residual factors = 0.2224, Bold figures indicate direct effects.

Path coefficient analysis is a tool to partition the observed correlation coefficient into direct and indirect effects of yield components on grain yield. Path analysis provides more clear picture of character associations for formulating efficient selection strategy. Path coefficient analysis differs from simple correlation that it points out the causes and their relative importance, whereas, the later measures simply the mutual association ignoring the causation. The concept of path coefficient was developed by Sewall Wright (1921) and technique was first used for plant selection by Dewey and Lu (1959)[4]. Path analysis has emerged as a powerful and widely used technique for understanding the direct and indirect contributions of different characters to economic yield in crop plants so that the relative importance of various yield contributing characters can be assessed. In the study, the path coefficient analysis was carried out using simple correlation coefficients between twelve characters. The high positive direct effects on grain yield per plant were exerted by biological yield per plant and harvest-index. Thus, biological yield per plant and harvest-index emerged as most important direct yield components on which emphasis should be given during simultaneous selection aimed at improving grain yield in aerobic rice. These characters have also been identified as major direct contributors towards grain yield by Pankaj *et al.* (2013)[7] and Gopikannan and Ganesh (2014) [5].The direct effects of remaining characters were too low to be considered important. Biological yield per plant exerted considerable positive direct effects on grain yield per plant via days to 50% flowering and panicle bearing tillers per plant while biological yield per plant exhibited negative indirect effect on grain yield via. harvest-index, flag leaf area, Days to 50% flowering and panicle length. Harvest–index exhibited high order of positive indirect effect on grain yield per plant via1000-grain weight, Days to 50% flowering and flag leaf area. In addition to emerging as most important direct yield contributors owing to their very high positive direct effects on grain yield, biological yield per plant and harvest-index, having considerable positive indirect effects via different characters, also appeared as most important indirect yield components. Jayashudha and Sharma (2011)[6] and Gopikannan and Ganesh (2014)[5] have also identified biological yield and harvest-index as important direct and indirect yield contributing characters. The indirect effects of remaining characters were too low to be considered important. In the path analysis identified biological yield per plant followed by harvest-index as most important direct as well as indirect yield contributing traits or components which merit due consideration at time of devising selection strategy aimed at developing high yielding varieties in aerobicrice.

In contrary to most of the previous reports in aerobic rice, comparatively small proportion of direct and indirect effects of different characters attained high order values in the present study. Majority of the estimates of direct and indirect effects were too low to be considered of any consequence. This may be attributed to presence of very high genetic variability and diversity in the fairly large number of germplasm lines. The existence of different character combinations in diverse germplasm lines might have led to different types of character association in different lines. Thus, presence of several contrasting types of character associations or inter-relationships might have resulted into cancellation of contrasting associations by each other ultimately leading to lowering of the net impact or effect.

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