in enhancing to enzyme and photosynthetic activities, accumulation of photosynthates thereby, higher yields. The beneficial effect of Mn and Cu in SMF might be associated with their role in nitrogen nutrition, photosynthetic activity and carbohydrate metabolism.

This could also be viewed that the foliar spray in Alfisol as short term effect since the foliar sprays were given only at critical stages and the micronutrients through microfood supplied would not have been effectively absorbed and transported to growing tissues of fruits and leaves (Palanivel and Ramanathan, 1992). The integration of both CCP and Azospirillum with microfood brought about much greater benefit in terms of fruit yield. The favourable C: N ratio and appreciably higher contents of nutrients and their ready availability due to its prolonged period of composting could be the possible reasons for its spectacular increase on fruit yield. (Darley Jose *et al.*, 1986). The additive effect of Azospirillum on yield might be not only due to fixation of N but also due to increased activity of hormones which would have had a positive influence on the physiological activity of the plants. (Thamburaj, 1991).

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Genotype x environment interaction in castor

P. MANIVEL AND H.S. JAVAD HUSSAIN
Oilseeds Research Station, TNAU, Tindivanam - 604 002, Tamil Nadu

Abstract : The phenotype stability of 79 genotypes of castor (60 hybrids and 19 parents) grown over four environments was studied for oil content, seed yield and other related traits. Variance due to genotypes, environments, G x E (liner) components was highly significant for all the traits. However, the liner component was more than the non-liner component except for capsules per plant and 100 seed weight. In general hybrids showed greatest stability for all the traits. The traits like number of nodes up to primary raceme, 100 seed weight and oil content were less affected by the changing environments on the other hand, substantial fluctuations due to change of environments was observed for plant height, length of primary raceme, number of capsules and seed yield per plant. The hybrids JP 65 x RC 1226, 240 x USSR2, LRES 17 x JH 120, LRES 17 x SH 63, and 240 x Salam local were considered to be superior and stable over environments. ***(Key words** : Castor, Ricinus communis, Phenotypic stability).*

Castor is one of the important non-edible oilseeds, having wider utilization in many commercial trades like pharmaceutical, soap, paint and lubricant industries, besides having many other uses. Quite often yield fluctuations hamper the growth of castor economy. Yield fluctuation results from sensitivity of crop to the environmental changes. Use of stable variety or hybrid may overcome this problem to a greater extent. Significant genotype x environment interaction for yield and related traits can be commercially exploited through identification of stable cultivars/hybrids. Stable cultivars/ hybirds of castor with high yield can be directly released for commercial cultivation or be utilized for development of stable cultivars through recombination breeding. Therefore, the present investigation was taken up to study the stability of yield and related traits over two locations in two seasons to identify the stable cultivars / hybrids.

Materials and Methods

The experiments were conducted at Oilseeds Research Station, Tindivanam (11°46' N, 79°46' NE, 45.6 masl, temperature range from 24.1° C to 31.7°C, annual rainfall of 1228.6mm, sandy loam soil with a pH of 7.4) and Sugarcane Research Station, Cuddalore (12°56'N, 79°50'E, 4.60m MSL, temperature range from 23.61° C to 32.80°C, annual rainfall of 1196.6mm, sandy loam soil with a pH of 6.8) during *summer* 1992 and *kharif* 1993. A total of 79 genotypes comprising of four cent per cent pistillate female lines, 15 male inbreds and their 60 hybrids (derived from L x T design) were planted in randomized block design with three replications. Each entry was planted in two rows each accommodating ten plants with a spacing of 90 cm x 45 cm. The data were recorded on 10 randomly selected plants for yield and related traits and analysed for stability parameters as per Eberhart and Russel (1996). The environmental index was calculated as deviation of the mean of all genotypes at a particular environment from the grand mean.

Results and Discussion

The pooled analysis of variance showed highly significant differences among the genotypes for all the traits indicating that the genotypes were genetically diverse (Table 1). The variance due to environments (linear and non-linear) and genotype x environment (non-linear) interaction were highly significant for all the traits except for nodes up to primary raceme and oil content. Higher magnitude of environment (linear) effect in comparison to G x E (linear) may be responsible for high adaptation in relation to yield and other traits (Rai *et al.,* 1989). G x E (linear) effect was highly significant when tested against pooled deviation except for oil content. Though the linear and non-linear components were significant for most of the traits, the linear component was more than the non-linear components were signifcant for most of the traits, the linear component was more than the non-linear component except for most of the trains, the linear component was more than the non-linear component except for capsules per plant and 100 seed weight. The arithmetic translations of the mean squares for the pooled data over environments into the estimates of genotypic component (σ^2g) and genotype x environment interaction component (σ^2gl) revealed the major share of genotypic component over the genotype x environment interaction components for all the traits (Table 1). Mean square for pooled deviation was highly significant for the traits (except nodes up to primary receme and oil content), suggested that variation in the perfromance of 79 genotpes over four environments was caused by unpredictable factors (Nijama and Patel, 1989). Since both genotype x environment and G x E (linear) effects were highly significant for all the traits, two parameters namely the deviation from regression (S^2d) and the regression co-efficient (b), respectively were considered along with mean yield in interpreting the stability for the traits. A genotype is considered to be stable in performance if it has high mean performance (X), unit regression co-efficient (bi=1) and least deviation from regression (S^2d). All the six hybrids that recorded seed yield exceeding pooled mean by 30 per cent possessed non significant deviation of bi from unity for seed yield and most other biometric traits (Table 2). Among them, significant deviation exceeding unity were recorded by 240 x USSR 2, LRES 17 x JH 120 and LRES 17 x Salam local for racemes per plant, while significant deviation of bi less than unity were recorded by JP 65 x RC 1226 and 240 x USSR 2 for days to 50 per cent flowering. Thus bearing unity isolated instances of significant deviation of bi from unity for one or two characters, the hybrids JP 65 x RC 1226, 240 x USSR2, LRES 17 x JH 120, LRES 17 x SH 63, and 240 x Salam local may be considered to be superior and stable over environments. Hirachand *et al.,* (1982) reported that the hybrids performed differently in different environments.

The results of the environmental index (EI) revealed that *kharif* 1993 at Tindivanam and *summer* 1993 at Tindivanam recorded substantial increase in the values of EI while at other environments, the EI was lower (Table 3). The kharif 1993 at Tindivanam has proved to be the best environment to realize increased seed yield which was accompanied by increased values in the EI for all other eight traits as well. The traits which have not recorded high EI at all in majority of the environments were node

Table 1. Analysis of variance for phenotypic stability. (All significant except ns)

Source	Days to 50% flowering	Plant height up to primary raceme	Nodes up to primary raceme	Length of primary raceme	Recemes per plant	Capsules per plant	Yield per plant (g)	100-seed weight (g)	Oil content %
Environments (E)	397.66	141903.7	17.56	2332.46	316.59	2983.0	3076.00	9.35	7.33
Genotypes (G)	213.62	3538.6	10.78	343.81	18.09	3367.5	2983.07	34.40	10.94
G x E	35.18	1388.6	2.57	99.71	6.51	1399.9	827.82	10.99	4.47
Environment (linear)	397.62	141905.6	17.45	2332.31	316.59	2982.9	3076.37	9.20	7.42
G x E (linear) (237)	13.26	1055.7	092ns	42.65	3.48	473.3	285.43	3.65	1.50
Pooled deviation (non linear)	5.78	394.5	0.50ns	15.24	0.43	514.7	251.96	4.07	1.37ns
Pooled error (624)	0.74	8.2	0.38	1.98	0.02	32.1	5.62	0.13	2.56
Linear/non-linear	2.29	2.67	1.84	2.76	8.09	0.9	1.13	0.89	1.09
$\sigma^2 g$	50.47	768.93	2.48	77.64	3.98	725.2	676.76	7.70	2.36
$\sigma^2 g l$	8.61	345.11	0.54	24.43	1.62	341.9	205.50	2.71	0.47
$\sigma^2 g/\sigma^2 g l$	5.86	2.23	4.56	3.17	2.45	2.1	3.34	2.84	5.02

Note : Significance of genotypes and G x E interaction were against pooled deviation and pooled deviation is against pooled error.

Table 2. Mean and stability parameters for yield and other traits in best six hybrids in Castor

Traits	JP 65 x RC 1226			240 x USSR 2			LRES 17 x JH 120			LRES 17 x SH 63			LRES 17 Salem local			240 x SH 63			Pooled mean
	M	bi	S^2d	M	bi	S^2d	M	bi	S^2d	M	bi	S^2d	M	bi	S^2d	M	bi	S^2d	
Days to 50% flowering	61.3	0.29*	-0.10	59.3	-0.83*	0.2	63.0	2.05	0.29	59.3	0.84*	0.5*	71.0	1.72	5.03*	68.0	0.54	21.55*	58.22
Plant height	69.1	0.63	21.78*	88.8	1.27	140.3*	96.3	0.51	48.69*	94.1	0.85	432.6*	128.4	2.14	745.50*	103.4	1.02	226.34	84.96
Nodes up to primary raceme	15.3	-1.48	0.06	14.8	-2.50*	-0.1	15.9	3.14	0.23	14.9	-1.72	0.1	17.6	3.62	1.73*	16.9	0.41	1.57	14.89
Length of primary raceme	61.6	0.24*	-0.17	34.4	0.08	9.9*	48.2	1.97	1.04	42.2	0.96	17.8*	36.3	-1.18	21.39*	43.4	0.17	8.27*	38.39
Racemes per plant	14.7	0.10	0.47*	9.5	2.43*	0.2*	12.0	2.73*	0.27*	11.3	1.05	0.2*	8.4	2.39	0.00	13.7	1.17	0.11*	9.65
Capsules per plant	223.9	0.64	10490*	172.3	-3.71	2477.0*	176.6	-1.39	279.59	181.0	-0.50	2181.5*	172.5	2.18	292.90*	183.3	8.92	731.90*	142.99
Seed yield per plant	183.2	-2.22	348.60*	182.7	3.47	2399.1	158.7	0.62	151.72	152.2	2.49	1304.0*	151.3	2.89	96.98*	147.8	8.15	280.60*	112.89
100 seed weight	27.5	0.91	0.39*	30.9	0.62	0.5*	29.9	2.55	0.67*	27.8	-3.02	0.3*	28.8	1.85	0.67*	26.6	0.46	0.11*	26.87
Oil content	49.2	-6.31	1.31	49.3	-0.47	-0.43	44.9	7.66	15.32*	48.6	0.01	-0.8	47.3	-3.6	0.24	48.6	1.14	-0.82	48.91

* Significant deviation

Table 3. Environmental index (I) and environmental mean (M) for different traits at different environments in castor

Traits	E1		E2		E3		E4		Pooled Mean
	I	M	I	M	I	M	I	M	
Days 50% flowering	-1.61	56.61	-1.00	57.22	1.42	59.65	1.19	59.41	58.22
Plant height	-19.61	65.25	-23.60	61.36	22.15	107.11	21.17	106.13	84.96
Nodes up to primary raceme	-0.36	14.53	-0.30	14.59	0.39	15.28	0.29	14.89	14.82
Length of primary raceme	-1.97	36.42	-5.02	33.37	5.04	43.43	1.96	40.35	38.39
Racemes per plant	-1.97	8.47	1.09	11.53	0.66	11.10	0.25	10.69	10.44
Capsules per plant	3.16	147.61	-5.07	139.38	0.55	145.00	1.37	145.82	144.45
Seed yield per plant	3.80	116.71	-1.88	111.01	5.99	118.88	-7.90	104.99	112.89
100 seed weigth	-0.21	26.65	-0.18	26.68	0.17	27.03	-0.28	27.14	26.86
Oil content	0.04	48.96	-0.17	48.75	0.17	49.01	-0.01	48.91	48.92

E1 - *Summer* 1993 at Tindivanam E2- *Summer* 1993 at Cuddalore
E3 - *Kharif* 1993 at Tindivanam E4 - *Kharif* 1993 at Cuddalore

number, 100 seed weight and oil content denoting that the fluctuation due to environments was much restricted for these traits. On the other hand, substantial fluctuations in EI could be observed at one or more environments for plant height, length of primary receme, number of capsules and seed yield per plant indicating that these traits were very much influenced by the variations in the environments. Considering the environments based on season and location, the study clearly brought out the importance of kharif season over summer and Tindivanam condition than Cuddalore condition for realizing increased seed yield besides enhanced values for all the important components of yield.

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