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Research Article

GENETIC VARIABILITY IN RAIN-FED LOWLAND RICE BREEDING POPULATION UNDER NORMAL AND DELAYED TRANSPLANTING CONDITIONS

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Abstract- The importance of additive gene effects for most of the nine traits in the three crosses under two transplanting conditions suggested substantial scope of improvement in yield status can still be achieved by using breeding procedures. GY/P, BY/P and PH possessed high heritability and genetic advance in both conditions and emerged as ideal traits for selection. G/P, T/P and DFF in E1 and HI in E2 appeared also as ideal traits for selection owing to their high estimates for both parameters in respective conditions. At both levels, positive correlation of GY/P was recorded with HI in both transplanting conditions. BY/P, PL in both transplanting conditions and T/P and G/P in E1 appeared as strong positive associates of GY/P at both levels. Path analysis identified BY/P and HI as most important direct components and PL and G/P as most important indirect components of GY/P in both conditions. These characters merit due to consideration in formulating effective selection strategy in rainfed lowland rice for developing high yielding varieties for normal and delayed transplanting.

Keywords- Rice, Normal and delay transplanting, GCV, PCV, Correlation, Direct and indirect effects

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Introduction

Rainfed lowland rice is a dominant rice culture in countries that form a belt from India to Cambodia. Barker et al. [1] found that research in rainfed lowland rice would produce higher rates of return than research on irrigated rice. At present, however, most research is directed to irrigate environments, even in countries where rainfed rice predominates. The research investment was lower in countries with a high proportion of rainfed rice compared to countries with predominantly irrigated rice [1].

Various agronomic and morphological characters, photoperiod sensitivity is another highly important and desirable feature of all rainfed lowland rice. According to Pushpavesa and Jackson [2], the photoperiod sensitivity provides adaptive advantages of tolerance to late transplanting and a dependable maturity date after the rainy season ends. Transplanting is the most widely used method by which rainfed lowland rice crops are established because it allows farmers to be flexible in dealing with water related stresses. In rainfed lowlands, drought or flooding often makes it impossible to transplant 3-4 week old seedlings which most agronomists consider as the optimum age for transplanting [3]. In fact, in more than 50 per cent of rainfed lowland rice area, transplanting is frequently delayed [4]. If drought occurs just after seeding due to delayed rains, the plants can be maintained in the seedbed until sufficient water in available for transplanting and subsequent growth. In medium deep area, farmers have to transplant older seedlings to escape or survive flood damage. The photoperiod sensitive cultivars are suitable for delayed transplanting because by virtue of having constant maturity date such cultivars are usually harvested before conditions become too dry. By contrast, photoperiod insensitive cultivars flower and ripen late on late transplanting which increases the chance that crop will fail due to drought. Thus, genetic studies in rainfed lowland rice and subsequent breeding efforts must be planned after taking into consideration photoperiod sensitivity and delayed transplanting aspects of this rice culture.

So far, rainfed lowland rice has got very little attention of rice breeders as compared to irrigated rice in India as well as abroad. The high yielding cultivars of irrigated rice often perform below satisfactory levels in adverse and diverse rainfed lowland conditions because different agronomic traits and plant type are needed for each type of rice cultures [5]. To understand of direct and indirect selection parameters also helps in effective application of selection in isolating superior genotypes for a particular environment or situation. However, very little literature is available in respect of gene effects and direct and indirect selection parameters in rainfed lowland rice, especially under delayed transplanting conditions. Keeping in view these facts, the present investigation was undertaken on rainfed lowland rice under normal and delayed transplanting conditions.

Materials and Methods

The investigation was conducted at Crop Research Station, Masodha, Faizabad (U.P.) during *Kharif* season. The site falls under sub tropical to semi arid region in Indo-Gangatic plains and lies between 26.47^{o}N latitude, 82.12^{o}E longitude and at an altitude of about 113 m above mean sea level.

Experimental Details

The two cytoplasmic male sterile (CMS) lines *viz*., IR-58025-A and NDMS-4-A, possessing Wild Abortive (WA) type of cytoplasm, were crossed with thirty genetically diverse pollen parents *viz*., NDRSB-96006-R, NDRSB-9730015-R, NDRSB-9830099-R, OR-1537-15-R, OR-1543-11R, OR-1547-9-1-R, OR-1564-5-

R, OR-1898-17-R, CR-792-B-4-2-1-R, IR-54112-B-2–CR-1-6-2-R, BARO-5-1-B-6-3-34-1-1-1-1-R, RAU-1411-4-R, IR-31917-R, TTB-517-17-SBIR-67401-17-2-R, TTB-517-17-SBIR-70149-35-R, CN-1035-36-R, CN-1045-6-R, OR-1537-6-R, R-710-437-1-1-R, IR-70-R, IR-600-76-I-R, IR-55838-B-2-3-2-3-R, IR-21567-18-3-R, IR-10198-66-2-R, IR-65515-47-2-1-19-R, R-971-2505-2-1-R, UPRI-92-79-R, CSR-21-R, RP-2932-2528-R and JR-82-1-10-R in line x tester mating fashion. A total of 60 F_1s were produced during *Kharif* 2003. The resulting set 60 F_1's their 32 parents (30 male parents + 2 female parents) and a standard check variety *i.e.* Sarjoo-52 were evaluated in Randomized Complete Block Design with three replications.

Fertilizer application

The fertilizers were applied @ 120 kg nitrogen, 60 kg phosphorus and 60 kg potash/ha through urea, di-ammonium phosphate and murate of potash recommended, for the rice crop. The full dose of phosphorus, potash and half dose of nitrogen were applied as basal and rest of nitrogen was applied in two splits as top dressing at tillering and panicle initiation stage.

Experimental Methods

Raising of CMS lines and male parents

The seeds of CMS lines were treated with 0.02 per cent mercuric chloride solution followed by subsequent washing with sterilized distilled water and then placed in petridishes holding a moist towel paper for proper germination at room temperature. Seven to ten days old seedlings were transplanted in earthen pots for their normal growth while male lines were direct seeded in nursery beds on three different dates to coincide the flowering dates of CMS lines for crossing purpose.

Production of hybrids

Each of the two cytoplasmic male sterile lines was crossed with thirty restorers, collected from diverse sources, in line x tester mating design. The seeds of F_1s obtained from these combinations were collected during wet season. Thus, a total of 93 genotypes (2 CMS lines + 30 diverse pollen parents + 60 F_1s +1 standard check-Sarjoo-52 were grown and evaluated during next year.

Observations recorded

Five randomly sampled plants entry^{-1} replication^{-1} for the non-segregating (parents and F_1s) were tagged in advance and all subsequent observations were recorded on them. Data were collected on days to 50 per cent flowering (DFF), plant height (PH), days to maturity (DM), ear bearing tiller plant^{-1} (EBT), panicle length (PL), number of spikelets panicle^{-1} (S/P), number of fertile spikelet panicle^{-1} (F/P), number of spikelet sterility panicle^{-1} (SS/P), 1000-grain weight (TW), biological yield (BY), harvest index (HI) and grain yield plant^{-1} (GY/P) following the standard procedure.

Statistical Analyses

The data on 12 characters were subjected to analysis of variance for Randomized Block Design (RBD) and whole set of treatments following [6].

Results and Discussion

Coefficients of variation

The coefficients of variation were computed for normal as well as delayed transplanting experiments to assess the existing variability in the experimental material. The high magnitude of PCV and GCV was observed for grain yield plant^{-1} in E_1 [Table-1]. This indicated possibility of obtaining high selection response in E_1. Reddy and De [7] and Tripathi et al. [8] have also reported high estimates of coefficients of variability for grain yield. In E_2, none of the nine characters exhibited high estimates of GCV or PCV [Table-1] which suggested suppression of variability expression in this condition. Moderate estimates of GCV and PCV were observed for BY/P, T/P, TW, PH, G/P and DFF in E_1 and GY/P, HI, BY/P, T/P and PH in E_2. This indicated reasonable scope of improvement in these traits through selection in respective E_1. Low estimates of GCV and PCV were recorded for PL in E_1 and E_2, HI in E_1 and TW, G/P and DFF in E_2. This indicated that selection directly based on these traits would not be much rewarding for improving the traits under transplanting condition. Chauhan et al. [9] reported considerable variation for TW and PL, while Sardana [10] found low GCV for DFF, PH, PL and T/P. Ganesan et al. [11] observed moderate GCV for PH and HI and low GCV for PL and TW.

Table-1 *Estimates of mean, phenotypic (PCV) and genotypic (GCV) coefficients of variation, heritability in broad sense (h^2) and genetic advance in per cent of mean (Ga) for nine characters in irrigated (E_1) and drought (E_2) conditions*

Characters	Condition	Grand mean (x)	PCV	GCV	h^2	Ga
DFF	E_1	98.62	10.02	9.94	98.5	20.32
	E_2	115.26	7.12	7.04	97.7	14.34
PH (cm)	E_1	116.60	12.69	12.65	99.4	25.97
	E_2	93.59	10.86	10.76	98.1	21.95
T/P	E_1	8.72	17.75	16.69	88.4	32.33
	E_2	11.29	15.93	15.03	89.1	19.57
PL (cm)	E_1	25.50	6.54	5.90	81.2	10.94
	E_2	23.08	6.61	5.46	68.2	9.27
G/P	E_1	139.09	11.96	11.76	96.7	23.66
	E_2	107.49	7.41	7.32	97.4	14.86
TW (g)	E_1	2.51	12.88	10.77	70.0	18.72
	E_2	2.33	9.62	6.20	41.5	8.15
BY/P (g)	E_1	41.15	18.33	18.16	98.1	37.05
	E_2	27.02	12.42	11.96	92.8	23.94
HI	E_1	26.59	8.05	7.43	85.3	14.36
	E_2	36.06	16.77	16.00	91.00	31.44
G/P (g)	E_1	11.18	21.06	20.84	97.7	42.48
	E_2	9.76	18.20	17.62	93.7	35.14

Heritability and genetic advance

Grain yield plant^{-1}, BY/P and PH showed high to very high h^2 as well as Ga in E_1 and E_2. These three characters emerged as ideal traits for improvement through selection for both transplanting conditions due to their high variability and transmissibility. Similarly, G/P, T/P and DFF in E_1 and HI in E_2 which suggested that high to very high response to selection can be achieved in these characters under respective conditions. Existence of high to very high estimates of heritability and genetic advance for characters mentioned above indicated predominant role of additive gene effects in their expression. Several reports on occurrence of high h^2 with Ga in rice are available in literature [11-13]. The TW recorded moderate heritability and genetic advance in E_1 but it showed low values for both parameters under E_2. Thus, the TW may be able to show considerable selection response in E_1 while it may prove an unreliable index for selection under adverse E_2. Panicle length with moderate h^2 and low Ga in E_2 was another character which is likely to provide poor selection response in E_2 besides TW.

The estimates of heritability and genetic advance in per cent of mean showed marked differences from E_1 to E_2 for almost all the characters under study. Harvest-index emerged as only trait under study possessing substantially higher h^2 as well as Ga estimates under adverse E_2 than E_1. Thus, HI emerged as a very important character which merits special attention at time of formulating selection strategy for lowland rainfed rice improvement for delayed transplanting conditions. The above discussion also points out that the genotype x environment interactions play crucial role in expression of variability and transmissibility of various characters in rainfed lowland rice.

Correlation coefficients:

In the present study, a very strong positive association of GY/P was observed at genotypic and phenotypic with HI in E_1 and E_2. Thus, HI emerged as most important associate of GY/P in both conditions [14]. In E_1 and E_2, positive association of GY/P with BY/P and PL was also found at both level. BY/P and PL appeared as important yield associates in the E_1 and E_2. BY/P and PL were also found to have positive association with GY/P by earlier workers [13,14]. In E_1, T/P and G/P recorded strong positive correlations with GY/P, indicating thereby, greater role of these characters in manifestation of GY/P under E_1 than E_1. Same results were also recorded by Verma and Mani [15,13]. Significant positive association at both levels was observed between PH and BY/P in E_1 and E_2.

In the present study, all the significant correlation coefficients between yield and

.**Table-2** *Estimates of phenotypic correlation coefficients between different characters in irrigated (E_1) and drought (E_2) conditions*

Characters	Condition	PH (cm)	T/P	PL (cm)	G/P	TW (g)	BY/P (g)	HI	GY/P (g)
DFF	E_1	-0.261	0.041	0.118	0.241	0.130	0.330	0.243	0.366
	E_2	0.488	-0.085	0.079	0.444**	0.240	0.612**	-0.161	0.272
PH (cm)	E_1		0.313	0.491*	0.173	-0.386	0.492*	-0.065	0.422
	E_2		-0.072	0.321	-0.042	0.090	0.465*	-0.127	0.231
T/P	E_1			0.542*	0.178	-0.053	0.365	0.458*	0.497*
	E_2			-0.287	0.146	-0.056	0.070	0.025	0.083
PL (cm)	E_1				0.318	-0.252	0.701**	0.123	0.645**
	E_2				-0.059	0.262	0.226	0.308	0.464*
G/P	E_1					0.057	0.451*	0.226	0.449*
	E_2					0.265	0.291	0.165	0.342
TW (g)	E_1						-0.263	-0.028	-0.230
	E_2						0.160	0.207	0.299
BY/P (g)	E_1							0.168	0.925**
	E_2							-0.293	0.448*
HI	E_1								0.517*
	E_2								0.713**
Genotypic correlation coefficients between different characters in irrigated (E_1) and drought (E_2) conditions									
DFF	E_1	-0.266	0.055	0.144	0.244	0.152	0.336	0.255	0.372
	E_2	0.503	-0.090	0.093	0.460	0.362	0.629	-0.162	0.281
PH (cm)	E_1		0.328	0.541	0.177	-0.470	0.499	-0.074	0.426
	E_2		-0.065	0.392	-0.044	0.104	0.482	-0.128	0.244
T/P	E_1			0.603	0.199	-0.083	0.382	0.515	0.521
	E_2			-0.294	0.151	-0.223	0.101	0.037	0.116
PL (cm)	E_1				0.356	-0.325	0.773	0.211	0.732
	E_2				-0.110	0.404	0.269	0.406	0.586
G/P	E_1					0.048	0.457	0.273	0.466
	E_2					0.385	0.302	0.191	0.370
TW (g)	E_1						-0.303	-0.056	-0.279
	E_2						0.227	0.386	0.498
BY/P (g)	E_1							0.204	0.941
	E_2							-0.281	0.462
HI	E_1								0.523
	E_2								0.718

* and ** significant at 5% and 1% probability level, respectively.

yield components were positive in nature in both conditions.. Remaining estimates were either positive or negative but non-significant or very low in magnitude. This reveals a less complex situation in attaining a proper balance between yield and its important components in context to rainfed lowland rice under normal as well as delayed transplanting as compared to complexities that arise due to existence of strong negative and positive associations often encountered between various characters in rice as well as in many other crops. At environment level, positive association was observed between GY/P and HI in both conditions. Significantly negative environmental correlation of HI with BY/P and G/P was also recorded in both environments. This showed that environment played important role in the conditioning the instances of positive or negative inter-relationships mentioned above.

Path-coefficient analysis:

In the present study, path analysis was carried out at both levels in E_1 and E_2. BY/P followed by HI exerted high order positive direct contribution on GY/P at both levels [Table-3] in E_1. In E_2, HI followed by BY/P exhibited highest positive direct contribution on GY/P at both levels. Direct effects of remaining six characters were too low to be considered of any consequence in both conditions at both levels. Thus, BY/P and HI emerged as important direct yield components for both conditions. Harvest-index has also been identified as major direct contributor towards grain yield in rice by Venkataramana and Hittalmani [16].

In E_1, PL, PH, G/P, T/P, DFF and HI exerted high order positive indirect effects on GY/P via BY/P at both levels. T/P also made considerable positive contribution on GY/P via HI at both levels. Thus, the six characters mentioned above were identified as important indirect contributors to GY/P under E_1. In E_2, PL, G/P and TW exerted substantial positive indirect effects on GY/P via BY/P and HI at both levels. Thus, these characters were identified as important indirect yield components for delayed transplanting condition. The path effects obtained in the present study are broadly in agreement with the reports of previous workers [16,14]. The above observations indicate that the character associations and cause and effect relationships in respect of yield and its components were not as complex as generally encountered in such studies in rice.

Table-3 *Direct and indirect effects of characters on grain yield plant^{-1} at phenotypic level in irrigated (E_1) and drought (E_2) conditions*

Characters	Condition	DFF	PH (cm)	T/P	PL (cm)	G/P	TW (g)	BY/P (g)	HI
DFF	E_1	**0.004**	-0.010	0.000	-0.003	-0.008	0.003	0.289	0.092
	E_2	**-0.028**	0.010	-0.001	0.001	-0.003	-0.001	0.443	-0.148
PH (cm)	E_1		**0.040**	0.004	-0.012	-0.006	-0.009	0.431	-0.025
	E_2		**0.020**	-0.001	-0.006	-0.000	0.000	0.336	-0.116
T/P	E_1			**0.012**	-0.014	-0.006	-0.001	0.320	0.173
	E_2			**0.015**	-0.005	-0.001	0.000	0.050	0.023
PL (cm)	E_1				**-0.025**	-0.011	-0.006	0.614	0.046
	E_2				**0.018**	0.000	-0.001	0.163	0.283
G/P	E_1					**-0.035**	0.001	0.395	0.085
	E_2					**-0.006**	-0.001	0.210	0.151
TW (g)	E_1						**0.023**	-0.231	-0.011
	E_2						**-0.005**	0.116	0.190
BY/P (g)	E_1							**0.876**	0.063
	E_2							**0.723**	-0.269
HI	E_1								**0.378**
	E_2								**0.918**
At genotypic level in irrigated (E_1) and drought (E_2) conditions									
DFF	E_1	**0.000**	-0.010	0.002	-0.010	-0.009	0.003	0.307	0.089
	E_2	**-0.033**	0.012	-0.001	0.002	0.000	-0.008	0.457	-0.149
PH (cm)	E_1		**0.037**	0.010	-0.037	-0.006	-0.008	0.456	-0.026
	E_2		**0.023**	-0.001	0.009	0.000	-0.004	0.350	-0.117
T/P	E_1			**0.030**	0.041	-0.007	-0.001	0.349	0.179
	E_2			**0.009**	-0.007	0.000	0.005	0.073	0.034
PL (cm)	E_1				**-0.069**	-0.013	-0.005	0.707	0.023
	E_2				**0.024**	0.000	-0.009	0.195	0.372
G/P	E_1					**-0.036**	0.001	0.418	0.095
	E_2					**0.001**	-0.008	0.220	0.175
TW (g)	E_1						**0.017**	-0.277	0.019
	E_2						**-0.022**	0.165	0.354
BY/P (g)	E_1							**0.914**	0.071
	E_2							**0.726**	0.258
HI	E_1								**0.348**
	E_2								**0.918**

Residual factors: -0.0025, underlined figures indicate direct effects.

However, the inter-relationships appeared comparatively more complex in DTP condition than NTP condition.

Like correlations, the path-coefficients also showed marked variation in nature and magnitude across normal and delayed transplanting conditions, indicating thereby, role of genotype x environment interactions in conditioning the inter-relationships between yield and its components in rice. Therefore, for precise understanding of underlying path effects, inferences should be drawn from the results of path analysis carried out in the environment in question.

Conclusion

The results suggested that exposure of genotypic and phenotypic variability among the genotypes was suppressed under adverse delayed transplanting conditions for most of the characters. Therefore, greater germplasm input and efforts may be required for creating sufficient variability in breeding populations generated for selection under delayed transplanting than normal transplanting conditions.

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Abbreviations:

CMS : Cytoplasmic male sterile
F_1 : First filial generation
PCV : Phenotypic coefficient of variation
GCV : Genotypic coefficient of variation

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