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Genotype x environment interaction and stability analysis for fruit yield and quality traits in pineapple (*Ananas comosus*)

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ABSTRACT : The present study was conducted to assess the existence of genotype x environmental (G x E) interactions and stability for yield and quality related traits in pineapple using four varieties over seven locations during the year 2012-13. Pooled analysis of variance over seven locations revealed that the genotypic variances were highly significant for all the characters which revealed considerable genetic variability in the population. Stability parameters revealed that the genotype 'Amritha' was found better under poor environments. 'Mauritius' and 'Amritha' showed stable and consistent performance for all quantitative and qualitative traits whereas, 'Mauritius' had above average response and high stability in better environments for yield only. Thus, genotypes 'Amritha' and 'Mauritius' may be utilized in hybrid breeding programme to exploit their consistent performance in all order of yield.

KEY WORDS : Genotype x environment interaction, Stability, Quality, Yield

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Pineapple (*Ananas comosus*) is an important fruit crop of sub-tropical regions to tropical regions of India, which belongs to the genus *Ananus* of Bromeliaceae family. Flowers are hermaphrodite with functional pollen and ovule but there is self incompatability, hence, the fruit set takes place parthenocarpically. The crop has cultivated in many tropical and subtropical regions of the world *viz.*, Malaya, South Africa, Hawaiian islands, queensland, Singapore and Ceylon. The release of first high yielding hybrid Amritha at Pineapple Research Centre of the Kerala Agricultural University as a result of hybridization attracted the attention of breeders to utilize the heterosis on commercial scale. Its yield potential is 85 tonnes per hectare. The fruit yield and shape of 'Amritha' is comparable with the highest yielding, cylindrical fruit of the female parent Kew and the fruit quality attributes such as flesh colour, flavour and sweetness matched those of the fruit of the male parent Ripley Queen.

A phenotype is a result of interplay of genotype and its environment. A particular genotype does not exhibit the same phenotypic characteristics under different environments and different genotype response differently to a particular environment. The crop yield is dependent on a genotyope, the environment and their interaction. When interaction between genotype and environment is present, ranking of genotype will be different under different environments. The plant breeder is always interested in the stability of performance for the characters which are of economically important. The desirable hybrids should have low genotype x environment interactions for important characters, so as to get desirable performance of hybrids over wide range of environmental conditions. Such hybrids are said to be

Table A : Details of environment

Sr. No.	Location	Environment	Date of sowing
1.	Andoor	E I	1.04.2011
2.	Malaivizhai	E II	5.04.2011
3.	Valiyatrumugam	E III	6.04.2011
4.	Itahaveli	E IV	7.04.2011
5.	Pechiparai	E V	8.04.2011
6.	Kaliyal	E VI	7.04.2011
7.	Thiruvattar	E VII	8.04.2011

Table B : Mean performances of pineapple genotypes over environment

Environment	Fruit yield (t/ha)				Fruit weight (kg)				No. of days to first harvest				Acidity (%)				TSS°Brix			
	G1	G2	G3	G4	G1	G2	G3	G4	G1	G2	G3	G4	G1	G2	G3	G4	G1	G2	G3	G4
E I	23.27	30.53	30.10	58.33	1.30	1.80	2.20	3.60	426	409	406	388	2.00	1.00	2.00	0.20	11.67	10.33	12.73	18.50
E II	23.40	29.10	29.47	67.63	120	1.80	2.20	3.10	428	409	404	389	2.00	0.80	1.50	0.20	10.33	12.30	13.73	16.67
E III	23.60	30.60	28.33	56.07	1.20	2.00	2.00	3.50	426	408	405	390	1.50	0.90	1.50	0.30	11.13	11.20	12.70	18.50
E IV	22.40	31.50	34.33	53.26	1.40	1.90	2.10	3.30	426	409	406	387	2.50	1.00	1.50	0.23	10.60	12.40	12.63	17.60
E V	22.97	30.07	30.20	54.03	1.30	1.70	2.20	3.10	428	407	405	389	2.00	0.90	2.00	0.30	11.17	12.36	12.80	18.43
E VI	23.40	30.47	26.56	58.36	1.60	1.80	2.10	3.50	427	407	405	388	2.50	1.00	1.50	0.60	11.20	10.87	12.67	18.60
E VII	22.27	29.40	28.43	54.57	1.00	2.30	2.20	3.70	428	410	406	388	1.50	0.70	0.50	0.53	9.10	12.17	11.77	17.67
Mean	23.04	30.24	29.63	57.47	1.28	1.90	2.14	3.40	427	408	405	388	2.00	0.90	1.50	0.34	10.67	11.66	12.72	17.99
G. mean	35.09				2.18				407				1.18				13.26			

Fruit yield and fruit weight – G4

stable because of their stable performance under changing environments. Genotype x environment interactions are of common occurrence and often creates manifold difficulties in interpreting results and thus, hamper the progress of breeding programmes aiming at further genetic improvement in crop plants, Hence, the knowledge of magnitude and nature of genotype x environment interaction is very useful to plant breeder.

Therefore, the present investigation was carried out with the intention of identifying stable genotype with high yield and quality using Eberhart and Russell model (1966).

RESEARCH METHODS

The experimental materials consisted of four varieties of pineapple Nagarcoil Local, Kew, Mauritius and Amritha. The field experiment was conducted as on farm trial at Krishi Vigyan Kendra, Tamil Nadu Agricultural University, Kanyakumari during the year 2012-13 with spacing of 60 x 30 cm in irrigated conditions. Experiment was laid out in Randomized Complete Block Design replicated thrice. The detail of location and date of sowing are depicted in Table A. The yield attributing characters *viz.*, fruit weight, yield, days to first harvest and quality attributing characters *viz.*, total soluble sugars and acidity were included for the study. Analysis of variance was performed and stability parameters were computed following the model proposed by Eberhart and Russell (1966). The type of stability was decided on regression coefficient (b_i) and mean values (Finlay and Wilkinson, 1963).

RESEARCH FINDINGS AND DISCUSSION

The analysis of variance for individual environments revealed highly significant mean squares due to genotypes for all the characters indicating the presence of genetic variation for different characters in the population (Table 1). Pooled analysis of variance revealed that the genotypic variances were highly significant for all the characters. The environmental variance was highly significant for all the characters studied indicating difference in the environments selected for the study. The variance due to G x E interaction was also highly significant for all the traits (Table 2).

The analysis of variance for stability of different characters, as per Eberhart and Russell (1966) model is given in Table 2. The mean squares due to genotypes,

environments, genotype x environment, environment (linear) and genotype environment (linear) were tested against pooled deviation. The pooled deviation was tested against pooled error. The significant mean sum of squares due to genotypes, environments and environment (linear) for all characters were observed when tested against pooled deviation.

The mean squares due to G x E interactions were significant for number of days to first harvest, fruit weight and fruit yield, which indicated differential response of genotypes in varying environment for these traits. The mean sum of square due to environment and environment (linear) were found highly significant for all the characters (Table 2), which revealed that differences due to environments were real and thus, the creation of environments was fully justified.

The stability parameters for fruit yield revealed that 'Amritha' registered higher mean, non-significant deviation from linear regression ($S^2 d_i$) and regression co-efficient less than 1(b_i<1). Therefore, it is better under poor environments. Two genotypes 1 and 3 (local and Mauritius), respectively, registered lower and medium mean for yield, non-significant deviation from linear regression and bi>1, considering suitability under favourable environments (Table 4). Similar findings were reported by Solanki and Joshi (2000).

Based on stability parameters for yield and yield attributing traits, it could be summarized that 'Amritha'

Table 1 : Analysis of variance (Mean square) for individual environment

Source of variance	d.f	Fruit yield per plant (kg)	Fruit weight (kg)	No. of days to harvest	Acidity (%)	TSS (^{o}Brix)
Environment I						
Replication	2	0.62	0.09	1.58	0.09	0.01
Genotype	3	724.82**	2.93**	729.42**	2.28**	40.65**
Error	6	0.13	0.06	0.58	0.09	0.09
Environment II						
Replication	2	0.02	0.01	2.08	0.05	0.01
Genotype	3	1241.88**	1.91**	772.67**	1.87**	21.32**
Error	6	0.15	0.05	1.08	0.08	1.38
Environment III						
Replication	2	0.05	0.20	0.58	0.03	0.01
Genotype	3	637.07**	2.77**	667.33**	1.15**	36.47**
Error	6	0.16	0.04	1.58	0.12	0.02
Environment IV						
Replication	2	0.10	0.07	0.33	0.08	0.16
Genotype	3	552.57**	1.94**	739.67**	2.78**	27.03**
Error	6	0.17	0.11	1.00	0.06	0.17
Environment V						
Replication	2	0.26	0.09	2.33	0.02	0.003
Genotype	3	771.87**	1.80**	766.08**	2.35**	31.40**
Error	6	0.10	0.08	2.00	0.08	0.02
Environment VI						
Replication	2	0.33	0.14	0.08	0.23	0.06
Genotype	3	612.36**	2.21**	740.08**	2.78**	38.82**
Error	6	0.09	0.01	1.08	0.11	0.12
Environment VII						
Replication	2	0.79	0.09	0.33	0.0	0.03
Genotype	3	250.10**	3.66**	781.67**	10.92**	38.78**
Error	6	3.66	0.06	1.67	0.01	0.01

* and ** indicate significance of values at P=0.05 and 0.01, respectively
Analysis of variance showed highly significant result for all the five characters studied

Table 2 : Pooled analysis of variance (mean square) over environment for different characters in pineapple

Source of variance	d.f	Fruit yield	Fruit weight	Harvest	Acidity	TSS
Genotype	3	1631.38**	5.52**	1726.80**	3.64**	74.59**
Environment	6	5.73**	0.03**	0.51**	0.17**	0.37**
G x E	18	8.39**	0.04**	0.92**	0.09**	0.59**
Pooled error	56	0.02	0.01	0.43	0.02	0.02

* and ** indicate significance of values at P=0.05 and 0.01, respectively
Genotypes taken for study over environment is highly significant
Environment showed significant result only for the characters fruit yield and acidity
Genotype x environment interaction showed significant result only for yield and its contributing traits

Table 3 : Analysis of variance (mean square) for stability for various traits in pineapple

Source of variance	d.f	Fruit yield	Fruit weight	Days to first harvest	Acidity	TSS
Genotype	3	1631.38**	5.52**	1726.80**	3.642**	74.59**
Environment $^{+ (G \times E)}$	24	7.73*	0.03	0.82	0.11**	0.53
Environment (linear)	1	34.42**	0.17**	3.76**	1.01**	2.23*
Genotype x Environment (linear)	3	23.61	0.07**	0.64	0.24**	0.41
Pooled deviation (non linear)	20	4.01**	0.02	0.70	0.05*	0.47**
Pooled error	56	0.04	0.01	0.42	0.02	0.02

*and ** indicate significance of values at P=0.05 and 0.01, respectively
Genotype 3 deviate non-significantly from zero (S^2 d = 0.77). Hence, it is stable.
Genotype b value more than 1 is said to be highly responsible – suitable for favourable environment.
b value is less than 1 is said to be low responsive – suitable for unfavourable environment.
The genotype – better than the grand mean may be recommended for all environments.

Table 4 : Estimates of stability parameters for different traits in different genotypes of pineapple

Genotypes	Fruit yield			Fruit weight			Days to first harvest			Acidity			Total soluble salts		
	Mean	bi	S^2 di	Mean	bi	S^2 di	Mean	bi	S^2 di	Mean	bi	S^2 di	Mean	bi	S^2 di
Nagercoil local	23.04	0.17	0.39	1.28	-0.09	2.19	427.04	1.35	1.95	2.0	1.6	1.05	10.67	2.13	1.36
Kew	30.23	-0.12	0.66	1.90	1.55	1.76	408.42	2.01	2.35	0.9	0.5	0.25	11.66	0.05	2.78
Mauritius	29.63	0.48	1.96	2.14	-0.10	0.91	405.47	0.33	1.43	1.5	1.9	1.46	12.71	1.03	1.55
Amritha	57.47	3.45	2.20	3.40	2.65	0.90	388.71	0.20	1.88	0.3	-0.1	0.78	17.99	0.77	2.22
Mean	35.09	-	-	2.18	-	-	407	-	-	1.1	-	-	13.25	-	-
SEM	0.81	-	-	0.05			0.34	-	-	0.09	-	-	0.28	-	-

consistently expressed stable performance under poor environments, whereas, the genotype mauritius found ideally stable for better environment (Table 4). Further, the mean for yield recorded in 'Amritha' is better than the grand mean and therefore, suitable for all the environments. These lines may be used as parental lines in further breeding programme of hybridization.

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