Indian J. Genet., 55 (1): 24–30 (1995)

STABILITY FOR YIELD IN SEED STOCKS AND CLONES OF TEA (*CAMELLIA SINENSIS* L.)

I. D. SINGH, S. CHAKRABORTY AND S. C. BORDOLOI

Botany Department, Tocklai Experimental Station, Tea Research Association Jorhat 785008

(Received: October 10, 1994; accepted: December 15, 1994)

ABSTRACT

Stability for yield of made tea was studied in 13 F_1 hybrid genotypes (seed stocks) in five environments. Genotype, year (linear and non-linear) and genotype x year (non-linear) interaction effects were highly significant. But genotype x year (linear) interaction was not significant. The genotype St. 462 was most stable for yield amongst all genotypes. It can be used in breeding as stable and heterotic hybrid. In another trial, stability for yield of made tea was examined in 11 diverse tea genotypes (clones) in five environments. Genotypes, years and genotype x year (G x E) interaction effects were highly significant. G x E (linear) effect was highly significant indicating thereby possibilities of prediction of yield performance over years. Significant pooled deviations showed that variation in yield of genotypes was influenced by unpredictable factors as well. Three genotypes namely, Nil PF 3/14, 480/13 and Tinga GH 3/18 were most stable coupled with medium yield performance. These genotypes could be used in future tea breeding programmes for yield improvement.

Key words: Yield, stability, tea.

Tea is a perennial plantation crop. Commercially desirable cultivars of tea should be not only high yielder but also stable in yield performance over years. This indirectly sustains the economy of tea growers and contributes to the ever-rising demand of made tea arising out of its increased rate of consumption as a beverage all over the globe. Quite often yield fluctuations are observed over years and this fluctuation hampers the growth of tea economy. Yield fluctuations results from sensitivity of the crop to the environmental changes. Significant genotype–environment interaction for yield can be commercially exploited through identification and planting of stable cultivars.

Stable cultivars with high yield can be directly released for commercial cultivation or can be utilised in breeding for developing stable cultivar through combination breeding. Although tea was grown in Assam more than a century ago, yet literature on stability of tea yield is nil. Therefore, in the present investigation, 13 seed stocks and 11 clones of tea were evaluated for stability of yield over five years under Assam conditions to identify stable genotypes.

MATERIALS AND METHODS

The experiments were conducted at Tocklai Experimental Station, Jorhat, Assam, during 1986–1992. A total of 13 promising F_1 hybrid genotypes (Biclonal seed stocks) of tea (St 203, St 379, St 449, St 460, St 461, St 462, St 463, St 464, St 466, St 490, St 491, St 492 and St 493) were planted in randomised block design with three replications in 1986 at 105 cm x 45 cm x 45 cm spacing. Similarly, the other trial consisted 11 promising clones namely, 480/11, 480/15, 106/1, 480/13, Nil PF 3/14, Tinga GH 3/18, Nil PP 4/4, 16/6/25, Tinga Gh 3/4, 3/242 and 16/10/22. Each plot comprised of 32 bushes. Yield data (kg/100 m^2) of made tea for each replication were recorded for each genotype for five consecutive years from 1988.

The data were analysed for stability parameters as per Eberhart Russell model [1].

RESULTS AND DISCUSSION

SEED STOCKS

The pooled analysis of variance showed that there were highly significant differences among the seed stocks for yield indicating that the seed stocks were genetically diverse with respect to yield (Table 1). Variance due to years (linear and nonlinear) and genotype x year (non-linear) interactions were highly significant. High magnitude of year (linear) effect in comparison to G x Y (linear) was recorded, which may be responsible for high adaptation in relation to yield [2]. G x Y (linear) effect was non-significant when tested against pooled deviation and pooled error. Hence, only mean performance ($\bar{x}$) and mean square deviation (S^2di) were considered to identify stable seed stocks for yield.

Table 1. Pooled analysis of variance for yield (kg/100 m^2) of made tea in 13 genotypes (seed stocks)

Source	d.f.	MS	Tested against G x Y MS	Tested against pooled deviation MS	Tested against pooled error
Genotype (G)	12	608.28	6.02**	5.03**	33.20**
Year (Y)	4	639.99	6.33**	5.29**	34.33**
G x Y	48	101.11	—	0.83	5.51**
Year (linear)	1	2559.93	—	21.18**	139.73**
G x Y (linear)	12	11.26	—	0.09	0.61
Pooled deviation	39	120.86	—	—	6.59**
Pooled error	130	18.32	—	—	—

**Significant at 1%.

Mean square for pooled deviation was highly significant, which suggests that variation in the performance of 13 genotypes over five years was caused by unpredictable factors [3].

The signs of environmental indices were negative for all years except 1991 (Table 2). Hence, only the environment of 1991 was rich for the manifestation of yield [3].

Table 2. Values of environmental indices for yield in tea

Environment (year)	Environmental index
1988	– 4.300
1989	– 0.465
1990	– 4.739
1991	– 12.188
1992	– 2.684

A genotype is considered to be stable in performance if it has high mean performance ($\bar{x}$), unit regression coefficient (bi = 1) and least deviation from regression (S^2di) [1]. In the present study, since G x Y (linear) effect was not significant, so regression coefficient (bi) was not taken into consideration to identify stable genotype for yield.

Stability in expression of a character could either result from homoeostasis [4] i.e., the tendency of genotypes to resist change or wide adaptability of genotypes accompanied by adjustments (plasticity) in ancillary characters leading to stable end results in varying environments [5, 6].

Table 3. Estimates of mean yield ($\bar{x}$), regression coefficient (bi) and deviation from regression (S^2di) for yield in 13 genotypes (seed stocks) of tea

Genotype	Yield (kg/100 m^2)		
	$\bar{x}$	bi	S^2di
St 203	49.09	0.731	12.93
St 379	49.06	0.839	60.28**
St 449	55.60	0.942	26.74
St 460	66.10	1.204	88.19**
St 461	62.75	1.211	39.65**
St 462	72.95	0.679	7.15
St 463	64.22	0.898	78.18**
St 464	65.70	1.106	30.79*
St 466	52.89	0.566	34.93*
St 490	46.87	1.117	253.36**
St 491	44.33	1.310	251.57**
St 492	39.34	1.168	210.25**
St 493	38.91	1.233	238.88**
GM	54.45	—	—
SE (M)	5.49	—	—
SE (bi)	—	0.783	—

**,*Significant at 1% level.

When mean yield and mean square deviation were studied for each genotype separately (Table 3), the highest mean yield ($\bar{x}$ = 72.95 kg/100 m^2) was recorded in St 462 followed by St 460 ($\bar{x}$ = 66.10) and St 464 ($\bar{x}$ = 65.70). These three seed stocks were preferred to other seed stocks for further testing of their stability by mean square deviation (S^2di). The lesser the magnitude of S^2di, the greater the stability. Using this standard, St 462 (S^2di = 7.15) was found to have lowest and nonsignificant deviation mean square followed by St 464 (S^2di = 30.79) and St 460 (S^2di = 88.19). Thus St 462, with high mean yield and lowest S^2di could be considered as the most stable and promising seed stock amongst all.

It may be used as seed cultivar for commercial cultivation in plains of N. E. India. Since it is a highly stable seed stock, the transgressive segregants are likely to be stable. Hence, St 462 could also be used for selecting desired clones.

Among the approved seed stocks St 203, St 379, St 449, St 462 and St 463 had lower than 1 regression coefficient (bi) and least deviation from regression (Table 3) which are indicative of their tolerance to stress conditions like drought. Contrary to these St 491 had much higher values of bi (1.301) and S^2di (251.57) which is indicative of its high performance potential in good growing conditions but poor performance under stress conditions. In commercial plantations, similar observations have been recorded.

CLONES

The stability analysis of variance for yield (Table 4) showed that the genotypes differed significantly among themselves for yield indicating that they were genetically diverse. Variances due to years and genotype x year interactions were highly significant. High magnitude of year (linear) effect in comparison to genotype x year (linear) interaction was recorded, which may be responsible for high adaptation in relation to yield [2]. Genotype x year (linear) effect was highly significant when tested against pooled deviations and pooled error. The significant of linear component further indicated possibilities of prediction of yield performance over years when its value is known in one of them [7].

Table 4. Stability analysis of variance for yield

Source	d.f.	MS	Tested against (G x E) MS	Tested against pooled deviation MS	Tested against pooled error MS
Genotypes	10	258.97	4.26**	9.70**	22.21**
Years	4	1115.70	18.36**	41.80**	95.68**
Genotypes x years	40	60.76	—	2.28*	5.21**
Years + (genotypes x years)	44	52.21	—	1.96*	4.48**
Year (linear)	1	1487.67	—	55.74**	127.58**
Genotype x year (linear)	10	150.11	—	5.62**	12.87**
Pooled deviations	33	26.69	—	—	2.29**
Pooled error	110	11.66	—	—	—

*,**Significant at 5% and 1% levels, respectively.

Variance for pooled deviations was highly significant which indicated that the variation in the performance of 11 genotypes over five years was caused by some unpredictable factors [3].

Since both genotype x year and genotype x year (linear) effects were highly significant, so two parameters namely; the deviation from regression (S^2d) and the regression coefficient (b), respectively were considered along with mean yield in interpreting the stability for yield.

The signs of environmental indices (Table 5) were negative for the years 1990, 1991 and 1992, hence the environments of those years were poor for the manifestation of yield of these genotypes [3].

Table 5. Values of environmental indices for yield in tea

Year (environment)	Environmental index
1988	9.24
1989	2.01
1990	- 5.22
1991	- 2.57
1992	- 3.46

A desirable genotype may show low genotype x environment interaction for agriculturally important characters like yield and quality [8]. Such genotypes are said to be "well buffered", as these can adjust their genotypic states in response to the changing environmental conditions. This is called "genetic homeostasis" [4]. Stability in the expression of a character could either result from genetic homeostasis i.e. the tendency of genotypes to resist change or wide adaptability of genotypes accompanied by adjustments (plasticity) in ancillary characters leading to stable end results in varying environments [5, 6].

When all the three parameters of stability (Table 6) were studied separately for each genotype, it was observed that the genotype 480/11 (TV 25) showed highest mean performance (51.25) with significant b (1.67) and significant S^2d (25.96) suggesting that both linear and nonlinear regressions accounted for G x E interaction [9]. This genotype can not be considered as stable.

Table 6. Estimates of means ($\bar{x}$) and stability parameters (regression coefficient, b and deviation from regression, S^2d) for yield of 11 genotypes of tea

Genotype	$\bar{x}$	b	S.E. (b)	S^2d
480/11 (TV 25)	51.25	1.67*	0.527	25.96*
106/1	46.65	0.68	0.479	19.45*
480/15 (TV 26)	50.88	0.75	0.772	68.94**
480/13	44.87	0.97*	0.186	- 6.96
Nil PF 3/14	43.76	0.93**	0.085	- 10.66
Tinga GH 3/18	41.08	0.96**	0.100	- 10.30
Nil PP 4/4	42.01	1.27*	0.347	4.64
16/6/25	44.41	1.28**	0.205	- 5.96
Tinga GH 3/4	42.39	1.24	0.839	83.75**
3/242	39.99	0.66	0.191	- 6.72
16/10/22	38.18	0.59	0.331	3.21
GM	44.13			
SE (M)	2.58			

*,**Significant at 5% and 1% levels, respectively.

Genotypes 106/1 and 480/15 (TV 26) showed high mean performance with nonsignificant b (0.68 and 0.75) but significant S^2d (19.45 and 68.94) indicating predominance of nonlinear component of G x E interaction. These genotypes are not stable because their yield performance cannot be predicted over environment.

Three genotypes namely 480/13, Nil PF 3/14 and Tinga GH 3/18 showed significant, less than unit b value (0.97, 0.93 and 0.96) but nonsignificant S^2d (- 6.96, - 10.66 and - 10.30) along with medium yield performance. Their performance could be predicted over environments due to predominance of linear component of G x E interaction. These genotypes are considered to be less responsive to the environmental change and, therefore, more adaptive and more stable [10]. Due to low mean performance, these genotypes may not be directly released as desired commercial cultivar but can be utilised in future breeding programme to incorporate stability character because they carry genes for stability.

The genotypes Nil PP 4/4 and 16/6/25 showed medium yield performance with significant b value (1.27 and 1.28) but nonsignificant S^2d (4.64 and − 5.96) suggesting predominance of linear component of G x E interaction. These genotypes are more responsive to environmental change and hence will show high yield performance in highly favourable environments [10]. These are less stable genotypes.

Two remaining genotypes namely 3/242 and 16/10/22 exhibited very low mean yield with low significant b value (0.66 and 0.59) and nonsignificant S^2d (− 6.72 and 3.21). These genotypes are not stable but will perform better in stress environments.

The results of the present study indicated that the genotypes were genetically diverse for stability of yield. Three genotypes namely 480/13, Nil PF 3/14 and Tinga GH 3/18 were more stable in yield performance despite their medium yield. In future tea breeding programmes, these genotypes could be used to incorporate genes for stability in the desired cultivar through combination breeding.

REFERENCES

1. S. A. Eberhart and W. A. Russel. 1966. Stability parameters for comparing varieties. Crop Sci., **6**: 36–40.

2. M. Rai, S. A. Kerkhi, S. Pandey, P. A. Nagri and A. K. Vashistha. 1989. Stability analysis for some quality components of seed and oil in linseed. Indian J. Genet., **49**: 291–295.

3. J. R. Nizams and U. G. Patel. 1989. Stability of single and three-way cross hybrids of cotton for lint yield. Indian J. Genet., **49**: 91–94.

4. I. M. Lerner. 1954. Genetic Homeostasis. Oliver and Boyd., London.

5. J. M. Thoday. 1955. Balance. Heterozygosity and Developmental Stability. Cold Spring Harbor Symp. Quant. Biol., **20**: 318–326.

6. J. E. Grafius. 1956. Components of yield in oats—a geometrical interpretation. Agron. J., **48**: 419–423.

7. B. S. Chhina and P. S. Phul. 1988. Stability for quality in sorghum. Indian J. Genet., **48**: 81–83.

8. M. M. Verma, K. S. Gill and D. S. Virk. 1987. Genotype — environment interaction — its measurement and significance in plant breeding. Communication Centre, PAU, Ludhiana: 26–48.

9. B. C. Sood and G. C. Saini. 1989. Stability for yield and maturity in mash. Indian J. Genet., **49**: 309–311.

10. R. K. Singh and B. D. Chaudhary. 1985. Biometrical Methods in Quantitative Genetic Analysis. Kalyani Publishers, New Delhi: 251–280.