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Estimations of Fibre Trait Stability and Type of Inheritance in Cotton

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Abstract

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Traits affecting fibre quality were evaluated in a multi-location environmental experiment. Four main cotton regions in Greece were selected as different environments. Five commercial cotton cultivars were used for evaluation of 10 fibre quality traits. Each cultivar was sown in 10 different fields in each region. Environmental fluctuations within regions affected each quality trait differently showing a different degree of inheritance. Four traits showed the lowest stability index values indicating quantitative inheritance, further four traits with intermediate values indicated determination by a few genes, while the more stable and thus with qualitative inheritance traits were considered to indicate fibre maturity and uniformity. The mean estimation of stability in multi-location experiments was found the same as in multi-genotype evaluation. Two cultivars (Elsa and Celia) were found to be more stable across the Greek environments and two regions favoured stability for almost all traits. Correlations between regions were high and the same was found between genotypes.

Keywords: multi-location; genotype and environment interaction; qualitative inheritance; quantitative inheritance

Stability across environments is considered of great importance for a commercial cultivar (Fasoulas 1988) and a stable genotype shows minimum interactions with the environments where it is cultivated, responding positively in favourable environments. Plant breeders are seeking a repeatable and reliable criterion for stability estimations, in order to develop cultivars for many environments (Jalaluddin & Harrison 1993). Stability estimations were based on variance values across years and locations. Fasoulas (1988) proposed the ratio between mean and standard deviation for stability estimations and later Fasoula (2013) used the squared form as a stability criterion. Many other researchers proposed b or r^2 as stability estimation criteria (Eberhart & Russell 1966). For breeders, qualitative or quantitative inheritance of traits is essential for applying the proper breeding method. Qualitative inheritance which is related with a low number of genes controlling a trait is essential and it is also associated with extensive stability of a trait (Fasoulas 1988). Generally, fibre quality traits show additive gene action and high heritability, but environmental conditions may affect the character expression (Smith *et al*. 2010). The purpose of this study was to estimate under multi-location and multi-genotype evaluation the kind of trait inheritance through stability estimations of 10 fibre quality traits, i.e. the qualitative or quantitative character of the traits studied in order to choose and apply the proper breeding method.

Five of the most commercial upland cotton cultivars (A: DP332, B: DP377, C: ST402, D: Celia and E: Elsa) were used as different genotypes for evaluation of their fibre quality traits. Four regions were selected as

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different environments: E1: Thessaly, E2: Macedonia, E3: Thrace, and E4: Sterea Ellas. Each cultivar was sown in 10 different fields (in order to exploit and evaluate different soil types) in each of the above-mentioned environments (in total 200 fields). Samples consisted of 300 randomly handpicked bolls (in all regions). Subsequently, samples were ginned on the same laboratory ginning machine. The harvesting time was fixed according the same maturity stage reached in all regions, since there was a few days difference between the four environments. Four samples from each field were collected to analyse fibre quality traits with an high volume instrument (HVI). Lint percentage (LP%) was calculated as the ratio of lint weight to the total seed plus lint weight. Quality traits were micronaire (MIC), calculation of maturity index (MAT%), fibre length (UHML) in mm, fibre strength STR (gram/tex), uniformity index (UNF%), fibre elongation (ELG), short fibre index (SFI), yellowness (+b), reflectance index (Rd). Stability estimations were based on stability index $(\bar{x}/s)^2$, where $\bar{x}$ and s are the entry mean yield and standard deviation (Fasoula 2013). Correlations (Pearson's coefficient) of corresponsive values of each trait were calculated between the four environments and also between the five cultivars.

Our results were used for estimating the type of trait inheritance (Fasoulas 1988; Bradow & Davidonis 2000). Short fibre index, yellowness, micronaire and fibre elongation showed the lowest stability index values 153, 346, 347 and 360, respectively (Table 1). Also, fibre strength, lint percentage, fibre length and reflectance index showed intermediate values 1011, 1188, 1657 and 2727, respectively, while fibre uniformity and maturity indices showed the highest values 9999 and 12 245, respectively. According to Fasoulas (1988), low stability index values indicate a rather unstable behaviour due to quantitative inheritance and multi-gene action. The intermediate values indicate a few genes and the high values show a qualitative inheritance based on one gene or a limited number of genes. For fibre strength, May (1999) reported quantitative inheritance but we have estimated an intermediate inheritance. Intermediate values may also exhibit a clear quantitative inheritance that is limited because of the narrow genetic basis of cultivated cultivars (Meredith *et al.* 1997). According to Fasoulas' (1988) theory only fibre uniformity and maturity indices showed qualitative inheritance based on increased stability across environments and genotypes. Thus, those two quality traits seem to be easily improved by plant breeders. Especially for maturity, some precaution is needed because of the complexity of this trait (Bradow & Davidonis 2000) and poor estimations of HVI. In other studies lint percentage, length and strength were strongly affected by genotype and a small number of testing locations was sufficient (Meredith 2003). Additionally, HVI does not have the ability to discern small genetic differences for strength and maturity (Green & Culp 1990). Also,

Table 1. Trait stability index $(\bar{x}/s)^2$ across environments and across cotton genotypes separately

		SFI	+b	MIC	LEG	STR	LP	UHML	Rd	UNF	MAT
Environments	E1	120	345	208	213	887	1 067	1 952	864	7 903	8 359
	E2	166	365	373	236	1 149	1 272	1 516	2 588	10 203	13 211
	E3	176	332	365	618	1 090	791	1 753	5 315	12 399	13 518
	E4	150	340	440	372	919	1 623	1 406	2 100	9 489	13 894
	mean	153	346	347	360	1 011	1 188	1 657	2 717	9 999	12 245
Genotypes	A	91	352	236	200	860	621	1 238	2 035	8 097	9 557
	B	117	256	400	154	799	1 128	1 406	2 470	7 724	13 161
	C	163	294	387	357	1 189	1 260	1 515	2 321	10 660	11 063
	D	219	432	334	236	1 324	1 644	2 195	3 764	13 317	12 829
	E	176	395	377	852	884	1 289	1 931	2 995	10 197	14 618
	mean	153	346	347	360	1 011	1 188	1 657	2 717	9 999	12 245

SFI – short fibre index; +b – yellowness; MIC – micronaire; ELG – fibre elongation; STR – fibre strength; LP – lint percentage; UHML – fibre length; Rd – reflectance index; UNF – uniformity index; MAT – calculation of maturity index; E1 – Thessaly; E2 – Macedonia; E3 – Thrace; E4 – Sterea Ellas; A – DP332; B – DP377; C – ST402; D – Celia; E – Elsa

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Table 2. Correlations (r-coefficient) between environments and cotton genotypes

Regions	E1	E3	E4	
E2	0.98	0.98	1	
E4	0.97	0.97		
E3	0.96			
Cultivars	B	C	D	E
A	0.98	1	0.99	0.99
B		0.96	0.95	0.99
C			1	0.98
D				0.97

E1 – Thessaly; E2 – Macedonia; E3 – Thrace; E4 – Sterea Ellas; A – DP332; B – DP377; C – ST402; D – Celia; E – Elsa

uniformity was found a less heritable trait according to Meredith (2003). Reflectance index may also be a trait of quantitative inheritance.

Stability and inheritance estimations based on the mean stability index were found the same across environments and also across genotypes as it is shown in the means of Table 1. This indicates that both stability and inheritance estimations may be easily performed only in multi-location or multi-genotype evaluations, and not in multi-factor experiments, using the stability index. This index is also referred to as coefficient of homeostasis including both stability of performance and high heritability (Fasoula 2013). In our study, environment affected differently the expression of each quality trait, especially under the consideration that there were 200 fields. Each genotype showed a different level of stability and inheritance for the various fibre quality traits. According to our findings, Elsa and Celia were found to be more stable across the Greek environments for almost all traits (as the measurements were over the average values), followed by cultivar ST402. Thrace and Macedonia favoured stability for almost all traits (measurements over the average values).

In Table 2 high correlations between environments and genotypes indicate that interactions between factors equally affected the expression of each fibre quality trait, i.e. each measurement was affected to the same extent by different environment or cultivar. Jalaluddin and Harrison (1993) reported that highly responsive genotypes in high-yielding environments were less responsive in low-yielding environments.

Concluding, environmental fluctuations within environments affected each quality trait differently showing a different degree of inheritance of each trait, but each measurement was affected to the same extent by different environment or cultivar. The more stable and with qualitative inheritance traits were calculated maturity and uniformity indices of fibre. Estimation of stability in multi-location experiments was found the same as in multi-genotype evaluation. Cultivars Elsa and Celia were found to be more stable across the Greek environments and the regions Thrace and Macedonia favoured stability for almost all traits. Correlations between environments and also between genotypes were high. Some quality traits may easily be improved by applying selection for the desirable trait among a few alleles.

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