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M Venkatesan
Assistant Professors, Department of Genetics and Plant Breeding, Faculty of Agriculture, Annamalai University, Annamalai Nagar, Tamil Nadu, India

R Eswaran
Assistant Professors, Department of Genetics and Plant Breeding, Faculty of Agriculture, Annamalai University, Annamalai Nagar, Tamil Nadu, India

P Karthikeyan
Assistant Professors, Department of Genetics and Plant Breeding, Faculty of Agriculture, Annamalai University, Annamalai Nagar, Tamil Nadu, India

KR Saravanan
Assistant Professors, Department of Genetics and Plant Breeding, Faculty of Agriculture, Annamalai University, Annamalai Nagar, Tamil Nadu, India

Correspondence
R Eswaran
Assistant Professors, Department of Genetics and Plant Breeding, Faculty of Agriculture, Annamalai University, Annamalai Nagar, Tamil Nadu, India

Genetic variability studies in f3 and f4 segregating generations for yield and its components in rice (*Oryza sativa* L.)

M Venkatesan, R Eswaran, P Karthikeyan and KR Saravanan

Abstract
Rice is the most important cereal crop and it is the main source of energy and income for the majority of the world's human population. In this study four crosses of F1 generation were advanced to F3 and F4 segregating generations for variability, heritability and genetic advance of rice genotypes. Among four cross combinations AD95137XADT36 and AD95157XADT36 showed good performance for most of the traits studied. These two cross combinations recorded high heritability coupled with high genetic advance as percent of mean and moderate heritability with moderate genetic advance as percent of mean indicating the presence of additive gene action in both F_3 and F_4 populations and hence these cross combinations can be selected for further improvement. The other two crosses combinations AD 95157 X ADT 43 and AD 95157 X IR 50 recorded mostly low heritability and low genetic advance as percent of mean in both the populations indicating the predominance of non-additive gene action.

Keywords: Rice, segregating generation, PCV, GCV, heritability and genetic advance

Introduction
Rice breeders are interested in developing high yielding cultivars with improved yield and other desirable agronomic characters. To achieve this goal, the breeder has the option of selecting desirable genotypes in early generations or delaying intense selection until advanced generations, when progenies are nearly homozygous. In early stages of breeding programs, direct estimates of yield are quite difficult. Plant breeders are commonly selecting for yield components which indirectly increase yield. Yield component breeding to increase grain yield would be most effective, if the components involved were highly heritable and genetically independent. The selection criteria for yield may depend on one or more yield related morphological components. Yield might be increased in small grains by selecting for the component of yield and that parental varieties should be selected on the basis of component attributes (Woodworth, 1931) [11].

An exhaustive survey of genetic variability and detailed understanding of genetic makeup of the crop is an important prerequisite for initiating crop improvement programme. The variability observed in any population could be due to the genetic and environment factors and also due to interaction between these factors. The genetic and environmental components of variation were discussed by Johannsen (1909) [6] who attributed the variation in a segregating population to heritable and non-heritable factors, while the variation within pure lines was attributed to environmental factors. The heritable variations could be further divided into additive and non-additive components. The heritable variations are also divided into dominant and inter-allelic interaction (Falconer, 1981) [3]. The broad sense heritability is the ratio of genotypic variance to the total variance in non-segregating population (Lush, 1945 and Hanson *et al.*, 1956) [9, 5]. The genotypic variance includes non-additive components which are not transmitted to next generation. Hence high heritability coupled with high genetic advance was reported to be more useful in practicing selection in a population (Johnson *et al.*, 1955) [7].

Materials and methods
The present investigation was carried out during 2016 to 2017 using the experimental material consists of high yielding varieties *viz., ADT 36, ADT 43 and IR 50 and the cultures* AD95137 and AD 95157 by adopting a spacing of 30 x 10 cm at Department of at experimental form of Genetics and Plant Breeding, Faculty of Agriculture, Annamalai University. The resulting F1 cross combinations were transplanted in Randomized Block Design with three replication. Segregating populations of F2, F3 and F4 crosses was raised in non-replicated plots. Single seedling per hill was planted with a spacing of 15 x 10 cm.

Recommended agronomic practices were followed throughout the crop growth period. Data were recorded 10 plants for replication in parents for 200 and 250 plants in F2's and F3's and F4's respectively for plant height (cm), number of productive tillers per plant (Nos), number of grains per panicle, 1000 grain weight (g), grain length grain yield per plant (g) in single plant observation for six crosses. The mean data for each charactery was subjected to statistical analysis. Standard statistical procedures were used for the analysis of mean, variance, genotypic and phenotypic coefficients of variation (Burton, 1952) [2] heritability and genetic advance.

Results and discussion

Among the four crosses studied in F_3 generation the cross combination (AD95137xADT36) recorded low plant height (83.17) with the range of 55-100cm, followed by the cross AD95157XADT36 with 89.48cm and the range between 67-107cm (Table 1 and Fig1). In F4 generation the same cross combinations exhibited low plant height viz; 82.50 and 89.55cm respectively and with the range between 60-95cm and 59-98cm respectively. These two crosses in both the generation can be selected if the objective is related to developing dwarf genotypes to avoid lodging. In F_3 population the phenotypic coefficient of variation ranged from 14.71 (AD95157XADT43) to 19.60(AD95137xADT36), while in F_4 the PCV ranged from 82.50 (AD95137xADT36) to 108.46(AD95157xIR50). The genotypic coefficient of variation ranged from 6.29 (AD95157xADT43) to 9.82(AD95137xADT36) in F_3 generation. In F_4 generation the GCV ranged from 8.25(AD95157XADT43) to 9.02 in AD95137XADT36 and AD95157XIR50 respectively. Heritability estimates were moderate in cross AD95137XADT36 (30.61 per cent) and AD95157XADT36 (33.50per cent) in F_3 generation and low for the crosses AD95157XADT43 (25.72per cent) and AD95157XIR50 (20.58 per cent). In F_4 generation all the crosses exhibited low heritable estimates for plant height. Similarly genetic advance as percent of mean exhibited low estimates for all the crosses in F_3 and F_4 except AD95137x ADT36 (20.96, 19.51) in F_3&F_4 population, where it exhibits moderate estimates.

Among the four crosses studied for productive tillers per plant, the cross AD95137XADT36 recorded highest productive tillers per plant (24.21 and 24.88) respectively in F_3 and F_4 population with a range of 7-26 and 8-25, followed by AD95157xADT36 in both the populations (Table 2 and Fig 2). The same trend was noticed for both PCV and GCV in both the populations of the crosses AD95137XADT36 and AD95157XADT36. High heritability coupled with high genetic advance as percent of mean were noticed for the crosses AD95137xADT36 and AD95157xADT36 in F_3 and F_4 populations indicating the presence of additive gene action and portrayed the possibility of selection per se in these crosses for the improvement of number of productive tillers per plant. The results were in accordance with the earlier findings of Sangeetha (2013) [10] and Koutu, (2013) [8].

The cross combination AD95137xADT36 recorded highest panicle length (22.17 and 21.46) in both the populations followed by AD95157xIR50. In both the population the cross AD95137XADT36recorded high PCV (16.52 and18.02), high GCV (11.82 and 12.06) with moderate heritability estimates (41.54 and 40.65) and moderate genetic advance as percentage of mean (19.36 and 16.07) for this trait followed by AD95157xADT36 in both the populations (Table 3 and Fig 3).

In both F_3 and F_4 populations the cross combination AD95137xADT36 (113.12 and 112.04) recorded more number of grains per panicle followed by AD95157xIR50 (106.09 and 107.37) respectively. GCV and PCV were also high for the cross AD95137XADT36 in both the populations followed by the cross AD95157xADT36 (Table 4 and Fig 4). Moderate heritability coupled with moderate genetic advance as percent of mean were exhibited by the cross AD95157XADT36 in F_3 and F_4 populations. The other two crosses portrayed low heritability and low genetic advance as percent of mean for this trait.

For the trait 1000 grain weight, the cross AD95137xADT36 (20.7) and the cross AD95157XIR50 (20.4) recorded high mean in F_3 population (Table 5 and Fig5). In F_4 population the cross AD95157xADT36 (19.9) exhibited high mean followed by the crosses AD95137xADT36 and AD95157x ADT43 in F_4 population. PCV and GCV were more for the cross AD95157XADT36 followed by AD95137XADT36. High heritability were observed in the cross AD95137xADT36 followed by AD95157XIR50 in F_3population coupled with high genetic advance as of mean for AD95137XADT36 and low genetic advance as percent of mean for AD95157XIR50. In F_4 population the crosses AD95137XADT36 and ADT95157XADT36 recorded high heritability coupled with high genetic advance as percent of mean. The cross combination AD95137XADT36 recorded high mean grain yield of 25.08 and 27.11 in both the generations followed by the cross AD95157XADT36 (Table 6 and Fig 6). The same two crosses recorded high PCV and GCV in both F_3 and F_4 generations. High heritability coupled with high genetic advance were recorded by the cross AD95137xADT36 in both the generations followed by AD95157XADT36. In general when compared with four crosses the cross combination AD95137XADT36 and AD95157XADT36 excelled good performance for most of the traits studied. These two cross combinations recorded high heritability coupled with high genetic advance as percent of mean and moderate heritability with moderate genetic advance as percent of mean indicating the presence of additive gene action in both F_3 and F_4 populations and hence these cross combinations can be selected for further improvement. The other two crosses combinations AD 95157 X ADT 43 and AD 95157 X IR 50 recorded mostly low heritability and low genetic advance as percent of mean in both the populations indicating the predominance of non-additive gene action.

Table 1: Estimates of variability for Plant Height in F_3 and F_4 populations of rice

Parameters	AD95137	X ADT 36	AD 95157	X ADT 36	AD 95157	X ADT 43	AD 95157	X IR 50
	F_3	F_4	F_3	F_4	F_3	F_4	F_3	F_4
Range (days)	55-100	60-95	67-107	59-98	60-110	65-104	75-123	71-119
Mean (days)	83.17	82.50	8.48	89.55	95.54	95.72	106.32	108.46
PCV (%)	19.60	18.85	19.24	17.50	14.71	14.25	17.82	16.07
GCV (%)	9.82	9.02	7.92	8.94	6.29	8.25	8.62	9.02
Heritability (%)	30.61	27.59	33.50	27.51	25.72	21.31	20.58	19.25
GAM (%)	20.96	19.51	9.35	9.27	7.38	6.01	8.89	8.50

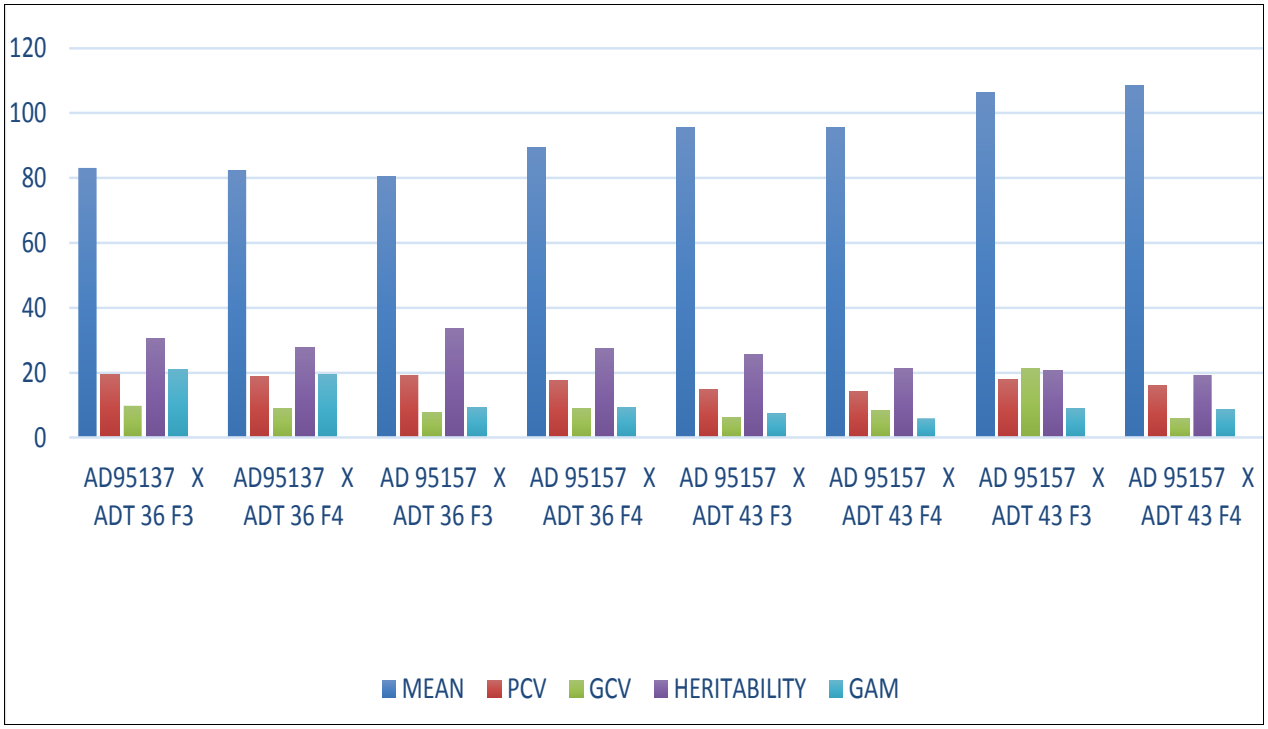

Fig 1: Estimates of variability for plant height in F3 and F4 populations of rice

Table 2: Estimates of variability for Productive Tillers per Plant in F_3 and F_4 populations of rice

Parameters	AD95137	X ADT 36	AD 95157	X ADT 36	AD 95157	X ADT 43	AD 95157	X IR 50
	F_3	F_4	F_3	F_4	F_3	F_4	F_3	F_4
Range (days)	7-26	8-25	5-23	6-25	6-20	4-21	6-21	7-23
Mean (days)	24.21	24.88	22.04	22.75	16.38	17.04	17.41	18.7
PCV (%)	32.70	30.42	26.95	27.91	18.72	18.36	16.22	14.90
GCV (%)	30.25	28.65	23.98	26.05	12.11	15.06	15.06	12.39
Heritability (%)	74.59	75.23	65.25	68.59	46.56	49.66	44.38	45.03
GAM (%)	25.25	29.58	22.05	24.81	13.87	15.53	19.30	19.91

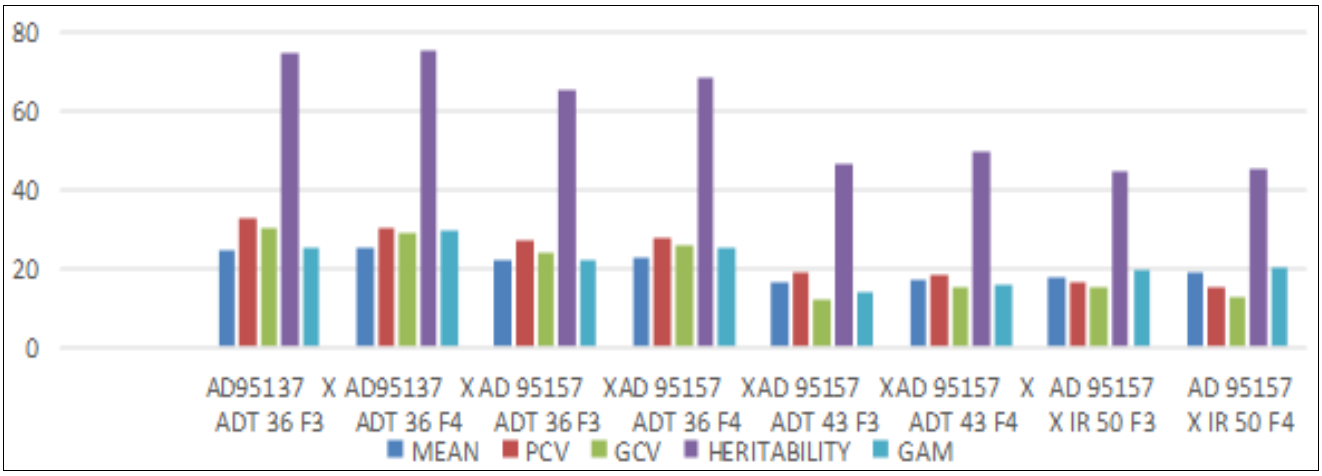

Fig 2: Estimates of variability for Productive Tillers per Plant in F3 and F4 populations of rice

Table 3: Estimates of variability for Panicle Length in F_3 and F_4 populations of rice

Parameters	AD95137	X ADT 36	AD 95157	X ADT 36	AD 95157	X ADT 43	AD 95157	X IR 50
	F_3	F_4	F_3	F_4	F_3	F_4	F_3	F_4
Range (days)	17.5-28	18-25.1	16.7-22.4	15-23.2	12.5-21.2	14.2-20.7	14.6-21.8	16.5-21.9
Mean (days)	22.17	21.46	17.87	18.67	17.56	17.63	18.67	19.06
PCV (%)	16.52	18.02	15.78	15.82	10.51	11.09	11.19	11.34
GCV (%)	11.82	12.06	10.01	10.12	6.74	7.11	7.0	9.07
Heritability (%)	41.54	40.65	35.71	36.95	19.71	14.56	25.55	29.70
GAM (%)	19.36	16.07	9.59	9.51	9.56	7.34	9.11	7.15

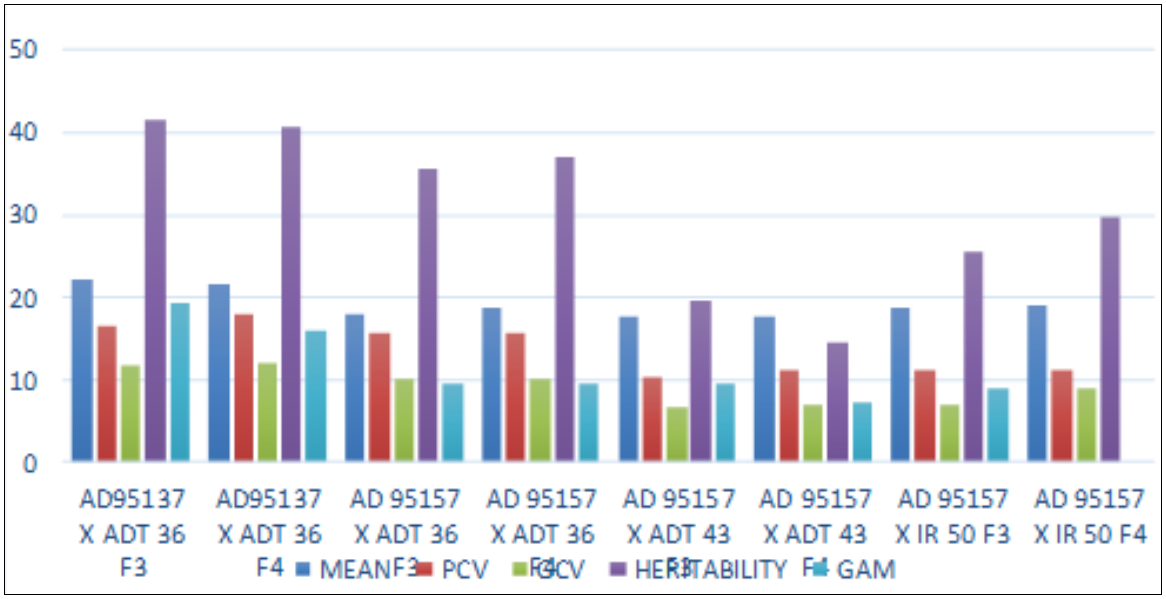

Fig 3: Estimates of variability for Panicle Length in F3 and F4 populations of rice

Table 4: Estimates of variability for Grains per Panicle in F_3 and F_4 populations of rice

Parameters	AD95137	X ADT 36	AD 95157	X ADT 36	AD 95157	X ADT 43	AD 95157	X IR 50
	F_3	F_4	F_3	F_4	F_3	F_4	F_3	F_4
Range (days)	98-137	90-129	89-121	92-125	67-111	79-109	77-117	85-119
Mean (days)	113.12	112.04	102.41	103.03	101.35	100.21	106.09	107.37
PCV (%)	23.28	22.98	18.07	18.60	12.64	10.09	15.86	13.49
GCV (%)	21.85	20.40	17.28	17.94	10.64	9.42	12.76	11.31
Heritability (%)	31.30	31.58	37.63	33.77	14.34	19.97	11.66	10.69
GAM (%)	15.19	14.06	9.58	8.16	7.14	6.24	5.07	4.77

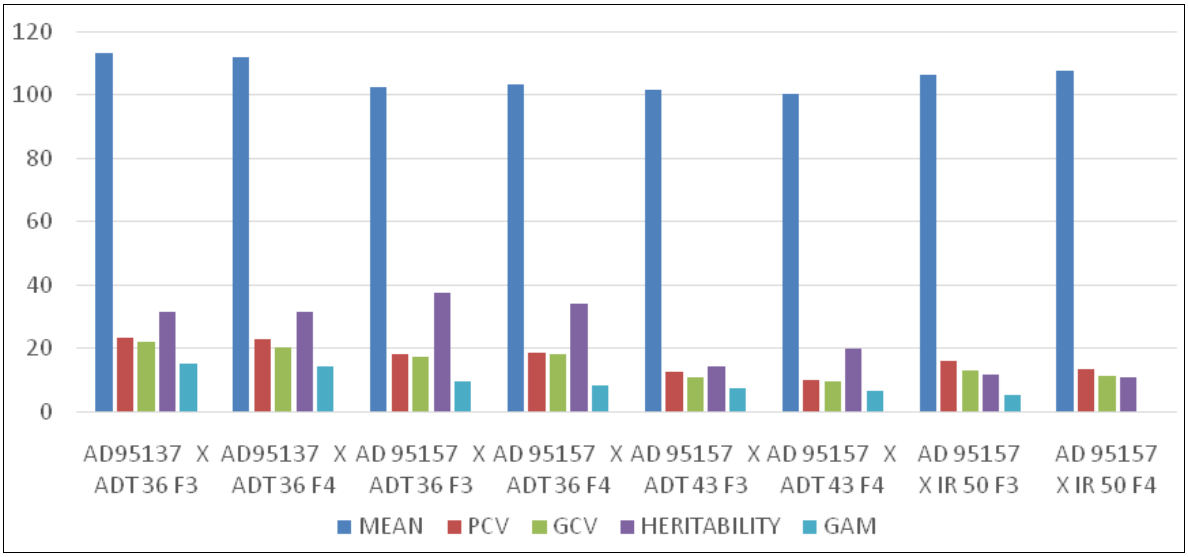

Fig 4: Estimates of variability for Grains per Panicle in F3 and F4 populations of rice

Table 5: Estimates of variability for 1000 Grain Weight in F_3 and F_4 populations of rice

Parameters	AD95137	X ADT 36	AD 95157	X ADT 36	AD 95157	X ADT 43	AD 95157	X IR 50
	F_3	F_4	F_3	F_4	F_3	F_4	F_3	F_4
Range (days)	20.2-22.6	20.2-22.3	17.4-23.5	18.4-23.4	15.8-21.4	16.4-24.1	16.0-21.9	20.4-23.1
Mean (days)	20.7	19.5	18.9	19.9	19.2	19.5	20.4	19.0
PCV (%)	22.05	22.59	26.92	27.74	14.20	13.83	16.05	14.67
GCV (%)	20.82	20.28	24.59	25.58	13.55	12.27	14.01	13.40
Heritability (%)	82.25	82.50	79.76	81.44	80.22	80.43	81.73	79.57
GAM (%)	21.05	21.85	20.41	20.75	20.53	20.05	18.90	19.27

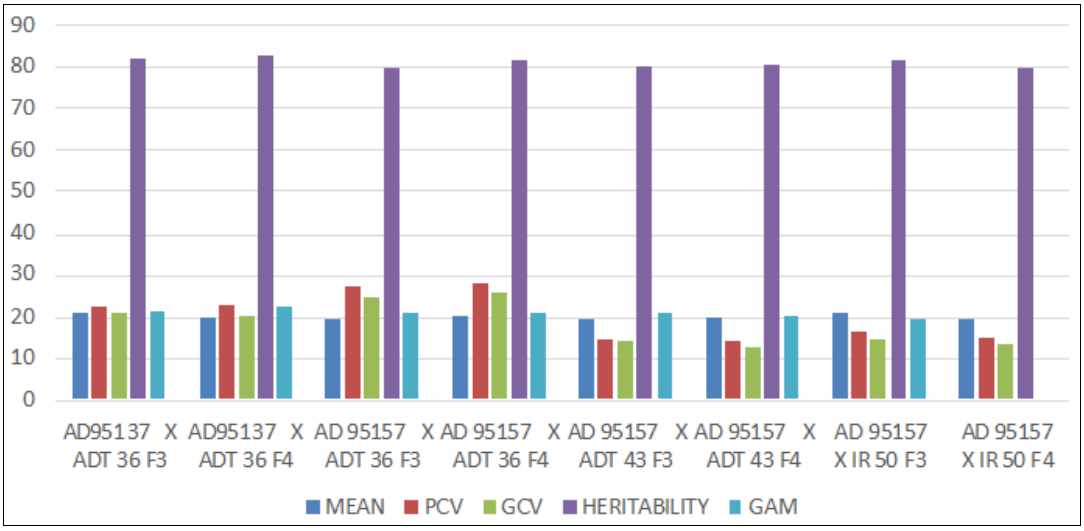

Fig 5: Estimates of variability for 1000 Grain Weight in F3 and F4 populations of rice

Table 6: Estimates of variability for Grain Yield Plant in F_3 and F_4 populations of rice

Parameters	AD95137	X ADT 36	AD 95157	X ADT 36	AD 95157	X ADT 43	AD 95157	X IR 50
	F_3	F_4	F_3	F_4	F_3	F_4	F_3	F_4
Range (days)	14.4-35.8	12.7-37.2	12.0-34.2	11.5-36.0	10.5-25.6	14.7-27.0	15.7-26.7	9.5-28.3
Mean (days)	25.08	27.11	24.01	25.07	18.7	18.62	19.6	19.62
PCV (%)	25.67	28.41	23.51	27.62	19.58	18.62	18.85	19.61
GCV (%)	23.37	25.58	20.89	24.91	11.65	11.07	14.98	14.52
Heritability (%)	73.0	76.14	69.41	71.29	45.78	48.25	57.25	51.58
GAM (%)	30.40	34.65	22.70	21.91	9.80	8.95	8.81	9.59

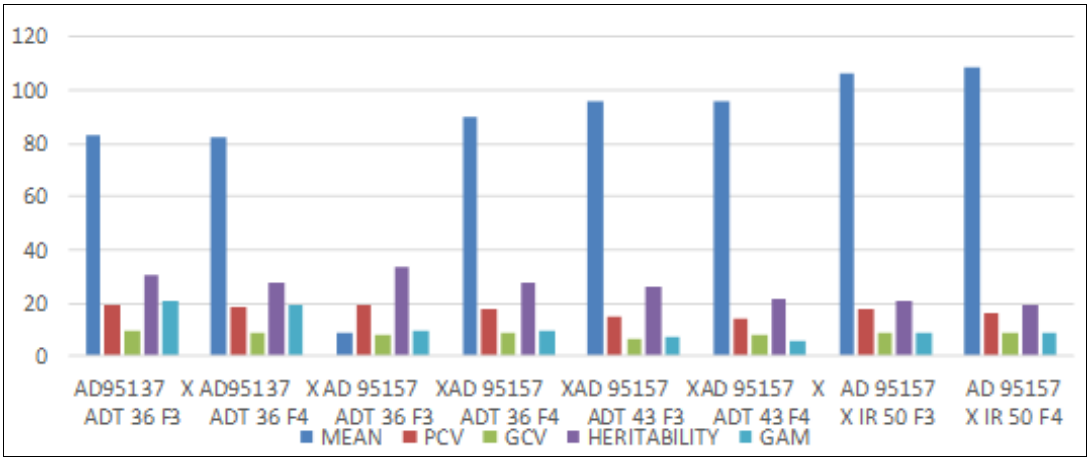

Fig 6: Estimates of variability for Grain Yield Plant in F3 and F4 populations of rice

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