Genotype traits, biplot analysis of cotton in Spain

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ABSTRACT

GGE biplot method was employed to study genotypes and traits with two-way data. The accuracy, reliability and precision of this analysis are critical for breeders in the selection of genotypes for a breeding program, determining with stability the best cultivars for the desirable characters that the breeders want to improve. Seven varieties (DP 5409, DP 20, Stv Kc 311, DeltaOPAL, DP 5111, DP 5690 and Sure-Grow 96) were tested at five different locations (Las Cabezas, Lebrija, Carmona, Aznalcazar and Marmolejo) for two years (1998 and 2000) in South Spain. The different characteristics studied were: yield, fiber percentage, earliness and fiber quality traits (fiber length, strength, uniformity and micronaire). A high correlation was presented between fiber length, uniformity and strength. Those characteristics did not show correlation with yield. The best varieties were: Sure-Grow 96 and Delta Opal for yield and fiber percentage; DP 5111 for earliness; and Stv Kc 311 and DP 5690 for uniformity, fiber length and strength. These varieties may be recommended in a breeding program to improve the characteristics of the varieties in this study.

Introduction

Improving the basic properties of cotton fibers, yield and its characters, and earliness has long been a goal in the development of seed varieties. Cotton breeders have two main types of objectives. The first is the development of superior agronomic characteristics, and the second is the development of superior cotton fiber characteristics. Agronomic breeding objectives include higher yields and earliness. The objectives of a breeding program for fiber traits include higher strength, fiber length and uniformity and lower micronaire (Collins, 1992). The combinations of those cotton characteristics tend to be somewhat different depending on every growing region of cotton.

The purpose of this paper is to present the latest results on this subject from trials conducted in Spain. This research was designed to meet the following objectives: To characterize a set of varieties by their agronomic and economic characteristics and provide recommendations for their use in a breeding program. To study the correlations between different characteristics such as yield, fiber percentage, earliness, and fiber quality traits (fiber length, strength, uniformity and micronaire). Correlations between and among the traits indicate relationship, but are often difficult to understand.

Experimental procedure

Field procedure

Seven varieties (DP 5409, DP 20, Stv Kc 311, DeltaOPAL, DP 5111, DP 5690 and Sure-Grow 96) were tested at five different locations in South Spain (Las Cabezas, Lebrija, Carmona, Aznalcazar and Marmolejo). At each location a randomized complete block design with four replications was used during two years (1998 and 2000).

The main plot consisted of 4 rows by 10 m in length with a row distance of 95 cm. The experiments received the same farm management practices as commercial crops at every location. Experimental plots were hand picked twice.

Collection of data

Seed cotton yield was determined from the 5 meters in each of the two central rows on every plot. Fiber percentage was determined as the relationship between fiber weight and seed cotton weight multiplied by 100, and earliness as a percentage of the first pick. Fiber properties were determined with the use of HVI instruments (Hake *et al.*, 1996) from lint samples of seed cotton after ginning. The measured characteristics were: fiber length (length in mm), fiber uniformity (uniformity), fiber strength (strength in grams per tex), and micronaire as a measurement of fineness and maturity level.

Statistical analysis

The GT biplot method (Yan and Rajcan, 2002) was employed to display the genotype by trait two-way data in a biplot. This method is based on the following formula:

$$\frac{(T_{ij}-\beta_j)}{S_j} = \sum_{n=1}^{2} \lambda_n \xi_{in} \eta_{jn} + \varepsilon_{ij} = \sum_{n=1}^{2} \xi^*_{in} \eta^*_{jn} + \varepsilon_{ij}$$

where T_{ij} is the average value of genotype "i" for trait "j", b_j is the average value of all genotypes in trait "j", S_j is the standard deviation of trait "j" among the genotype averages, l_n is the singular value for principal component PCn, x_{in} and h_{jn} are scores for genotype "i" and trait "j" on PCn, respectively, and e_{ij} is the residual associated with genotype "i" in trait "j". To achieve symmetric scaling between the genotype scores and the trait scores the singular value l_n has to be absorbed by the singular vector for genotypes x_{in} and that for traits h_{jn}. That is, $x^*_{in} = l^{0.5}_n x_{in}$ and $h^*_{jn} = l^{0.5}_n h_{jn}$. Only two PC, PC1 and PC2, are retained in the model because such a model tends to be the best model for extracting pattern and rejecting noise from the data. The GT biplot is generated by plotting x^*_{i1} and x^*_{i2} against h^*_{j1} and h^*_{j2}, respectively, so that each genotype or trait is represented by a marker in the biplot. In the GT biplot, a vector is drawn from the biplot origin to each marker of the traits to facilitate visualization of the relationships between and among the traits. All analyses were conducted using SAS (SAS Institute, 1996).

Results and Discussion

The results of this research are represented in Figures 1, 2, 3, 4, 5 and 6. Each figure represents at each location the behavior of the different cultivars for the characteristics studied and the relationship between traits. First of all, let us consider correlations presented by the following characteristics: uniformity, fiber length and strength for all studied environments, with values close to the one at Marmolejo in 2000 (Figure 6). Yield and its component fiber percentage, showed medium correlation in Las Cabezas in 1998, and in Aznalcazar and Marmolejo in 2000, with a high value in Lebrija in 2000 (Figures 1, 4, 5 and 6). Yield and earliness presented high correlations in Aznalcazar and Carmona in 2000 (Figures 4 and 5). Perhaps this result was due to late first pick in those environments. The relationship between yield and micronaire was higher in Carmona and Lebrija in 2000 than in Lebrija in 1998, where the value of the correlation was not so high (Figures 2, 3 and 4). Micronaire and fiber percentage showed good correlation in different environments (Las Cabezas and Lebrija in 1998 and Lebrija in 2000) and with a value near to one in Carmona in 2000, maybe as a consequence of the late harvest (Figures 1, 2 and 4). Micronaire was the only one of the quality fiber traits presenting a correlation with yield and its component fiber percentage. Yield did not show a correlation with the quality fiber traits of uniformity, fiber length and strength in most of the environments. Correlations between fiber length, uniformity and strength were observed as a result of their great stability. However, micronaire, which has been used as a measure of maturity and fineness of the fiber, did not correlate with the characteristics aforementioned.

In the study of agronomic and cotton fiber characteristics for different varieties, we have various cultivars located in the vertex, near to center and center of the polygon in each figure. Cultivars placed in the vertex were the best for traits situated in their area, with values higher than the mean for every character. However, varieties situated close to center of polygon, showed values lower than the mean for characteristics located in their areas. The varieties placed at the same distance from the center and the vertex of the polygon have medium values (close to the mean) for traits located in their area.

Studying the varieties individually, DeltaOPAL has shown a higher value than the mean for yield at two locations, Las Cabezas in 1998 and Lebrija 2000; for fiber percentage at Lebrija in 1998 and 2000; and for fiber length, uniformity and strength at Aznalcazar in 2000 (Figures 1, 2 and 4). However, at Carmona in 2000, this cultivar was located near to the center of the polygon, indicating a value below the mean for yield (Figure 3). On the other hand, it was observed that Sure-Grow 96 was the variety with a higher value for fiber percentage at Las Cabezas in 1998 and Aznalcazar in 2000; for yield and earliness at two localities (Aznalcazar and Marmolejo in 2000); and for micronaire at Lebrija in 2000 (Figures 1, 4, 5 and 6) . However, this cultivar was located close to the center of the polygon for yield at Carmona in 2000 with low values for micronaire at Lebrija in 1998 (Figures 2 and 3). These results suggest that DeltaOpal and Sure-Grow 96 may be recommended in breeding programs to increase yield and fiber percentage. The variety Stv Kc 311 presented the highest value for fiber length, uniformity and strength at Las Cabezas in 1998, and at Lebrija and Carmona in 2000 (Figures 1, 3 and 4). However, this variety presented lower values for those characters at Lebrija in 1998 (Figure 2). These results indicate that Stv Kc 311 is the most recommendable variety to improve the studied fiber properties. The variety DP 5409 showed a high value for micronaire at Lebrija in 1998 and fiber percentage at Carmona in 2000, though presented a lower value for micronaire at Aznalcazar in 2000 (Figures 2, 3 and 5).

The cultivar DP 20 was located at the vertex of the polygon at Lebrija in 1998 for earliness and at Carmona in 2000 for fiber length; but its value was not as high for earliness at Lebrija in 2000 (Figures 2, 3 and 4).

The variety DP 5111 showed the highest value for earliness at most of the studied environments. This cultivar also presented highest values for strength and uniformity at Carmona in 2000, as well as for micronaire at Aznalcazar in 2000 (Figures 3 and 5). These results would suggest to include the cultivar in a breeding program to enhance the earliness. DP 5690 was the variety with a higher value than the average for strength and fiber length at Lebrija in 1998 and 2000 and Aznalcazar in 2000; and for uniformity at Lebrija in 1998 and Aznalcazar in 2000 (Figures 2, 4 and 5). DP 5690 and Stv Kc 311 are the best varieties to improve fiber properties.

Conclusions

The research demonstrated that the fiber quality traits - uniformity, fiber length and strength - showed a high correlation in all environments indicating that these characteristics are very stable within these varieties.

Another important fact is that yield did not present a correlation with fiber traits and it was even found to be negative with some of the fiber quality traits aforementioned.

Regarding the agronomic and cotton fiber characteristics of different varieties and locations, results suggest that Sure-Grow 96 and DeltaOpal are the best varieties for yield and fiber percentage, DP 5111 for earliness and Stv Kc 311 for uniformity, fiber length and strength. Based on these results, we would like to point out that the varieties most favorable for inclusion in breeding programs within the studied environments are: Sure-Grow 96 and DeltaOPAL to improve yield and fiber percentage; DP 5111 to increase earliness and Stv Kc 311 and DP 5690 to enhance uniformity, fiber length and strength.

References

- Allard, R.W. and Bradshaw, A.D. (1964). Implications of genotype-environment interactions in applied plant breeding. *Crop Sci.*, ***4***: *503-507*.
- Collins, H.B. (1992). Breeding for improved production efficiency and fiber quality. Proceedings Beltwide Cotton Conferences. National Cotton Council, Memphis TN: 1200-1201.
- Hake, K.D., Bassett, D.M., Kerby, T.A. and Mayfield, W.D. (1996). Producing Quality Cotton. *In* Cotton Production Manual Hake S.J., T.A. Kerby y K.D. Hake (eds). University of California, Publication ***3352****: 134-49*.
- Meredith, W.R. Jr. 1(984). Quantitative genetics. Koel R.J. y C.F. Lewis (eds). *Agronomy*, **24**: 131-50.
- SAS INSTITUTE, (1996). SAS/STAT user's guide, second edition. SAS Ins. Inc., Cary, N.C., USA.
- Yan, W. and Rajcan, I. (2002). Biplot analysis of test sites and trait correlations of soybean in Ontario. *Crop Sci*., **42**: 11-20.

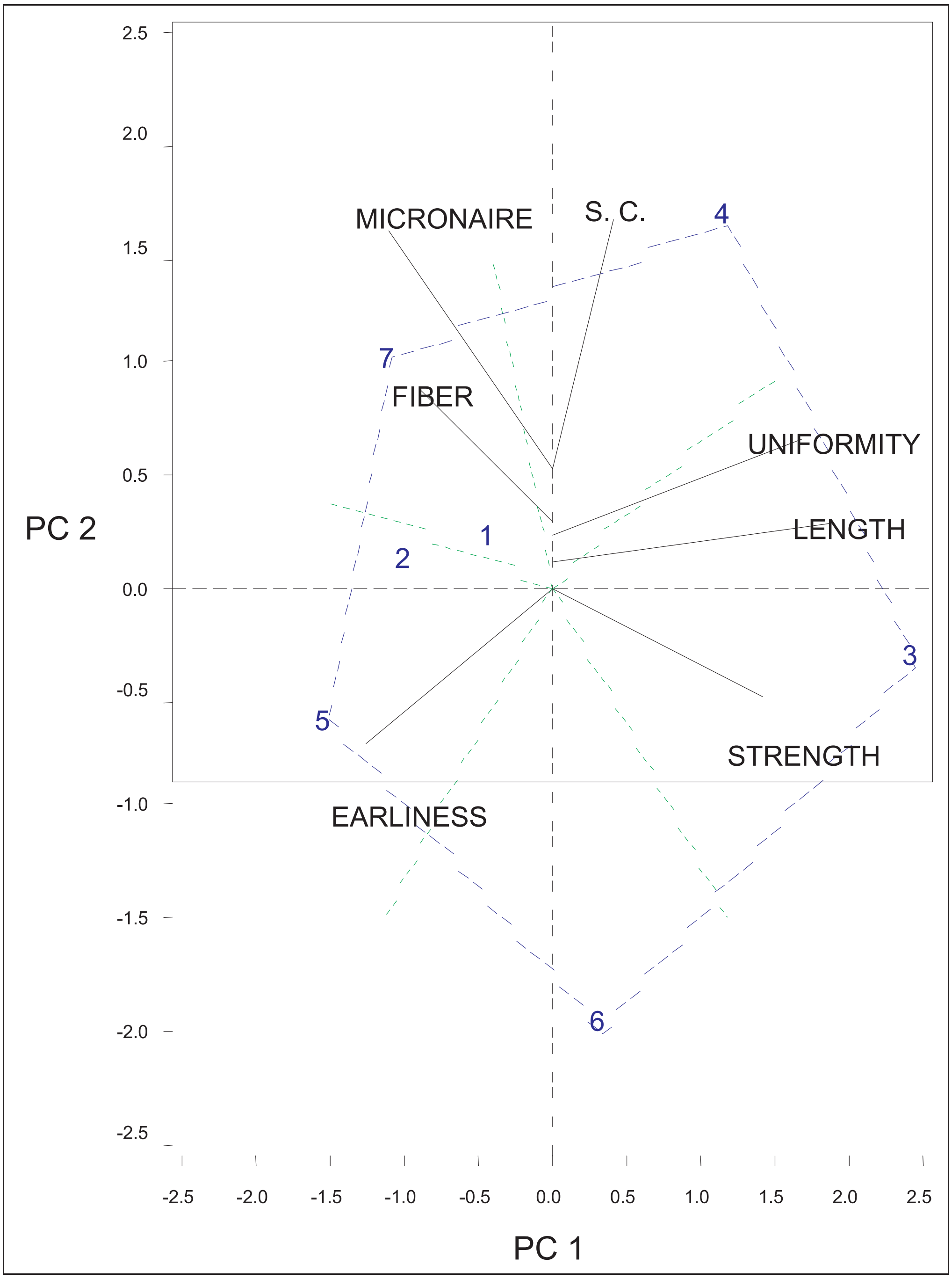

Figure 1.
GGE Biplot for Las Cabezas (1998). Key to varieties: 1: DP 5409; 2: DP 20; 3: Stv Kc 311; 4: DeltaOPAL; 5: DP 5111; 6: DP 5690; 7: Sure-Grow 96.

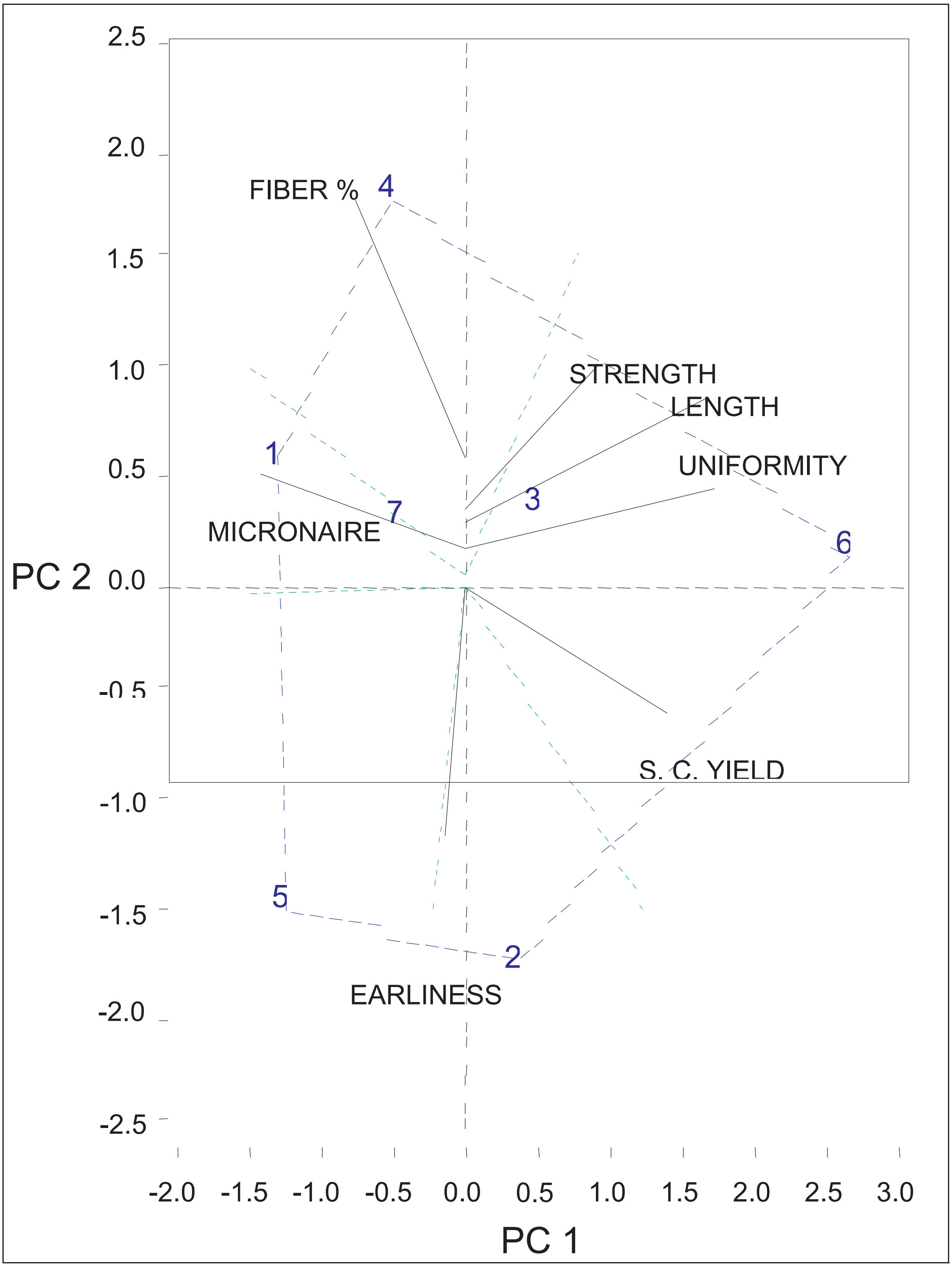

Figure 2.
GGE Biplot for Las Cabezas (2000). Key to varieties: 1: DP 5409; 2: DP 20; 3: Stv Kc 311; 4: DeltaOPAL; 5: DP 5111; 6: DP 5690; 7: Sure-Grow 96.

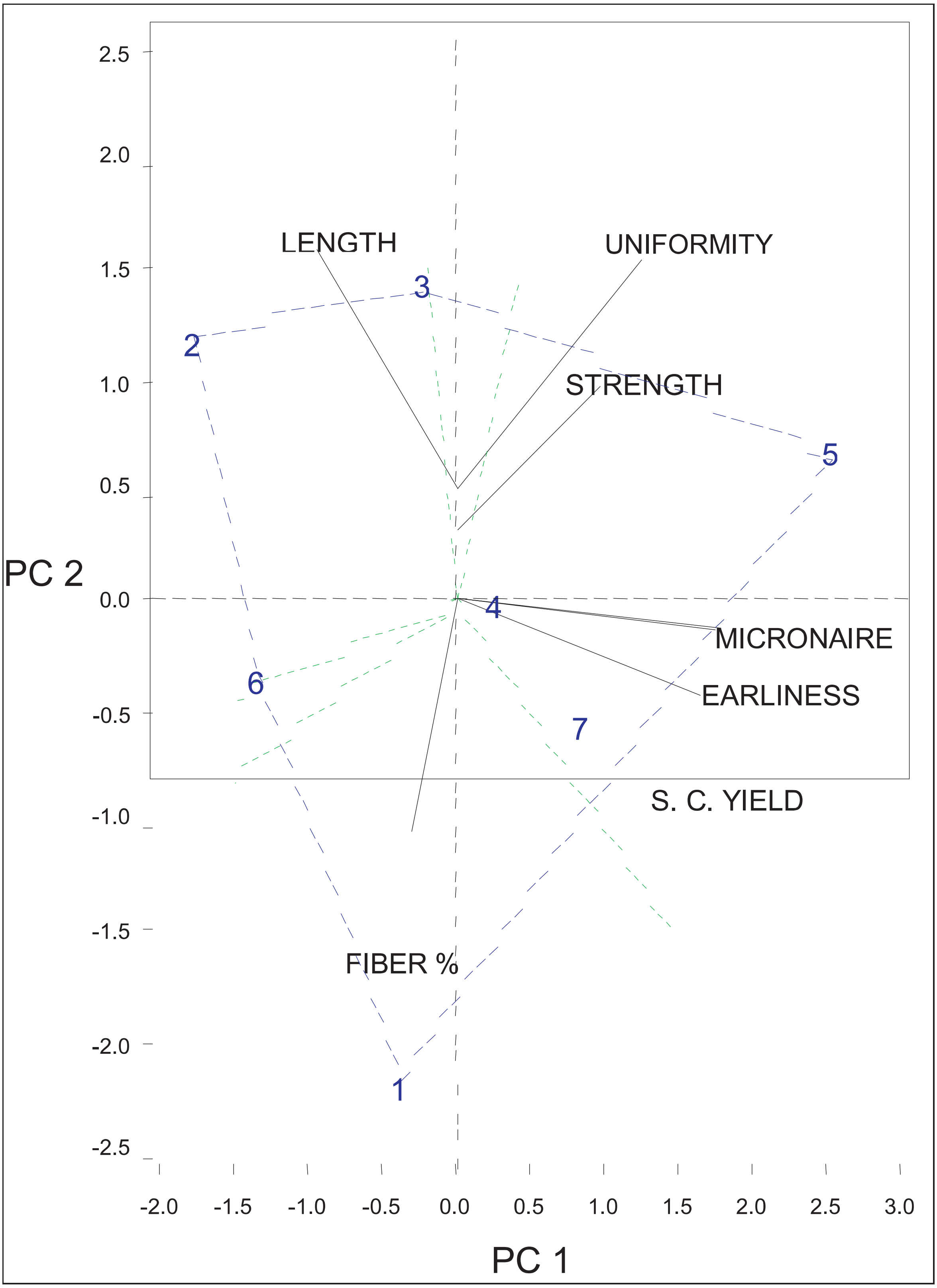

Figure 3.
GGE Biplot for Carmona (2000). Key to varieties: 1: DP 5409; 2: DP 20; 3: Stv Kc 311; 4: DeltaOPAL; 5: DP 5111; 6: DP 5690; 7: Sure-Grow 96.

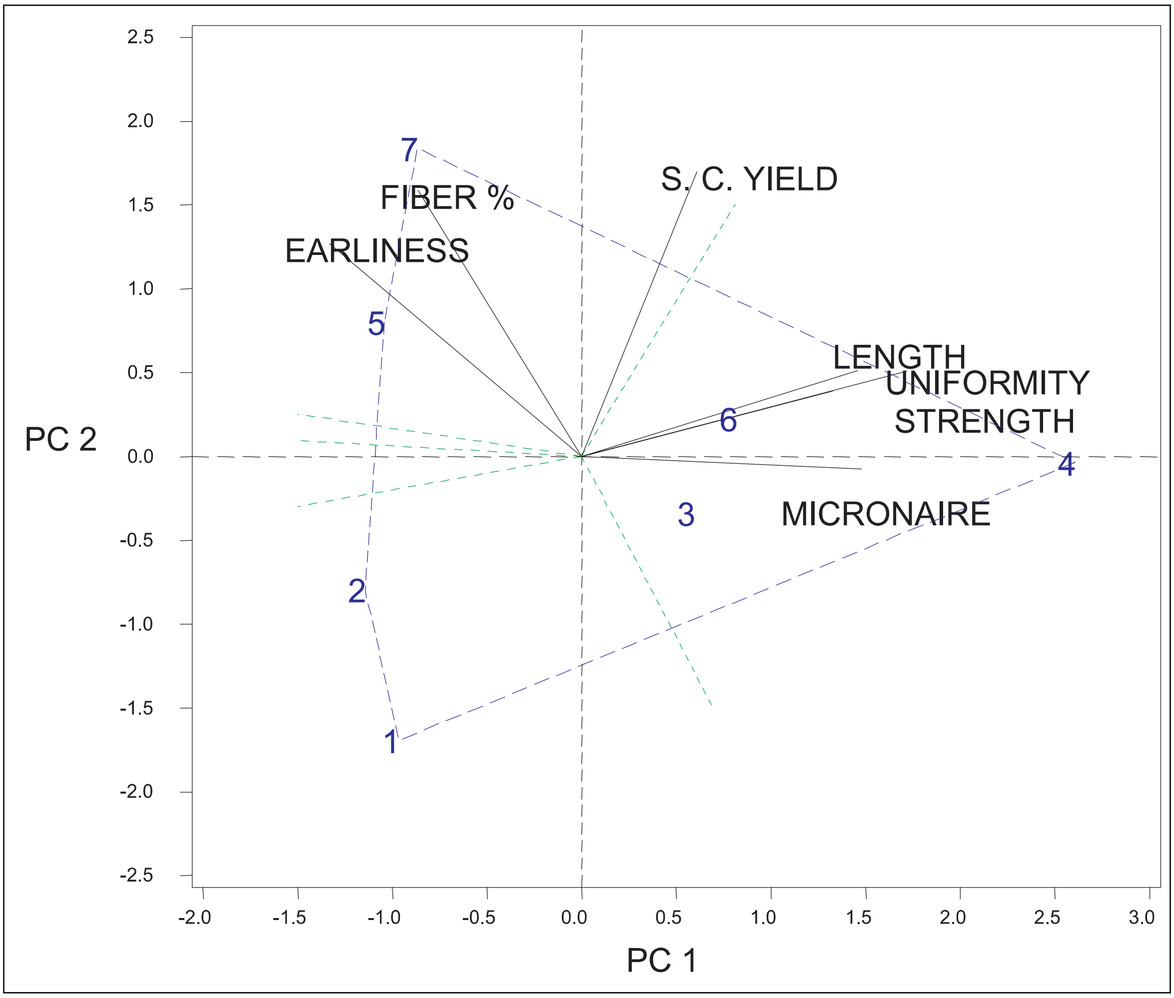

Figure 4.
GGE Biplot for Lebrija (2000). Key to varieties: 1: DP 5409; 2: DP 20; 3: Stv Kc 311; 4: DeltaOPAL; 5: DP 5111; 6: DP 5690; 7: Sure-Grow 96.

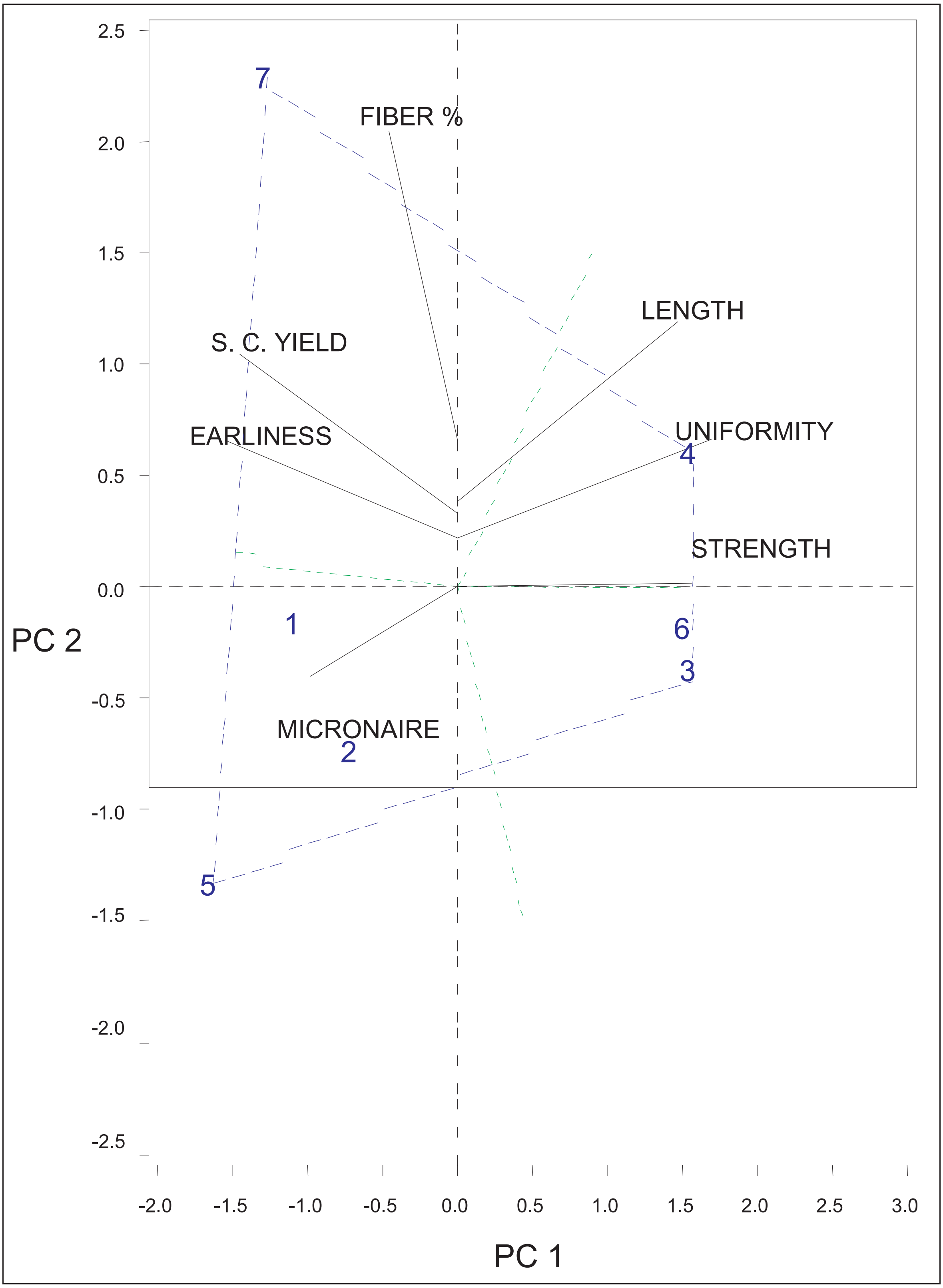

Figure 5.
GGE Biplot for Aznalcazar (2000). Key to varieties: 1: DP 5409; 2: DP 20; 3: Stv Kc 311; 4: DeltaOPAL; 5: DP 5111; 6: DP 5690; 7: Sure-Grow 96.

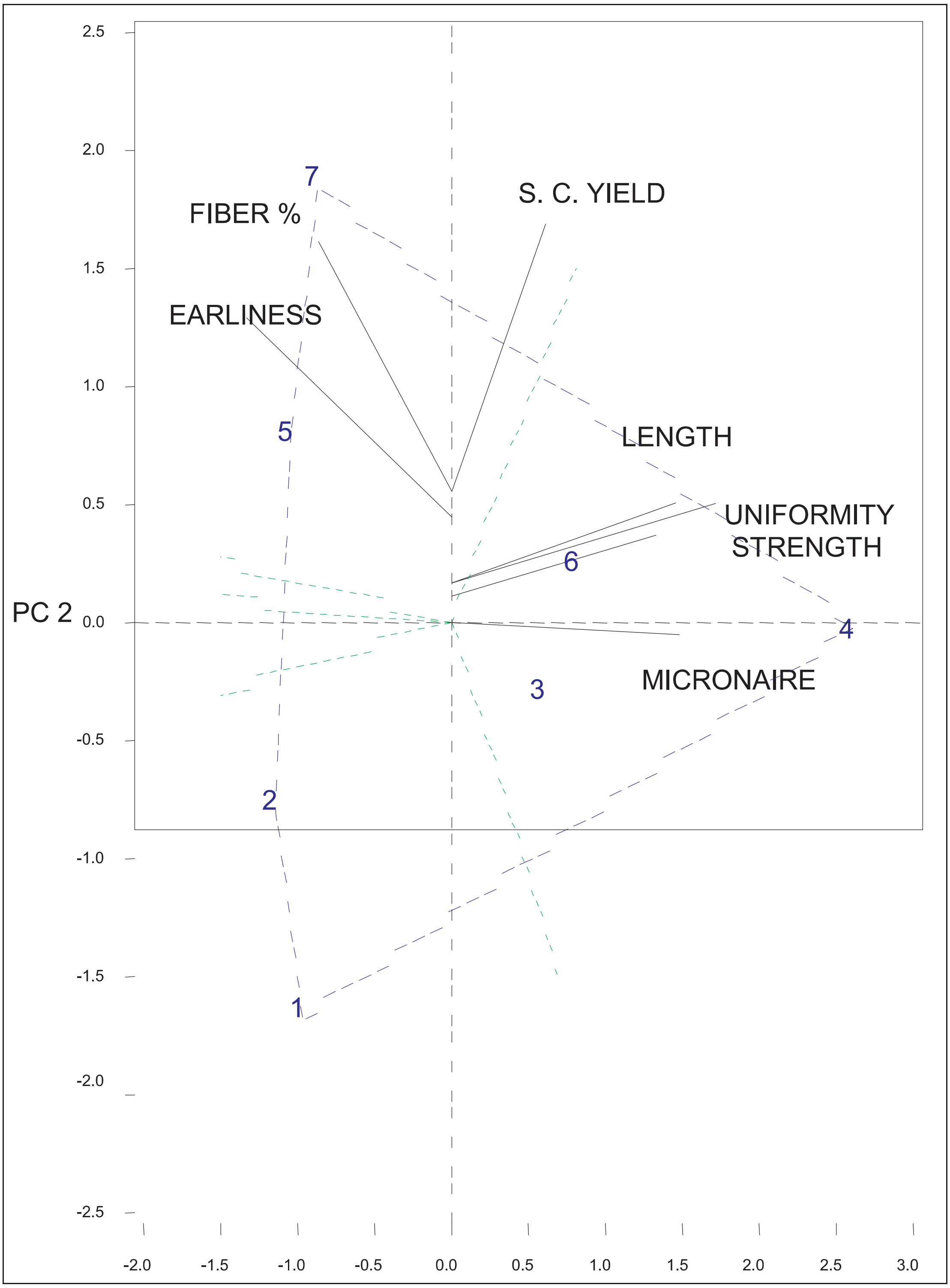

Figure 6.
GGE Biplot for Marmolejo (2000). Key to varieties: 1: DP 5409; 2: DP 20; 3: Stv Kc 311; 4: DeltaOPAL; 5: DP 5111; 6: DP 5690; 7: Sure-Grow 96.