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Variability and Frequency Distribution Studies in F_2 Segregating Population of Rice with Phosphorous Starvation Tolerance Gene (*OsPSTOL* 1) Introgressed

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A B S T R A C T

The F_2 segregating generation of two crosses *viz.*, Anna (R) 4 x IR 64 *Pup* 1 and Anna (R) 4 x Samba mahsuri *Pup* 1 were evaluated for variability parameters and frequency distribution. The results revealed that both the crosses exhibited high PCV and GCV for the traits *viz.*, number of tillers per plant, number of productive tillers per plant, number of filled grains per panicle, shoot P content and single plant yield. The traits *viz.*, plant height, number of tillers per plant, number of productive tillers per plant, number of filled grains per panicle, hundred grain weight, shoot P content, grain P content and single plant yield showed high heritability coupled with high genetic advance as per cent of mean indicating the presence of additive gene effect and selection for these traits may be effective. The trait panicle length and grain P content had negative skewness and selection may be effected to evolve high yielding phosphorous deficient tolerant variety in rice.

Introduction

Rice is one of the most important stable food for more than half of the world's population and an important model for cereal crops. Rice production is seriously threatened by various factors out of which nutrient deficiencies are critical in many parts of the world (Dobermann and Fairhurst, 2000). Phosphorous (P) is one of the important key nutrients required for plant growth and development.

It is most problematic macronutrient in rice farming because it forms complexes with Fe^{3+} under submerged conditions and Al^{3+} ions under dry conditions present in the soils and becoming limitedly available to the plants (Shen *et al.,* 2011). Phosphorous deficiency constitutes a major intricacy and leads to reduced tillering, rate of assimilate production per leaf area and rate of leaf expansion (Radin and Eidenbock, 1984). Application of fertilizers may solve the problem but it is very expensive and can cause environmental and health problems and therefore, the development of phosphorous deficient tolerant cultivars is one of the most effective and eco-friendly solutions. Crop improvement for particular trait has been achieved through effective use of segregating population and fixing desirable combinations (Khandappagol *et al.,* 2019).

Estimates of genetic variability parameters for yield and related traits provide immense value in the selection of superior segregants. Information on skewness and kurtosis reflects the nature of variability existing in a genetic population. Therefore, the investigation was undertaken to assess the variability and pattern of frequency distribution for yield and its component traits of phosphorous deficiency tolerance in the two crosses involving two tolerance and one susceptible parents for phosphorous starvation.

Materials and Methods

The study was carried out at Agricultural College and Research Institute, Madurai during *Kharif* 2018 in two F_2 population of rice *viz.,* Anna (R) 4 x IR 64 *Pup* 1 (Cross 1) and Anna (R) 4 x Samba mahsuri *Pup* 1 (Cross 2). Anna (R) 4 is a drought tolerant variety but susceptible to phosphorous starvation tolerance. IR 64 *Pup* 1 and Samba mahsuri *Pup* 1 are the lines tolerant to phosphorous deficiency carrying *OsPSTOL*1 gene. Recommended agronomic practices were followed to raise the crop. Observations were recorded in all the individual F_2 segregants for days to first flowering (days), plant height (cm), number of tillers per plant, number of productive tillers per plant, panicle length (cm), number of filled grains per panicle, hundred grain weight (g), shoot phosphorous content (mg/g), grain phosphorous content (mg/g) and single plant yield (g). Phosphorous content in shoot and grains were estimated using the Vanadomolybdate yellow colour method using spectrophotometer (Piper, 1966). Statistical method suggested by Burton (1952) for variability, Lush (1940) for heritability, Johnson *et al.,* (1955) for genetic advance as percent of mean (GAM) were adopted. Skewness, the third degree statistics and kurtosis, the fourth degree statistics were estimated by adopting the procedure given by Kapur (1981) to understand the nature of distribution of quantitative traits in F_2 segregating population.

Results and Discussion

The mean, range, variability parameters and frequency distribution for various characters in two crosses are presented in Table 1 and 2. The results indicated that the estimates of phenotypic coefficient of variation (PCV) were higher than the genotypic coefficient of variation (GCV) for all the traits studied in both the crosses indicating the magnitude of environmental influence. Number of tillers per plant, number of productive tillers per plant, number of filled grains per panicle, shoot P content and single plant yield showed high PCV and GCV in both the crosses which were in accordance with Sheshaiah *et al.,* (2018) for number of tillers per plant, number of productive tillers per plant and single plant yield; Nezam Ali *et al.,* (2018) for number of filled grains per panicle and single plant yield and Abhilash *et al.,* (2018) for number of productive tillers per plant and single plant yield. Low estimates of PCV and GCV were recorded by days to first flowering in both the crosses and plant height and panicle length in cross 2. Similar finding was also observed by Balat *et al.,* (2018) for plant height and Lingaiah *et al.,* (2018) for panicle length. The trait hundred grain weight showed moderate PCV and GCV in both the crosses and grain P content in cross 2. These results were in parallel with the findings of Mohana Sundaram *et al.,* (2019) for 100 grain weight. Plant height, panicle length and grain P content had moderate PCV and low GCV in cross 1. Similar results were observed by Nezam Ali *et al.,* (2018) and Khandappagol *et al.,* (2019) for panicle length. Selection based on these characters with high PCV and GCV will be effective for improvement of these traits.

High heritability and genetic advance as per cent of mean (GAM) was observed for all the traits in both crosses except days to first flowering, panicle length and grain P content in cross 1 and days to first flowering and panicle length in cross 2 exhibited high heritability with moderate GAM.

The present findings were in agreement with the finding of Khandappagol *et al.,* (2019) for plant height, number of productive tillers per plant, filled grains per panicle, grain yield per plant, days to first flowering and panicle length and Mohana Sundaram *et al.,* (2019) for number of productive tillers per plant and hundred grain weight. High heritability and genetic advance as per cent of mean indicated that prevalence of additive gene action in their inheritance. Hence early generation selection may be effective to improve these traits due to the presence of additive gene action.

Significant and positive skewness was observed for days to first flowering, number of tillers per plant, number of productive tillers per plant, number of filled grains per panicle, shoot P content and single plant yield in both the crosses. Traits observed with positive skewness indicate that more proportion of individuals present in low end of distribution.
Days to first flowering and shoot P content were positively skewed, which implies that more number of early flowering and low shoot P segregants were obtained from both the crosses and selection can be done for earliness and low shoot phosphorous content.

Plant height, panicle length and grain P content had significant and negative skewness in cross 1 and only grain P content in cross 2 indicating that more proportion of segregants with higher panicle length in Anna (R) 4 × IR 64 *Pup* 1 cross and grain P content in both the crosses. Isolation superior segregants with low shoot and high grain P content with high yield could be useful for developing phosphorous deficient tolerant genotypes. Frequency distributions of various traits for two crosess were represented in Figure 1 and 2. Regarding kurtosis, even though significant leptokurtic nature of distribution was observed for plant height, panicle length, number of filled grains per panicle, hundred grain weight, shoot P content, grain P content and single plant yield in cross 1 and number of tillers per plant, number of productive tillers per plant, number of filled grains per panicle and hundred grain weight in cross 2, wide range of distribution was recorded for these traits.

Table.1 Variability parameters for different characters in F_2 population of Anna (R) 4 x IR 64 *Pup*1

Character	Mean			Range		PCV (%)	GCV (%)	h^2 (%)	GAM %	Skewness	Kurtosis
	P_1	P_2	F_2	Min	Max						
Days to first flowering	81.13	95.33	98.01	89.00	116.00	4.99	4.92	97.20	10.53	0.64**	0.72
Plant height (cm)	93.88	93.26	80.18	48.00	97.40	10.15	9.94	95.74	21.10	-0.61**	1.48**
Number of tillers per plant	17.19	22.83	14.22	3.00	32.00	37.92	35.93	89.82	73.90	0.56**	0.46
Number of productive tillers per plant	14.75	19.17	8.20	2.00	21.00	45.83	44.13	92.71	92.21	0.65**	0.27
Panicle length (cm)	25.42	23.06	22.80	13.10	29.20	10.80	9.15	71.69	16.80	-0.38**	1.01**
Number of filled grains per panicle	113.06	88.08	86.98	30.00	199.00	32.30	32.13	98.97	69.36	0.93**	1.55**
Hundred grain weight (g)	2.33	2.39	2.35	1.20	3.20	11.94	10.98	84.60	21.92	-0.14	2.45**
Shoot P content (mg/g)	0.115	0.189	0.100	0.047	0.189	27.30	26.12	91.58	54.25	1.01**	1.39**
Grain P content (mg/g)	0.312	0.330	0.302	0.209	0.348	10.31	8.45	67.10	15.01	-1.11**	0.96*
Single plant yield (g)	26.02	22.62	12.36	5.10	34.40	44.08	43.23	96.17	92.00	1.41**	2.44**

*, ** significant at 5 % and 1 % levels, respectively

P_1=Anna (R) 4; P_2= IR 64 *Pup* 1; Min = Minimum; Max = Maximum; PCV = Phenotypic coefficient of variation; GCV = Genotypic coefficient of variation; h^2 = Heritability (%); GAM = Genetic advance as per cent of mean.

Table.2 Variability parameters for different characters in F_2 population of Anna (R) 4 x Samba mahsuri *Pup*1

Character	Mean			Range		PCV (%)	GCV (%)	h^2 (%)	GAM %	Skewness	Kurtosis
	P_1	P_2	F_2	Min	Max						
Days to first flowering	81.13	105.53	97.22	85.00	118.00	6.65	6.49	95.17	13.73	0.64**	0.10
Plant height (cm)	93.88	79.25	78.52	55.90	96.00	9.75	9.58	96.62	20.43	-0.29	0.07
Number of tillers per plant	17.19	13.73	13.91	2.00	30.00	35.51	33.32	88.05	67.86	0.70**	0.81*
Number of productive tillers per plant	14.75	11.53	9.42	1.00	29.00	47.31	45.23	91.41	93.83	0.91**	1.42**
Panicle length (cm)	25.42	22.55	22.90	17.30	28.70	9.82	8.28	71.03	15.14	0.30	-0.07
Number of filled grains per panicle	113.06	176.47	108.34	43.00	249.00	36.58	36.45	99.30	78.82	0.86**	0.78*
Hundred grain weight (g)	2.33	1.36	1.83	1.20	3.00	13.41	12.25	83.39	24.27	0.30	2.73**
Shoot P content (mg/g)	0.115	0.141	0.085	0.041	0.181	39.62	37.95	91.75	78.89	1.18**	0.63
Grain P content (mg/g)	0.312	0.340	0.249	0.125	0.309	17.30	15.76	82.99	31.15	-1.08**	0.51
Single plant yield (g)	26.02	20.93	14.57	5.50	38.90	50.63	50.27	98.57	108.30	1.07**	0.62

*, ** significant at 5 % and 1 % levels, respectively

P_1=Anna (R) 4; P_2= Samba mahsuri *Pup* 1; Min = Minimum; Max = Maximum; PCV = Phenotypic coefficient of variation; GCV = Genotypic coefficient of variation; h^2 = Heritability (%); GAM = Genetic advance as per cent of mean.

Fig.1 Frequency distributions for biometrical traits in F_2 population of cross Anna (R) 4 x IR 64 *Pup* 1

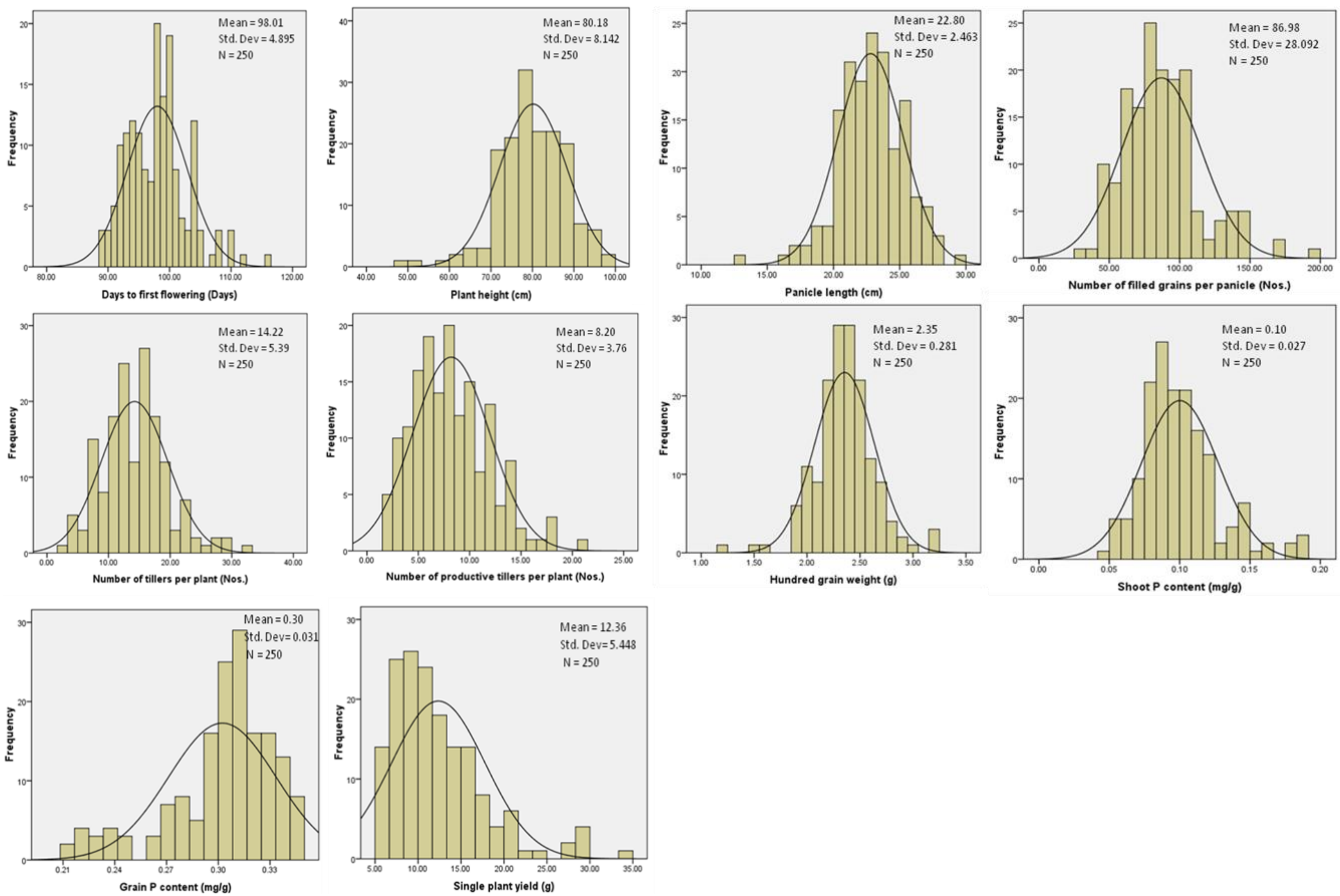
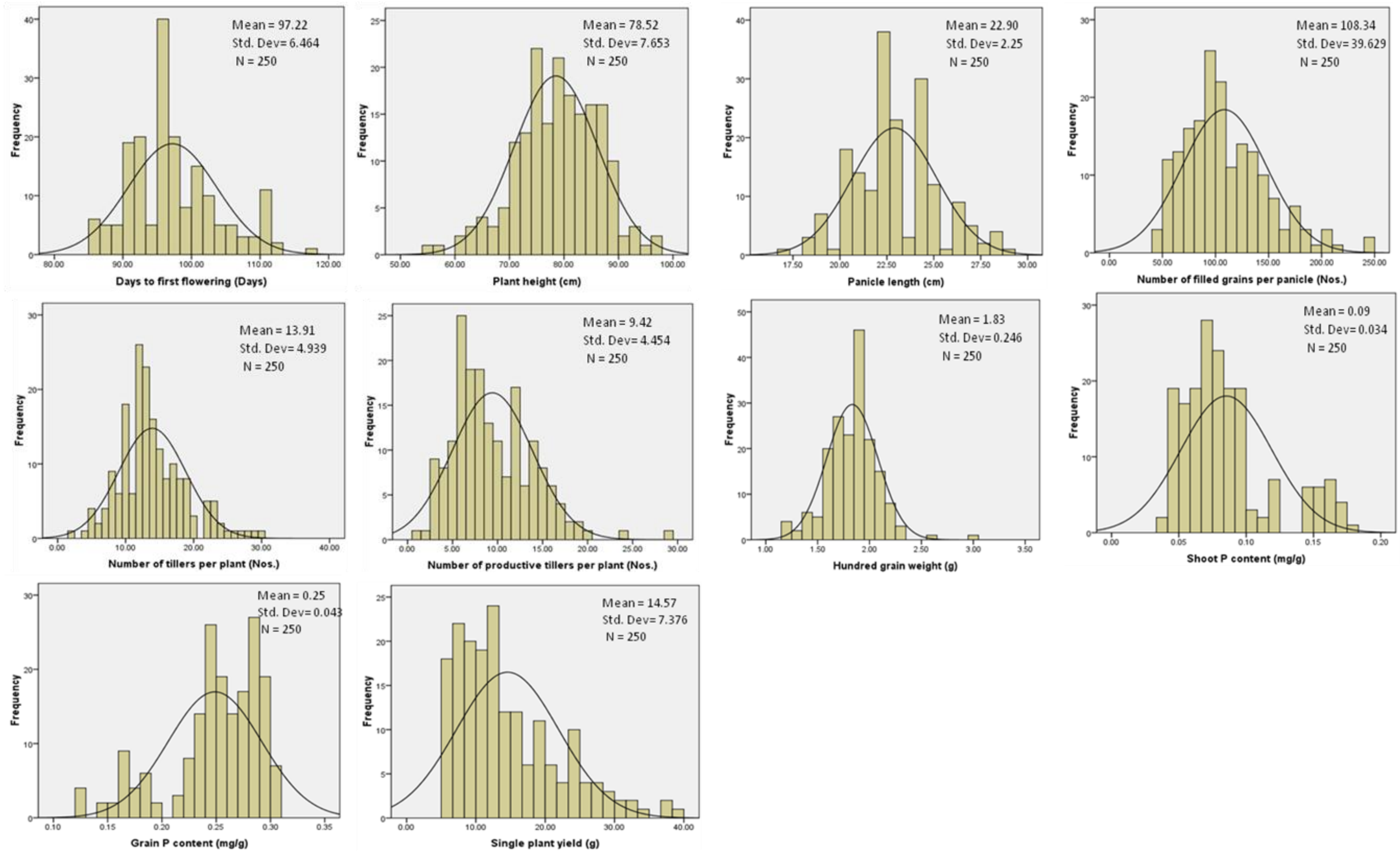


Fig.2 Frequency distributions for biometrical traits in F_2 population of cross Anna (R) 4 x Samba mahsuri *Pup* 1



The study revealed high heritability coupled with high genetic advance as per cent of mean recorded for plant height, number of tillers per plant, number of productive tillers per plant, number of filled grains per panicle, hundred grain weight, shoot P content, grain P content and single plant yield in F_2 populations.

Considering the skewness, the trait panicle length and grain P content had negative skewness in Anna (R) 4 × IR 64 *Pup* 1 cross and grain P content in Anna (R) 4 × Samba mahsuri *Pup* 1 cross indicated that the individuals are clustered towards higher mean values.

The characters days to first flowering and shoot P content in both the crosses recorded positive skewness which indicated that the individuals are clustered towards lower mean values. Therefore, these traits should be taken into account while selecting superior and desirable plants that would offer scope for developing high yielding and P deficient tolerance in rice breeding programme.

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