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Correlation analysis for yield and its attributing traits among the doubled haploids developed through androgenises

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Abstract
Doubled haploid technique offers prominent opportunities in achieving homozygosis within a short period of time. The present investigation focussed on advancement of anther derived promising Doubled Haploids to assess the yield and yield associated characters namely days to 50 % flowering, plant height, panicle length and grain yield. Analysis of variance showed notable variations among the DHs with regard to all the studied attributes. There is a significant variation observed between the correlation coefficient of genotyping and phenotyping analysis. Among all the studied traits, a significant positive correlation was recorded between days to 50 % flowering and grain yield. This study showed a strong correlation among all the yield related traits of the DHs. The DHs possessing the promising yield traits could be utilized in breeding programme for increase the rice productivity.

Keywords: Correlation coefficient, doubled haploid, another culture, rice, yield components

Introduction
Rice is a staple food for more than half of the world's population with more than 3.5 billion people relying on it for 20 % of their daily calories (Fahad *et al.*, 2019) [1]. It is also known as global grain and is extremely essential due to its diversity (Ashfaq *et al.*, 2014) [41]. Crop diversification is seen as a viable technique to increase dietary diversity and nutritional status, with a rising focus on nutritional diversity (Nicholson *et al.*, 2021) [3]. To fulfil the demands of the growing population along with maintaining self-sufficiency requires 40%increase of rice production by 2030 (Calicioglu *et al.*, 2019) [4]. Considerable efforts were being directed towards increment of rice productivity out of which hybrid rice technology had been one of the feasible options (Rout *et al.*, 2016) [7]. Buthigher seed cost, poor seed-set, low to moderate levels of heterosis and poor grain and cooking quality of rice are the major hindrances for limited adoption of the technology (Rout *et al.*, 2016 [6]; Naik *et al.*, 2017 [7]) [6]. The application of doubled haploid technology through androgenises represents substitute aid for the conventional crop enhancement programmes. The doubled haploid technique is a practicable approach to initiate fertile, stable recombinants because of the demonstration of androgenises capacity to produce homozygous lines in a single generation (Naik *et al.*, 2016) [6]. Doubled haploid approach not only speed up the breeding process, but they also allow for greater genotype discrimination within a generation (Maria *et al.*, 2006) [8]. The adoption of the doubled haploid method has resulted in the production of over 280 varieties in several crops (Kaushal *et al.*, 2015) [9].
One of the most significant and intricate characteristics of rice is grain yield (Zhang *et al.*, 2017) [10]. Environmental factors and management practises both have a significant impact on the main grain yield component (Garcia *et al.*, 2015) [11]. In general, traits such as grain yield, are complex in nature and are therefore influenced by the contributions of other variables (Donde *et al.*, 2020) [12]. The proficiency on inter correlation of plant characters with seed yield and among themselves is of profound significance in breeding programmes (Thippani *et al.*, 2017) [42] in order to differentiate genotypic correlations into their direct and indirect consequences (Jeke, 2021) [14]. Although very helpful in assessing the amount and direction of trait connections, correlation coefficients might be deceptive if a strong correlation between two qualities is due to the indirect influence of other traits (Bizeti *et al.*, 2004) [15]. This is so because the associated features are connected to other traits rather than existing alone

(Singh *et al.*, 2022) [22]. The direct influence of one attribute on another is measured by standardised partial regression coefficient notably known as path coefficient (Ratna *et al.*, 2015) [17]. It divides the components of the correlation coefficient into direct and indirect effects, allowing for a more comprehensible visualisation of the relationship (Zahid *et al.*, 2006) [18]. Correlation coefficient analysis would provide a better understanding of the cause-and-effect relationship between various pairs of characters (Prem Kumar *et al.*, 2015) [19]. This paper therefore presents yield and yield component traits correlations study conducted on 100DHs generated from 27P63 mainly aiming at the objective of breeding for high yield.

Materials and Methods

Plant materials

The study was conducted at the experimental farm of National Rice Research Institute, Cuttack, and Odisha, India. A total of 100 DHs were generated from the anther culture of F_1 rice hybrid '27P63', a quality rice Hybrid developed by M/S Dupont Pioneer. Under irrigated conditions, the DHs were assessed using an expanded design consisting of 10 blocks, each with 20 test entries and 3 controls (Parent; 27P63, Naveen; mid early duration and Samba-Mahsuri; medium duration). Further, using a randomised complete block experimental design with three replications, 19 DHs were identified based on their agronomic characters and evaluated in the field together with an F_1 hybrid and the checks Naveen and Samba-Mahsuri in the field.

Experimental Strategy for Yield Evaluation of the selected lines

Each DH was planted on a plot size of 10 m^2, one-two plants per hill, at a spacing of 15 cm x 20 cm, in a well-puddled field with a total area of 500 m2. The seedlings were nurtured in moist beds when they were 30 days old. There were eight rows of 32 plants each in each plot. Three splits of the recommended N:P:K (100:50:50) kg/ha were applied, and crop protection measures based on need were undertaken. Hand weeding was done, and the plots were kept in good condition to prevent pests and diseases until harvest. From the initiation of flowering to crop maturity in the replicated individuals, the observable traits were measured. Between *Kharif* (2019), *Rabi* (2019) and *Kharif* (2020), yield attributes were tested in three subsequent generations. The agronomic traits were evaluated based on the following parameters (Table-1): plant height(cm), days to 50 % flowering of the plants in a plot, panicle length (cm), and grain yield (g) were recorded according to the standard evaluation system for rice (IRRI, 2002) [43].

Table 1: Quantitative traits studied under the trial

Sr. No	Trait	Description
1	Days to 50 % flowering	The genotypes were closely observed from the date of seed sown, to the initiation of a flower blooming in 50 % of the plants in a line, were recorded for each treatment, in each replication.
2	Plant height (cm)	Plant height is measured in terms of centimetre at the time of maturity from the ground level to the top of the spike excluding awns
3	Panicle length (cm)	The length of the panicle was recorded by measuring from the base to tip of the Panicle.
4	Grain yield (g)	The grain yield per plot was measured in grams using sensitive balance after moisture of the seed is adjusted to 12.5 %.

Statistical Analysis

In the present investigation, the data as subjected to analysis of variance (ANOVA) employing WASP 1.0 software (ICAR-CCARI, Goa). The least significant difference (LSD) test was used to compare the means of the various treatments at 5 % levels of significance. Correlation coefficient among all studied traits were enumerated applying Crop Stat 7.2 software (International Rice Research Institute, Philippine). The assessment of the phenotypic and genotypic correlation coefficients between two variables was done as delineated by Singh and Chaudhary (1985) [20].

Results

Agronomic performance of DHs

A potent androgenic protocol was followed to derive DHs from a popular quality rice hybrid 27P63 (Pattnaik *et al.*, 2020) [21]. A total of 100 DHs were appraised in the field for three consecutive seasons established on their agronomic characters. Eventually, 19 DH lines showing at par agronomic performances with the parent and checks were selected for further assessment. Plant height and days to 50 % flowering of DHs varied from 74 cm to 119.3 cm and 91 to 113.3 days respectively. Similarly, panicle length of DH lines ranged from 22 cm to 30.3 cm while grain yield varied from 3.89 t/ha to 5.96 t/ha; no. of DHs showed at par with the parent hybrid with a yield of 6.09 t/ha. Additionally, analysis of variance divulged considerable significance at 5 % for all the four characters (days to 50 % flowering, panicle length, plant height and grain yield) with CV % ranged from 6.2 to 14.94 % (Table 2).

Table 2: Morpho-agronomic characters of DHs along with rice genotypes

No	Genotype	DFF	Plant Height (cm)	Panicle length (cm)	Yield (t/ha)
1	27P63 (Parent)	98.66	112	25	609.33
2	DH1	101.33	111.66	25	421.66
3	DH2	102.33	106	27	397
4	DH3	98.33	107.66	25.66	351.66
5	DH4	93.33	110.66	27	414
6	DH5	105.66	112.66	26.33	467.33
7	DH6	109	111	27.33	425.33
8	DH7	113.33	91.333	29.33	571
9	DH8	101	108	28	567.33
10	DH9	91	111.33	26.33	495.33

11	DH10	92.33	114.33	30.33	548.66
12	DH11	96.66	112.33	26.66	449.66
13	DH12	103.33	112	26.33	537
14	DH13	108.33	81	23.66	496.33
15	DH14	107	74	20.66	389
16	DH15	110	83	21.66	484.66
17	DH16	109.66	97	24	514
18	DH17	97	119.33	28.33	596.66
19	DH18	105.66	108.66	24.33	513
20	DH19	104	111.33	22	531.66
21	Naveen	87.78	106.23	23.89	487.89
22	Samba Mahsuri	110.65	84.76	21.89	475.33
	Mean ± STD EV	102.11±7.05	103.92±12.69	25.49±2.55	488.35±69.57
	CV (%)	6.2	11.99	9.71	14.94
	LSD (5 %)	0.932084	1.77325	0.839567	14.3263

Correlation coefficients of all given traits are given in Table 3. The highest positive correlation was observed between DFF and grain yield with a value of 0.97463 at 1 % significance. A significant positive correlation with a value of 0.003029 was found among days to 50 % flowering, plant height and panicle length whereas there was genotypic correlation of 0.080026 observed. Negatively correlation was noticed with plant height and panicle length with a value of-0.62799 and -0.40064 respectively. Likewise, a positive significant correlation was found between DFF and grain yield with a value of 007601.Similarly, plant height is substantially positively correlated with panicle length and grain yield with the value of 0.008092 and 0.40663 respectively. The panicle length was positively correlated with plant height (0.57429) and grain yield (0.25725). The grain yield displayed positive correlation between plant height (0.19639) and panicle length (0.26586) respectively.

Table 3: Phenotypic correlation (below diagonal) and genotypic correlation (above diagonal) between agronomic and yield related traits in 20 DHs and 2 checks

	DFF	**PH**	**PL**	**YLD**
DFF	1	0.003029*	0.080026	0.97463
PH	-0.62799	1	0.008092*	0.40663
PL	-0.40064	0.57429	1	0.25725
YLD	0.007601*	0.19639	0.26586	1

In the correlations table; *DFF:* day to fifty percent flowering *PH:* plant height, *PL*: panicle length, *YLD*: Grain yield (t/ha)
* = significant at α 0.01 level

Discussion

A crucial tool in plant breeding is doubled haploid application because it offers the quickest approach to create genetically diverse populations of meiotic recombinants in a stable condition (Dash *et al.*, 2022) [22]. As homozygosis is accomplished in a single generation, as it expedites the selection process for breeding programmes resulting new varieties. The most requisite step of selecting propitious lines is agronomical characterization of DH lines in the field (Naik *et al.*, 2017) [6]. Correlation coefficient analysis is a salient feature to ascertain the association among characters corresponding to yield (Akbar *et al.*, 2019) [23]. It computes the association between two variables (Dabholkar, 1992) [24]. The amalgamation of plant characters ascertained by correlation coefficient, is advantageous as the principle of selecting the desirable plant. This allows you to compare the relative effects of different factors on grain yield Therefore, details on character associations, direct and indirect effects imparted by each character on yield will be an added supremacy in facilitating the selection process (Jeke *et al.*, 2021) [14].

A total of 13, 3 and 12 DHs were found to be higher in terms of DFF, plant height and panicle length than the parent (27P63) respectively while 4 DHs were at par with the parent in relation to the grain yield. This is in accordance with the results who studied the agronomical performances of rice doubled haploid derived from another culture Grewal *et al.* (2011) [25] and Faz *et al.*, 2016) [26]. Besides, at par yield of DHs with the parental rice hybrids are in conformity with Mishra *et al.* (2015) [27].

The analysis of variance propounded that there was considerable variability among DHs for the traits under investigation. The distinct variances among DHs suggest that there is diversity within them which is a requisite for crop breeding as superlative lines could be utilized as parents during hybridization. Since yield is a complicated, quantitatively inherited feature with limited heritability, direct selection for yield is ineffective (Akbar *et al.*, 2021) [23]. As a result, character association offers information on the traits that are related to one another in order to increase yield, allowing for indirect selection of the component characters contributing to yield (Ravikumar *et al.*, 2015) [29]. In the present study, it is divulged that genotypically, the correlation coefficients are more notable than phenotypic correlation coefficients illustrating that genetic expression are more pivotal than phenotypic expression as the latter is minimized under the impact of natural surroundings which is corroborated with Divya *et al.* (2018) [30].

Considering DFF, it showed positive correlation with plant height, panicle length and grain yield genotypically which is alike to the recent findings report of (Lohiteswararao *et al.*, 2021) [31] but shows negative association with plant height and panicle length phenotypically (Tilahun *et al.*, 2022) [32]. Interestingly, DFF also exhibited remarkable correlation with grain yield phenotypically which is in accordance with the result of Bagudam *et al.*, 2018 [33]. The highest positive correlation was noticed between DFF and grain yield genotypically which is similar to the Vijay Kumar *et al.*, 2015 [34] and Anis *et al.*, 2016 [35]. Plant height is a vital growth factor since it determines or modifies yield-contributing features, which in turn affect grain production (Shrestha *et al.*, 2021) [36]. In the current study, plant height displayed positive association with panicle length and grain yield phenotypically specifying that increase of plant height could certainly meant augmentation of grain yield which is contrary to Zaid *et al.*, 2006 [44] who disclosed grain yield is negatively correlated

with plant height in Basmati rice. Similarly, direct correlation was observed between panicle length and grain yield both genotypically and phenotypically. It is suggested that a longer panicle might retain more grains than a shorter panicle (Rathod *et al.*, 2016 [45] and Bekele *et al.*, 2013) [39]. In the current study, the correlation coefficients between grain yield and all the studied traits were positive. It demonstrated that increase of grain yield depends on the traits exhibiting positive and favourable association with the grain yield which is similar to the findings of findings of Li *et al.*, 2019 [46]; the relationship between yield and yield related traits for rice varieties released was explored. As a result, since, they (days to 50 % flowering, plant height, panicle length and grain yield) were positively related to yield, these traits could be utilized as the selection criteria for other rice varieties.

Conclusion

Doubled haploid approach through androgenises could be used to achieve doubled haploids with favourable morphological characteristics within short span of time. The results of this study depicted that there was positive correlation between the grain yield and other studied traits (days to 50% flowering, plant height and panicle length). The details on the inter relationship among the yield-assigning characteristics revealed the type and degree of those relationships. As a result, this will aid breeding programmes in improving various traits as well as productivity.

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