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Character Association among Morpho-physiological and Agrometeorological Indices for Photothermal Response of Rice

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

The experiment was conducted at the Dr. Rajendra Prasad central agricultural university, pusa, Bihar in a randomized block design with three replications during kharif season, 2017.The present study revealed the effects of photo thermal response on rice yield to adapt better in changing climatic scenario. Thirty two genotypes of rice were evaluated to work out heritability and trait association among important morpho-physiological traits and agro-meteorological indices for yield and yield contributing traits under directly seeded condition. The results indicated that PCV was higher than the GCV for almost all the traits. High heritability was observed for spikelet fertility (95%) followed by 1000 grain weight (91%), relative water content (88%), days to fifty per cent flowering (87%), days to physiological maturity (87%), growing degree days (86%), helio-thermal unit (86%), photo-thermal unit (85%), grain yield per plant (80%) and heat use efficiency (76%) suggesting that these traits were primarily under genetic control. Correlation studies indicated a significant and positive association of grain yield with traits viz. plant height, panicle length, number of tillers per plant, number of panicles per plant and relative water content. Based on heritability and association analysis, plant height, panicle length, number of tillers per plant, number of panicles per plant, heat use efficiency and relative water content were found major contributing indices. Therefore, this should be considered as selection criteria for discrimination of outstanding rice genotypes under directly seeded condition.

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Keywords: Correlation; GCV; PCV; Heritability; DSR.

1. INTRODUCTION

Rice (*Oryza sativa* L.) is the most important food grain crop with regard to human nutrition and calorie intake. It plays an important role in providing food to two third of the world population particularly in Asian countries. Hence, rice is known as Asia's lifeline. It is most consumed cereal grain in the world constituting the dietary food for more than half of the world population and hence, is considered as "Global grain". In India, the demand for rice is growing every year and it is estimated that by 2030 the requirement would be increased to 185 million tonnes [1]. To sustain present food self-sufficiency and to meet food requirements, India has to increase its rice productivity by three per cent per annum.

Worldwide, rice is grown on 161.10 million hactares, with an annual production of about 487.46 million tonnes [2]. The productivity of rice is affected by several abiotic factors among which shortage of water is one such factor. Performance of rice genotypes has been evaluated many a times under lowland rice production system. However, lowland rice production is being threatened by growing water scarcity and moisture stress during its growth period which drastically affects the crop yield. Traditionally, rice is established through a transplanting of 25-30 days old seedlings into a puddle seed bed particularly during kharif season. This method is cumbersome, costly and labor intensive. Direct seeded rice (DSR) is a potential alternative in quest of higher water productivity and to eliminate time and edaphic conflicts in the rice-wheat cropping system [3]. At the present scenario, the temperature is going up day by day, which highly affects the crop at different phenophases, ultimately yield. Sunil and Sharma (2005) endorsed that temperature is a most influential factor, affecting the chemical, physiological and biological characteristics of plants. Thus there is a need to develop the heat-tolerant varieties in this challenging era. Growing degree days (GDD), photo-thermal unit (PTU), helio-thermal unit (HTU), photo-thermal index (PTI) and heat use efficiency (HUE) which frequently been used as weather based parameters for assessing the crop phenology. Heat use efficiency *i.e.* efficiency of utilization of heat in terms of dry matter accumulation or economic yield of rice depends on solar radiation interception, leaf area development and crop management practices [4]. Girijesh et al. [5] also used agrometeorological indices to discriminate the heat tolerant lines. All growth and developmental stages of crop estimated more accurately in regards of GDD [6]. Heritability estimates provide the authentic information regarding particular genetic attribute which will be transmitted to the successive generations and constitute an efficient guide for breeders in the preference of parents for crop improvement programmes [7]. However, heritability in broad sense alone may not be helpful for selection based on phenotype, because it is influenced by environment. Thus, estimate heritability along with genetic advance jointly is reliable and helpful in predicting the gain under selection than heritability alone [8]. Moosavi et al. [9] reported that grain yield is a complex trait, quantitative in nature and a combined function of a number of constituent traits. Consequently, selection for yield may not be satisfying without taking into consideration yield component traits. Thus, positives correlation between yield and yield components are required for an effective increase in grain yield in rice [8]. So, it is important for plant breeders to understand the degree of correlation between yield and its components.

Therefore, the present study was conducted with the objective of assessing the heritability and association between yield and yield components of 32 rice genotypes.

2. MATERIALS AND METHODS

The field experiment was conducted to evaluate the heritability and correlation coefficient among different traits at Rice research farm of Dr. Rajendra Prasad central agricultural university, Pusa (25.98ºN and 85.67ºE) during kharif season 2017. Thirty two genotypes of rice were evaluated for different morphological traits and agro-meteorological indices in a randomized block design with three replications. The studied traits were recorded based on the standard evaluation system for rice. Plot size was 2.5m X 1.8m (4.5m^2) with Spacing between plant to plant 20 cm and row to row 15 cm. The standard package of agronomic practice was followed as per recommendation to raise a healthy crop. Data for 10 agro morphological traits were taken at appropriate growth stage following the standard evaluation system for rice. Observations were recorded on plot basis for GY/P, the yield harvested on plot basis and adjusted to 14% moisture content before weighing. All the remaining morphological traits were recorded on the plant basis by randomly taking 5 plants in each plot and trait mean were used for the analysis. Agro-meteorological data were collected from weather parameters on the daily basis. The characters that were evaluated included days to 50% flowering (DFF, day), days to physiological maturity (DPM, day), plant height (PH, cm), panicle length (PL, cm), number of tillers per plant (TPP), number of panicles per plant (PPP), spikelet fertility (SF), 1000 grains weight (TGW, g), Growing degree days (GDD), helio thermal unit (HTU), photo thermal unit (PTU), photo thermal index (PTI), heat use efficiency (HUE), relative temperature depression (RTD), critical temperature at reproductive stage (CT), relative water content (RWC) and grain yield per plant (GY/P, g/plant). The data recorded on morphological traits from the genotypes used, were subjected to statistical analysis. Statistical analysis was carried out using statistical package, Windostat 9.1and statistical tools viz., ANOVA, genotypic and phenotypic coefficient of variability, phenotypic correlation coefficient, heritability in broad sense, genetic advance and descriptive statistics were used in the analysis. The correlation analysis was conducted by using the same statistical software to determine the degree of association between yield and its components. In order to assess and quantify the genetic variability among the genotypes for the characters under study the variance components and values of heritability and genetic advance were estimated.

Heritability in broad sense (h^2) was computed as the ratio of genetic (Vg) variance to the total phenotypic variance (Vp).

$$h^2 \text{ (broad sense)} = \frac{Vg}{Vp} \times 100$$

The genetic advance (GA) and genetic advance as per cent of mean (GAM) were estimate using the formula given below:

Genetic advance (GA) = K. $\sigma_{p.}$ h^2

$$GA\ (\%) = \frac{GA}{\overline{X}} \times 100$$

Where, h^2 = heritability in broad sense; k = Selection differential which is equal to 2.06 at 5% intensity of selection; $\sigma^2 g$ = Genotypic variance; X= general mean of the character.

3. RESULTS AND DISCUSSION

The analysis of variance clearly showed that there was a highly significant ($p \leq 0.01$) differences among the genotypes evaluated for all the traits. This indicates the genotypes are highly variable especially with those traits which showed a significant difference. Thus, the possibility of genetic improvement through selection is highly promising. High variability of breeding materials will increase the probability of producing desirable recombinants in successive generations. The range of differences in mean value was comparatively wide for almost all the morpho-physiological traits and agro-meteorological indices showed a greater extent of variability among the genotypes for these traits (Fig. 1). Similar results were obtained in studies of Mohammadi et al. [10] and Singh et al. [11] who reported that characters with wide range of variation have a positive scope of improvement through simple selection.

The genetic variation result showed that phenotypic coefficient of variation (PCV) was relatively higher in magnitude than the corresponding genotypic coefficient of variation (GCV) for all the morpho-physiological traits and agrometeorological indices. This result revealed the influence of environment on phenotypic expression of each trait. Most of the traits have high to moderate GCV and PCV. Very high GCV and PCV were recorded for number of tillers per plant, number of panicles per plant and grain yield, indicates the importance of these traits and in the selection of genotypes for hybridization programme. The traits viz. days to fifty per cent flowering, days to physiological maturity, spikelet fertility and relative water content exhibited small difference between the phenotypic and genotypic coefficient of variability which indicates the presence of sufficient genetic variability and less influenced by environment and visual selection. Therefore, these traits can be easily improved through simple selection. The traits like plant height, panicle length, number of tillers per plant and grain yield exhibit moderate difference between PCV and GCV. Similar differences were reported by Sarangi et al. [12] for panicle length and grain yield per plant. The coefficient of variation doesn't offer the full scope of heritable variation. It can be found out with greater degree of accuracy when heritability is in conjunction with genetic advance. Heritability and genetic advance are important selection parameters. Heritability coupled with genetic advance is more helpful in predicting the gain under selection than heritability estimates alone [13]. However, it is not necessary that a character showing high heritability will also exhibit high genetic advance. The estimates of heritability help the plant breeder in the selection of elite genotypes for unique traits in a genetic population. Heritability (broad sense) ranges from 23% (photo-thermal index) to 95 % (spikelet fertility) in Table 1. According to Johnson, Robinson and Comstock [14] broad sense heritability classified as low (30%), medium (30% to 60%) and high (>60%). This shows most of the traits studied can be easily improved through selection. Highest heritability were exhibited by spikelet fertility (95%) followed by 1000 grain weight (91%), relative water content (88%), days to physiological maturity (87%) and grain yield per plant (80%), growing degree days (86%), helio-thermal unit (86%) and photo-thermal unit (85%). The moderate heritability in plant height, number of tillers per plant and number of panicles per plant showed the more influence of environment on this trait. Therefore, direct selection for this trait is not effective. Similar results of heritability were reported by Akter et al. [15] for spikelet fertility and 1000 grain weight, Manickavelu et al. [16] for grain yield per plant and Muthuswamy [17] for number of productive tillers in rice plant and grain yield. Konate et al. [18] obtained high heritability for traits *i.e*. days to fifty per cent flowering and number of panicles per plant. Similar results were reflected by Khalid et al. [19] for panicle length, number of productive tillers per plant and by Kumar et al. [13] for photo-thermal unit. High heritability estimates suggest that these traits have high transmitting ability to the next generation. The difference in findings may be due to various reasons including the genetic material used and environmental conditions. Since heritability do not always indicate genetic gain, heritability coupled with genetic advance is more effective for selection. Genetic advance indicates the expected progress as the result of selection. It used to estimate the type of gene action in polygenic traits. Genetic advance as percent of mean classified as low (<10%), moderate (10-20%) and high (>20%). In this study, it ranges from 0.61% for photo-thermal index to 34.59% for number of tillers per plant. The highest value of genetic advance as per cent of mean was displayed by number of tillers per plant (34.59%) followed by number of panicles per plant and grain yield per plant with value of 30.94% and 25.95% respectively (Table 1). Spikelet fertility, growing degree days, helio-thermal unit and photo-thermal unit exhibited high heritability with moderate genetic advance as percent of mean which indicated these traits were less influenced by environment, governed by both additive and non additive gene action and there is a possibility of direct selection for these characters through phenotypic selection. Panicle length, relative temperature depression and critical temperature at reproductive stage have medium heritability and low genetic advance. This shows this character is totally governed by non-additive gene action. So, heterosis breeding could be used for such kind of traits.

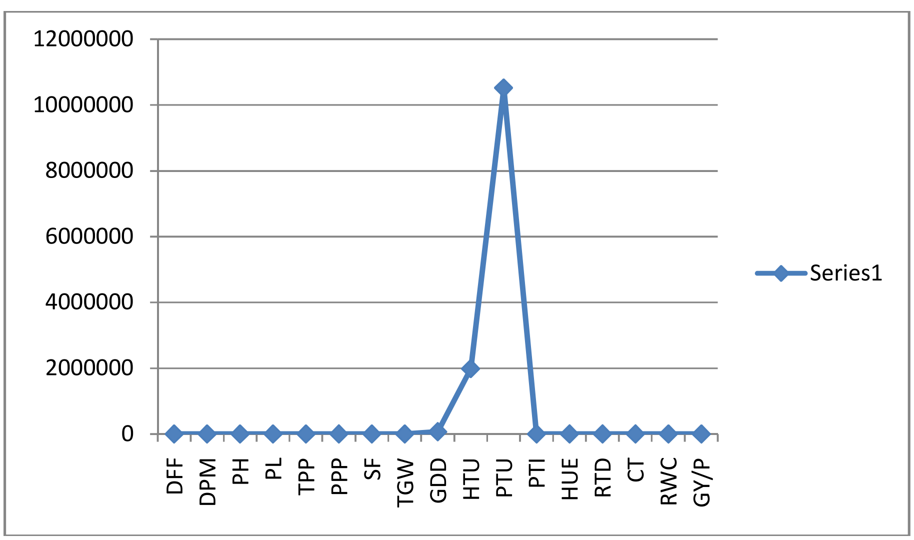

Fig. 1. Mean of different morphological traits and agro meteorological indices of 32 genotypes of rice

Table 1. Estimates of descriptive parameters, GCV, PCV and genetic advance for different morphological traits and agro meteorological indices of rice under direct seeded condition

Characters	Mean	Range	GCV	PCV	h^2 (Broad sense) %	Genetic Advance as per cent of Mean
Days to 50% Flowering	76.68	63.00 - 105.67	11.15	11.96	87	21.43
Days to Physiological maturity	97.70	83.67 - 125.00	9.27	9.95	87	17.79
.Plant height (cm)	89.16	71.77 - 105.73	7.31	9.02	66	12.19
Panicle length (cm)	22.41	20.14 - 25.63	5.59	8.33	45	7.73
Number of tillers per Plant	10.16	6.67 - 15.33	19.32	22.23	76	34.59
Number of panicles per Plant	7.72	5.67 - 11.66	19.34	24.90	60	30.94
Spikelet fertility (%)	80.82	55.00 - 90.33	9.90	10.15	95	19.90
1000-grain weight (gm)	24.16	16.30 - 32.74	11.91	12.52	91	23.34
Growing degree days (Degree days)	70037.18	81200.95	9.12	9.82	86	17.45
Helio-thermal unit (Degree-days hours)	1984509.25	2303570.25	9.34	10.06	86	17.85
Photo-thermal unit (Degree-days hours)	10518175.00	12310128.00	8.72	9.44	85	16.61
Photo-thermal index (Degree-days day^{-1})	0.03	0.14	0.61	1.27	23	0.61
Heat use efficiency (Kg ha^{-1} degree days)	0.05	0.06	14.48	16.81	74	25.68
Relative Temperature depression	0.03	0.07	0.84	1.30	42	1.11
Critical temperature for reproductive stage (^{0}C)	0.09	0.18	1.01	1.43	51	1.49
Relative water content (%)	69.86	53.36 - 83.89	11.50	12.27	88	22.21
Grain yield per plant (gm)	12.81	8.58 - 16.31	14.09	15.75	80	25.95

Table 2. Inter character phenotypic correlation of yield with various morpho-physioloical traits and agrometeorological indices in rice under direct seeded condition

Characters	DPM	PH	PL	TPP	PPP	SF	TGW	GDD	HTU	PTU	PTI	HUE	RTD	CT	RWC	GY/P
DFF	0.9768**	0.3900*	0.4252**	0.3259*	0.2466	-0.0632	0.0593	0.9811**	0.9794**	0.9734**	-0.0023	-0.3585*	0.5936**	-0.0525	0.2726	0.2373
DPM		0.4034*	0.4553**	0.3718*	0.2688	-0.0675	0.0665	0.9819**	0.9769**	0.9718**	-0.0047	-0.3611*	0.6137**	-0.0576	0.2676	0.2369
PH			0.3748*	0.4384**	0.4500**	0.1560	0.2127	0.4135**	0.4098**	0.3872*	-0.0225	0.2275	0.2772	-0.1825	0.2583	0.4848**
PL				0.4594**	0.3372*	-0.0062	0.0901	0.4481**	0.4472**	0.4228**	0.0908	0.1312	0.4078*	-0.0334	0.3516*	0.4153**
TPP					0.7923**	0.0975	0.1550	0.3344*	0.3203*	0.3257*	-0.0243	0.3950*	0.2494	-0.1490	0.3602*	0.6375**
PPP						0.0810	0.1484	0.2725	0.2673	0.2551	-0.0665	0.2947	0.2052	-0.0508	0.3381*	0.4893**
SF							0.2486	-0.0413	-0.0539	-0.0345	0.1639	0.2212	-0.0263	-0.3468*	0.0564	0.2067*
TGW								0.0764	0.0656	0.0718	-0.0718	0.1311	0.0768	-0.0696	-0.2438	0.1846
GDD									0.9970**	0.9947**	0.0336	-0.3757*	0.6159**	-0.0342	0.2731	0.2317
HTU										0.9920**	0.0358	-0.3828*	0.6151**	-0.0205	0.2794	0.2217
PTU											0.0341	-0.3800*	0.6130**	-0.0382	0.2580	0.2239
PTI												-0.0625	0.1240	-0.0075	0.0981	-0.0516
HUE													-0.2460	-0.1903	0.2187	0.8107**
RTD														-0.0710	0.1534	0.1132
CT															-0.1426	-0.2054
RWC																0.3864*

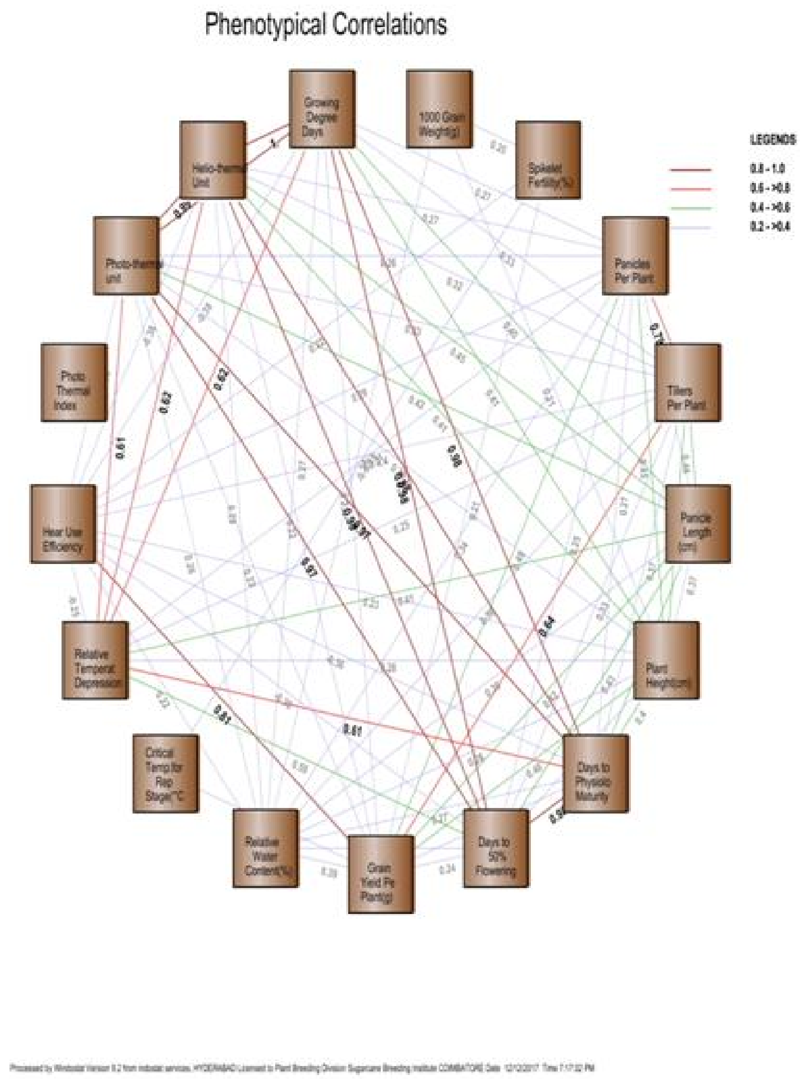

Fig. 2. Phenotypical correlations for seventeen traits

The correlation coefficients among various morpho-physiological and agro-meteorological indices with grain yield under direct seeded condition were established and are presented in Table 2. The result of correlation showed that the genotypic relationship were recorded higher in compared to their corresponding phenotypic correlation coefficients demonstrating that the observed relationships due to genetic causes *i.e* linkage or pleotropic effect. Similar findings have earlier been reported by Singh et al. [11], Singh et al. [20]. By exploiting the estimates of useful correlations, the breeder would be able to decide the breeding methods for improvement and the undesirable ones modified by generating fresh variability [21]. In present investigation, it was evident that grain yield showed significant and positive association ($p \leq 0.05$) with plant height, panicle length, number of tillers per plant, number of panicles per plant, heat use efficiency and relative water content at phenotypic level (Fig. 2). Therefore, these characters should be considered for selection for better performance of genotypes of rice under directly seeded condition. However, the extent of HUE was significantly higher in compared to other parameters indicated their importance and this index might be utilised for rice improvement in relation to heat stress. Significant and positive association of grain yield with panicle length indicates when panicle length will be more then grain yield will also be high. Similarly, number of tillers per plant and number of panicles per plant leads high grain yield. This finding is in agreement with Singh et al. [22] and Abarshar et al. [23] for panicle length, number of tillers per plant. Manickavelu et al. [16] and Paul et al. [24] observed similar results while working on upland direct seeded rice by using advanced breeding lines for the association of grain yield with plant height.

Among the component traits, days to fifty per cent flowering were positively and significantly associated with days to physiological maturity, plant height, panicle length, number of tillers per plant, growing degree days, helio-thermal unit, photo-thermal unit and relative temperature depression. Ranawake et al. [25] reported the effect of days to fifty per cent flowering on plant height as negative association, when days to fifty per cent was shortest then plant height was highest. Days to fifty per cent flowering and the grain yield per plant had a cubic relationship while the relationship between days to fifty per cent flowering and plant height has a quadratic relationship. Chandra et al. [26] reported a significant positive correlation of days to 50 per cent flowering with panicle length. Days to physiological maturity was significantly and positively correlated with plant height, panicle length and number of tillers per plant, growing degree days, helio-thermal unit and photo-thermal unit. Plant height exhibited positive correlation with number of tillers per plant, number of panicles per plant, growing degree days, helio-thermal unit and photo-thermal unit up to a certain limit since most of the genotypes were early maturing. Association between panicle lengths with traits like number for tillers per plant, number of panicles per plant and relative water content were highly positive significant. Tillers number was positively related to panicles number and relative water content while panicles number only positively correlated with relative water content. Growing degree days exhibited strong positive and significant association with helio-thermal unit, photo-thermal unit, relative temperature depression and negatively significant with heat use efficiency. Helio thermal unit showed strong positive and significant association with photo-thermal unit and relative temperature depression and negatively significant association with heat use efficiency. Therefore, selection for any trait among these characters would bring in simultaneous improvement of other characters and ultimately improve the grain yield. Since, these characters are mutually correlated among themselves and can be effectively utilized for the improvement of rice.

4. CONCLUSIONS

The overall result showed the presence of adequate variability in the genotypes studied. This variation could be effectively manipulated using appropriate breeding techniques and program to develop improved varieties. High estimate of heritability and genetic advance were observed in most of the traits, indicating the predominance of additive gene action and the possibility of direct selection through these traits. The phenotypic correlation showed most of the traits evaluated is important for selection of high yielding genotypes. The strong association of DPM, TPP, GDD, RWC and HUE might be added in breeding programme for screening of genotypes for photo thermal response of rice under direct seeded condition.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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