A multivariate procedure for the study of the adaptability of cotton varieties: Assessment of the contribution of productivity earliness and resistance to verticillium wilt

Michailidis Z., Kechagia U., Sotiriadis S.

in

Braud M. (ed.), Campagne P. (ed.).
Le coton en Méditerranée et au Moyen-Orient

Montpellier : CIHEAM
Options Méditerranéennes : Série Etudes; n. 1988-I

1988
pages 151-158

A multivariate procedure for the study of the adaptability of cotton varietes

(Assessment of the contribution of productivity earliness and resistance to *Verticillium* wilt)

Z. MICHAILIDIS, U. KECHAGIA, S. SOTIRIADIS

Cotton and Industrial Plants Research Institute -Sindos

Summary

A multivariate procedure was used to study the adaptability of nine cotton varieties tested over a range of environments in Greece.

The yields of the varieties from the different environments were analysed into principal components. It was found that 77,9% of the total variability is accounted for by the first three components which are related to earliness, productivity and resistance to Verticillium wilt. According to these components and to every possible pair, the varieties were classified by single linkage cluster analysis.

The individual component scores were regressed on the mean values of each environment to obtain estimates of adaptability parameters of the varieties

---

Breeding for varieties with desirable adaptabilityover a wide range of environments has received much attention recently. Regression methods of adaptability analysis was used in many cases (Finlay and Wilkinson, 1963 ; Ebehart and Russell, 1966 ; Tai, 1971). The regression coefficient and the deviation from regression of a variety on environmental indices were considered as parameters for measuring the adaptability of a variety. Some methods using external environmental variables have also been proposed (Wood, 1976). Other workers, because of the complexity of crop production ecosystems and the necessity for collection and interpretation of large amounts of data relative to crop development and yield, proposed the development and use of database sophisticated software systems (Grube et al., 1983).

Multivariate statistical methods (Perkins, 1972) as well as cluster (Lin and Thompson, 1975) and path analysis (Tai, 1975) have also been used for the analysis of the genotype x environment interaction.

In Greece, the yield of a cotton variety is mainly related to its productivity, earliness and resistance to Verticillium wilt. The present paper describes a multivariate statistical procedure for the assessment of the contribution of these components to adaptability of the cotton varieties.

I - Material and methods

Nine cotton varieties were tested over 15 varying environments (location x year). Each trial was grown in a randomized complete block design with six replications. Each row was 20 m long with 14 plants/m^2. The adjacent rows were 1.0 m apart. The percentage of infested plants from

Verticillium wilt in the experimental fields was in between non to 30, with a mean degree 1 to 2.

The data used for the present analysis were the mean seedcotton yield of individual varieties in each environment.

The yields were analysed into principal components using the variance-covariance matrix. The size and sign of the coefficients of the latent vectors and the relationship between the individual components of each variety and the cotton yield, earliness and resistance to *Verticillium* wilt were used to interpret the meaning of the components. The individual components were plotted to visually obtain the distribution of the varieties within the first independent components axes.

From the matrix of the Euclidean distances between every pair of the components, the minimum spanning tree was calculated and the dendrogram, for single linkage clustered analysis, was constructed to separate groups of varieties.

The individual component scores for each variety in each environment were regressed on the mean value for each environment to obtain estimates of the specific adaptability parameters of the varieties.

For the analysis of the data, programs in BASIC Level II have been constructed.

II - Results and discussions

The seedcotton yield of the nine varieties are given in Table 1, and the variance-covariance matrix in the Table 2.

In Table 3, the first six latent roots li and vectors aij of the variance and covariance matrix and, in Table 4, the first six principal components zi of the varieties are given.

The 77.9% of the total variability is represented by the first three components, that is, 40.1%, 26.5% and 11.3%, respectively.

In Table 5, the mean yield of each variety, as percentage of the control variety 4S, and the Mean Date Maturity (MDM) as calculated by Christidis and Harisson (1955) are given.

The first component is related to the earliness of the varieties, r = 0.64, the second one to the mean yield, r = 0.67 (data from Tables 4 and 5). The third component is the result of the contrast of the resistant and sensitive to *Verticillium* wilt varieties (characterization of the varieties, from the Annual Report of the Cotton and Industrial Plants Institute, Sindos, 1985), the other components accounting for the rest of the variability were not identified. The components zij give the average behaviour of the varieties concerning their main characteristics (earliness, productivity and resistance to *Verticillium* wilt).

In Figure 1, the distribution of the nine varieties within the first three independent components along with the minimum spanning tree calculated from the matrix of the Euclidean distances between every pair of the components, are given.

It is seen from Table 4 and Figure 1, that early varieties are located on the right part of the plot a. and productive ones, on the upper side. Varieties on the upper right part, are characterized by early and high production. In plot b., the varieties on the upper part are sensitive to *Verticillium* wilt, and on the lower part, relatively resistant. Early and relatively resistant to *Verticillium* wilt varieties are located on the lower right corner of the plot. In plot c., the varieties on the lower right part are characterized by productivity and relative resistance to *Verticillium* wilt. In plot d., the distribution of the varieties among the three components helps to separate the varieties with high productivity, earliness ans relative resistance to *Verticillium* wilt, such as the varieties numbered as 7, 8 and 3, are, that is, varieties located on the right upper and in the front region of the diagram.

A classification of the varieties according to the three components may be obtained by cluster analysis (Figure 2). It is seen that the clustering of the varieties changes with the component studied. For example : in plot a. (z_1 component of earliness), the varieties 4, 6 and 1 are outliers, and the varieties 5, 9 and 8, 3, 7 are tight clusters. In plot c. (z_3 component), the varieties 4 and 6 belong to different clusters while variety 2 is now the distinct outlier. Finally, by examining the clustering of the varieties according to all three components together (plot g.), one can see that the varieties 8, 3 and 7 construct a tight cluster, while varieties 6, as well as, 1 are the outliers.

The estimates of the specific adaptability parameters of the varieties from the regression of the individual component scores of each variety in each environment on the mean values for each environment are given in Table 6.

The regression coefficients, b_{ij}, are estimates of the specific adaptability, concerning earliness, productivity and resistance to *Verticillium* and describe the dynamic behaviour of the varieties to varying environments. In general, it may be emphasized that the greater the value of the repression coefficient of a variety for earliness, b_{1j}, the better the behaviour of this variety to short season environments, comparatively. Similarly, a high b_{2j} value means a better adaptation of a variety to high yielding environments. As the regression coefficient b_{2j} of a variety decreases, the variety becomes more stable to changes of the environment's yielding ability. A high b_{3j} value of a variety means that the resistance of the variety to *Verticillium* decreases more than the resistance of a variety with a lower b_{3j} value as the degree of infestation in a field increases.

The varieties 6, 4, 5 and 2 are more adaptable to late season environments : the varieties 1, 7, 3 and 8 to short season environments. Variety 45 is of mean adaptability.

The varieties 9, 8, 2, 7 and 6 are adaptable to high yielding environments while the varieties 1, 4, 5 and 3 to low yielding ones.

From Table 6 and Figure 2, one can see that the varieties 7, 1, 8 and 3 respond better in fields with less infestation from *Verticillium* wilt.

As the infestation increases, the response of the varieties changes. In the fields with the highest observed infestation, the varieties 6 and 4 had the lowest losses, followed by the varieties 9, 6, 2 and 3, while the varieties 7, 8 and 2 the highest losses.

Conclusions

Earliness productivity and resistance to *Verticillium* wilt account for the 77.9% of the total yield variability that is 40.1%, 26.5% and 11.3%, respectively. It appears that earliness should be the most important objective in a breeding programme for the environments sampled.

The clustering of the varieties changes with earliness, productivity and resistance to *Verticillium* wilt.

The general adaptability estimated from the yields is not sufficient for varietal evaluation. The specific adaptability gives a better description of the dynamic behaviour of a variety to varying environments and should be examined along with the observed mean behaviour.

Literature

1. Cotton and Industrial Plants research Institute (Greece).- *Annual Report*, 1985.

2. Christidis B.G., Harrisson (G.J.).- Cotton growing problems. New York : Mc Graw-Hill Book Company Inc..- p. 633.-1985.

3. Eberhart S.A., Russell (W.A.).- Stability parameters for comparing varieties. *Crop. Sci.*, *6* : 36-40.-1966.

4. Finlay K.W., Wilkinson (G.N.).- The analysis of adaptation in a plant breeding programme. -*Australian J. Agr. Res.*, *14* : 742-54.-1983.

5. Grube M., Steinhorst (R.K.), Wiese (M.Y.).- RETREV : a software system for managing comprehensive crop survey data.- *Agron. J.*, *75* : 574-77.-1983.

6. Lin C.S., Thompson (B.).- An empirical method of grouping genotypes based on a linear function of the genotype-environment interaction. *Heredity 34* : 255-63.-1975.

7. Perkins J.M..- The principal component analysis of genotype-environmental interactions and physical measures of the environment. *Heredity 29* : 51-70.-1972.

8. Tai G.C.C..- Genotypic stability analysis and its application to potato regional trials. -*Crop. Sci.*, *11* : 184-90.-1971.

9. Tai G.C.C..- Analysis of genotype-environment interactions based on the method of path coefficient analysis.- *Can. J. Genet.* *17* : 141-49.-1975.

10. Wood J.T..- The use of environmental variables in the interpretation of genotype-environment interaction.- *Heredity* *37* : 1-7.-1976.

Row 1	1	435.9	2	514.0	3	263.7	4	71.0	5	40.8	6	-5.6	7	130.4	8	52.2	9	-36.5	10	27.0	11	66.0	12	137.7	13	-199.1	14	-65.9	15	-122
Row 2	2	1326.3	3	669.5	4	138.2	5	64.8	6	1..4	7	410.4	8	233.7	9	192.3	10	-20.7	11	348.2	12	281.3	13	94.3	14	-210.2	15	-327.2		
Row 3	3	603.0	4	182.5	5	-61.9	6	33.0	7	237.8	8	156.8	9	226.5	10	-27.0	11	342.0	12	191.9	13	-1.3	14	-18.0	15	153.6				
Row 4	4	86.4	5	-29.5	6	28.0	7	34.3	8	36.7	9	46.5	10	30..5	11	93.1	12	93.2	13	-31.0	14	0.9	15	48.2						
Row 5	5	96.8	6	-11.8	7	46.3	8	20.0	9	50.5	10	12..8	11	-50.3	12	-7.1	13	15.0	14	13..9	15	-190.3								
Row 6	6	103.9	7	66.8	8	3..6	9	-41.0	10	28..8	11	12..9	12	1..4	13	-64.8	14	-71.6	15	-109.7										
Row 7	7	343.0	8	138.0	9	-20.4	10	-39.8	11	88.7	12	-12.8	13	21..2	14	-111.3	15	-294.8												
Row 8	8	80.4	9	45.4	10	-13.2	11	90.6	12	32.1	13	75.0	14	-28.4	15	-75.7														
Row 9	9	669.5	10	-72.5	11	184.8	12	68.6	13	35.9	14	284.8	15	309.4																
Row 10	10	70.6	11	-26.7	12	61.1	13	-26.3	14	-40.6	15	-101.3																		
Row 11	11	321.1	12	99.8	13	177.4	14	-32.0	15	253.0																				
Row 12	12	169.0	13	-9.2	14	-22.7	15	-6.4																						
Row 13	13	465.4	14	-79.6	15	47.1																								
Row 14	14	257.4	15	268.6																										
Row 15	15	1004.9																												

Table 2: Variance - covariance matrix of the yield of the nine varieties in the 15 environments.

Variety	(location x year)														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1. 73468	333	501	276	192	335	97	352	171	344	223	177	292	141	291	308
2. Aglaia	350	453	279	198	338	88	328	161	388	221	171	291	95	343	372
3. Erato	317	485	267	188	348	78	329	167	424	215	163	294	132	346	334
4. Early Dwarf	315	411	206	175	345	80	290	143	356	230	139	284	126	324	336
5. Ark. Sindos	332	461	241	168	342	80	335	156	377	201	153	262	115	327	347
6. Thalia	274	391	237	180	330	87	317	157	385	210	169	263	151	338	385
7. Ston. Sindos	332	488	273	185	340	64	320	168	393	211	195	291	169	330	389
8. Sindos 80	324	478	266	186	345	97	325	160	419	218	192	289	139	324	360
9. 4S	322	460	274	192	316	83	299	150	391	214	181	296	119	330	408

Table 1: Seedcotton yields of the nine varieties (kg / 1000 m2).

Environments i	Latent vectors aij j = 1	2	3	4	5	6
1	0.29002	- 0.05780	- 0.47284	- 0.11249	- 0.16751	- 0.34255
2	0.71978	- 0.01081	0.03418	0.01510	- 0.31811	- 0.19086
3	0.41068	0.26629	- 0.08903	- 0.14878	0.34073	0.20130
4	0.10014	0.07953	- 0.09351	- 0.09128	0.09015	0.34914
5	0.03350	- 0.10512	0.03871	0.028151	- 0.12906	- 0.09864
6	0.02464	- 0.07828	- 0.03739	- 0.03149	0.29729	0.39583
7	0.26357	- 0.19388	0.17628	0.15754	0.62478	- 0.21933
8	0.14377	0.00038	0.13368	0.03803	0.15266	- 0.01779
9	0.10701	0.44626	0.04315	0.71803	- 0;07034	0.17145
10	- 0.00323	- 0.07930	- 0.07073	- 0.06705	- 0.16125	0.38007
11	0.21230	0.27634	0.22833	- 0.20803	0.10220	0.12806
12	0.15794	0.06625	- 0.12255	- 0.08249	- 0.33235	0.42715
13	0.03361	0.07356	0.77508	- 0.11295	- 0.26697	- 0.05414
14	- 0.11137	0.24573	- 0.15772	0.38122	0.02987	- 0.10576
15	- 0.17955	0.71593	- 0.08222	- 0.34917	0.06176	- 0.28662
Latent roots Lj	2445.7	1616.4	689.6	585.2	326.5	237.7
%	40,10%	26,50%	11,30%	9,60%	5,40%	3,90%
Cumulat. %	40,10%	66,60%	77,90%	87,50%	92,90%	96,80%

Table 3: The first six latent roots Li and vectors aij of the variance - covariance matrix.

Variety	Principal components Zi Z1	Z2	Z3	Z4	Z5	Z6
1. 73468	757.6	459.6	- 47.4	223.3	- 21.2	2..4
2. Aglaia	706.3	538.7	- 111.3	252.4	- 12.1	- 5.7
3. Erato	725.5	526.6	- 59.7	300.7	- 40.0	1.0
4. Early Dwarf	619.4	474.7	- 74.6	249.7	- 60;8	- 2.1
5. Ark. Sindos	686.8	495.4	- 74.8	265.2	- 22.1	- 40.6
6. Thalia	611.8	543.5	- 28.0	252.3	- 5.5	- 2.8
7. Ston. Sindos	728.0	564.0	- 34.9	237.4	- 50.1	- 27.4
8. Sindos 80	723.0	544.4	- 51.9	270.1	- 33.4	4..3
9. 4S	689.6	576.1	- 84.1	225.8	- 34.6	- 2.8
Mean	694.2	535.1	- 69.6	253.0	- 31.9	- 8.2

Table 4: The first six principal components Zi of the varieties.

Variety	Seed-cotton % control	MDM ± control
1. 73468	100%	- 0.3
2. Aglaia	101%	- 0.4
3. Erato	102%	0.2
4. Early Dwarf	94%	1..3
5. Ark. Sindos	97%	2..1
6. Thalia	97%	1..7
7. Ston. Sindos	103%	1.0
8. Sindos 80	103%	- 0.9
9. 4S (control)	(269 kg)	(2 / 10)

Table 5: Mean yield as percentage and MDM ± of the control variety

Variety	Components					
	Z 1		Z 2		Z 3	
	b 1j	Se	b 2j	Se	b 3j	Se
1. 73468	1.058	5..46	889	6..57	1.026	4..30
2. Aglaia	.0990	3..82	1.023	3..22	0.974	3..23
3. Erato	1.034	3..04	0.982	6..95	0.984	1..47
4. Early Dwarf	0.889	10..41	0.944	20.62	0.950	2..69
5. Ark. Sindos	0.973	16.67	0.970	2..54	0.972	4..31
6. Thalia	0.866	7.00	1.033	5..48	0.952	6..48
7. Ston. Sindos	1.049	9..47	1.001	3..82	1.083	6..45
8. Sindos 80	1.024	2..16	1.018	5..12	1.014	2..59
9. 4S	1.001	3..83	1.071	7..77	0.968	3..18

Table 6: Specific adaptability parameters.

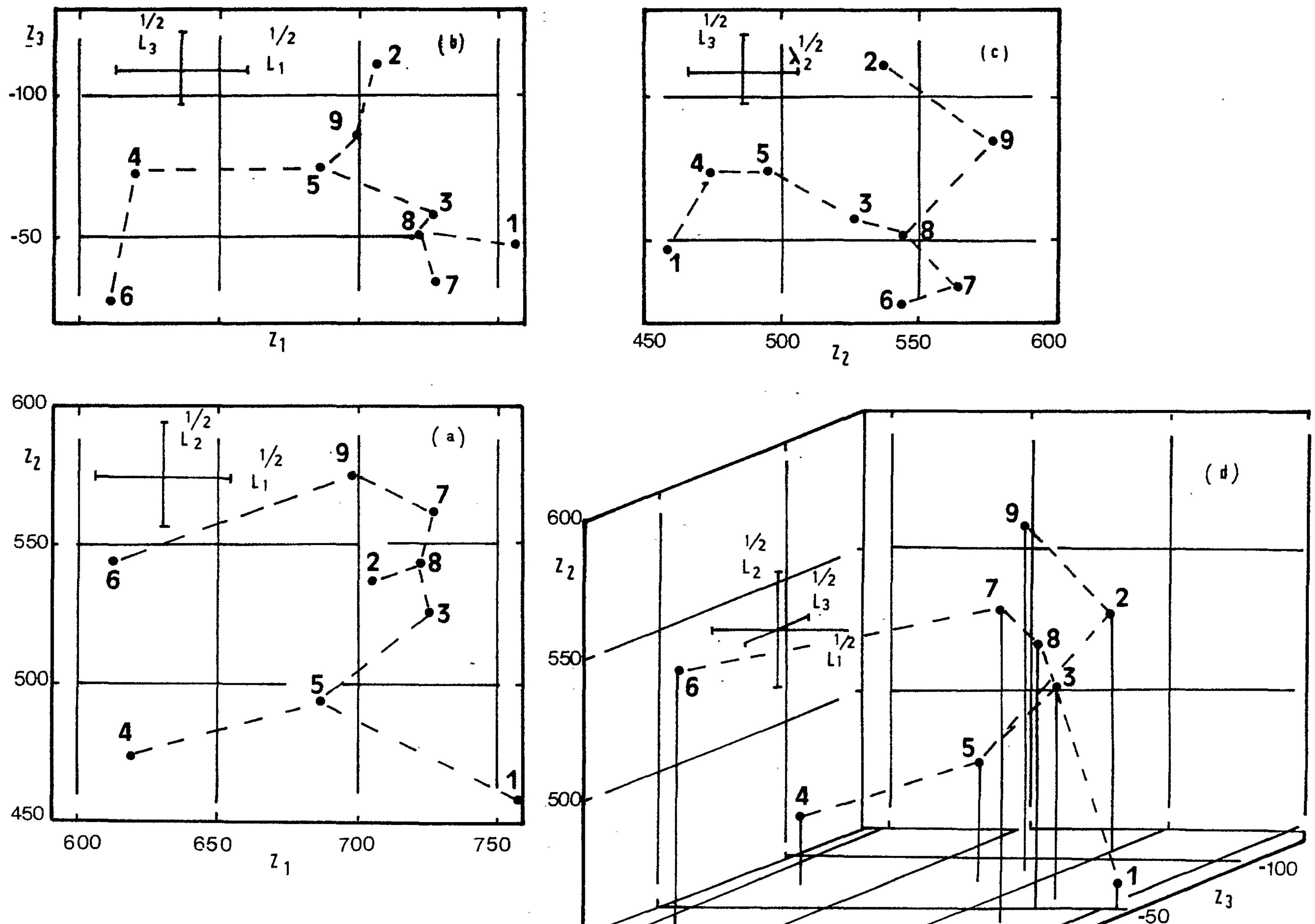
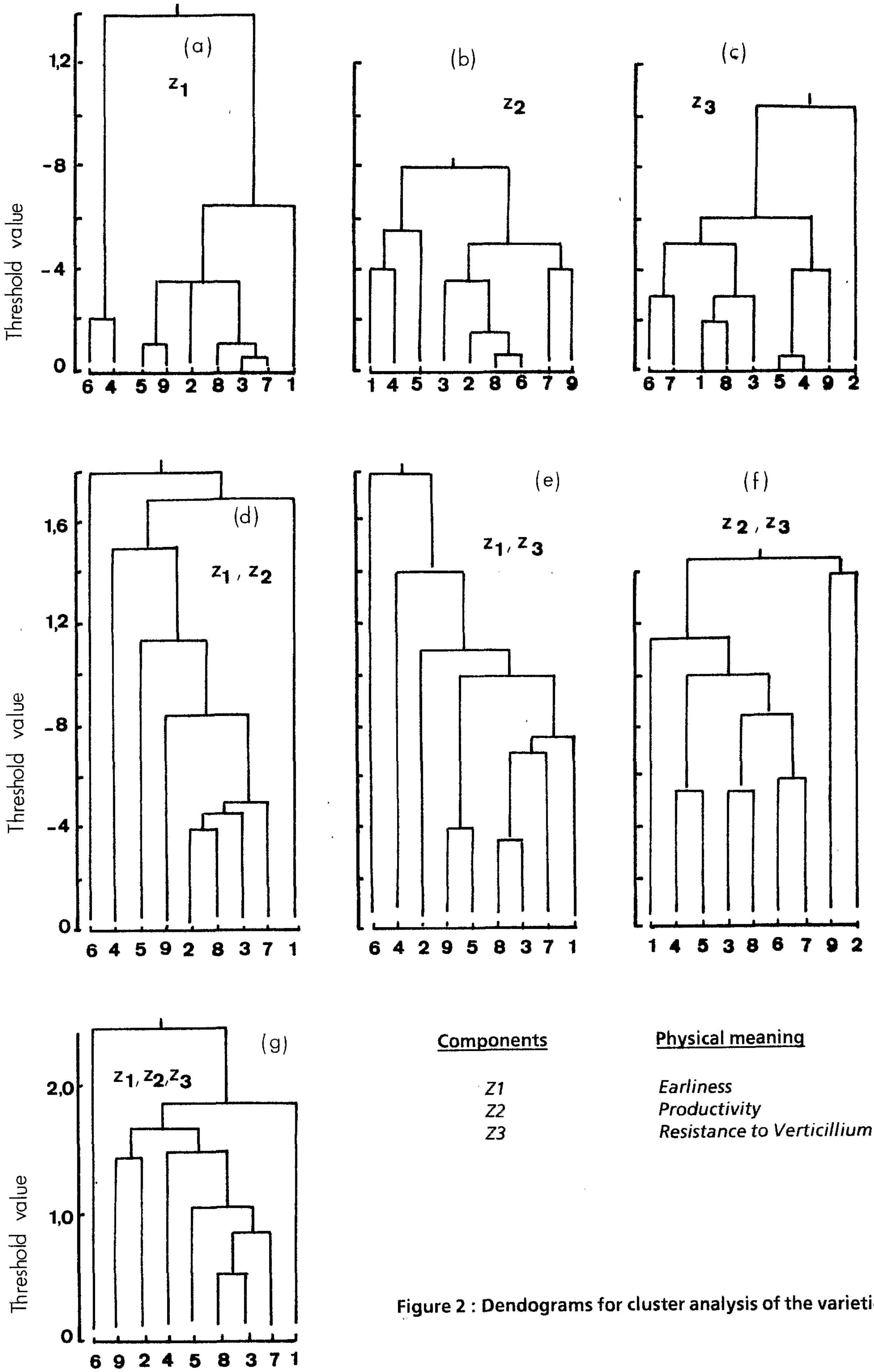


Figure 1 : Distribution of the nine varieties on the first three components. Minimum spanning tree ($\mathrm{Var}(z_i) = \frac{l\,v_2}{l}$)



Components	Physical meaning
Z1	*Earliness*
Z2	*Productivity*
Z3	*Resistance to Verticillium*

Figure 2 : Dendograms for cluster analysis of the varieties