Weed communities described by multivariate analyses

C. Andreasen, J.E. Jensen and J.C. Streibig
The Royal Veterinary and Agricultural University
Dept. of Agricultural Sciences, Section of Crop Science
40 Thorvaldsensvej, DK-1871 Frederiksberg C, Denmark

Summary
Multivariate methods, such as cluster and factor analysis, were used to describe distribution patterns among 20 weed species which occur in Danish fields. The resultant patterns were found to be due mainly to differences in life span and ecological optima of the weeds.

Introduction

The composition of the weed flora in arable ecosystems is the result of a long-term cropping history, where abiotic and biotic factors are correlated with agricultural management. A knowledge of the composition of the weed vegetation is therefore essential if guidelines for proper weed control are to be given.

The purpose of this paper is to indicate how correlation, classificatory and ordination tecniques can be used to detect patterns in the frequencies of weed species. These methods reveal any underlying patterns in the data better than conventional regression analysis, where species are usually analysed individually.

Materials and methods

This paper presents an analysis of frequency data from a survey of weed occurrence on arable land in Denmark. The data has been described previuosly (2).

Data for the 20 most frequent weed species in Denmark were analysed by correlation, cluster and factor analyses, the aim being to find groups of weed species which occur together with a high probability.

Both cluster and factor analysis start from a variance/covariance matrix. Cluster analysis groups together those weed species having the greatest similarites, in the form of a hierarchical tree diagram (4). Factor analysis, on the other hand, derives new variables or factors, which hopefully gives a better understanding of the underlying structure of the data (7). The resulting factors may then be interpreted biologically on the basis of prior knowledge of the species concerned (4, 5).

The results obtained from cluster and factor analyses are complementary in several respects. Thus cluster analysis provides a classificatory approach, which gives an apparently valid, though simplified, relationship between weed species, whereas factor analysis yields detailed information on similarities and does not enforce an hierarchical structure upon the material.

Results and discussion

Figure 1 shows the results of the cluster analysis based on the correlation coefficients between weed species. *Myosostis arvensis* (L.) Hill (MYOAR) and *Veronica arvensis* L. (VERAR), being the most highly correlated of the species, are therefore clustered together. Consequently, the probability of finding these two species together

in the same field is high. Comparing the results of this cluster analysis with logistic regression analysis (2, 3), reveals that both species occur with high frequencies in cereal crops (Table 1). Futhermore, the occurrence of both species is negatively correlated with the magnesium content of the soil. However, since magnesium was the only soil property to affect both species significantly, the correlation is probably caused by other factors such as crop rotation.

TABLE 1. Observed frequencies in different crops and their weighted average. The total area covered by eight crops was used as weights. Bayer codes (1) are used for the name of the weed species.

Species code	Fodder beets	Sugar beets	Winter rye	Winter wheat	Winter barley	Spring barley	Peas	Rape	Weighted average
STEME	35.4	36.8	29.4	41.7	39.6	49.0	55.9	62.2	47.2
POAAN	50.5	9.7	21.4	39.0	31.3	32.2	43.5	40.2	34.7
CHEAL	59.4	35.3	8.2	2.4	0.3	24.0	33.3	25.5	22.1
VIOAR	26.0	15.1	40.8	31.9	16.0	16.5	24.7	20.8	22.0
POLCO	24.2	22.4	16.4	13.4	6.6	20.0	19.7	21.1	18.7
MYOAR	10.8	4.6	30.0	15.8	12.6	15.4	19.0	7.1	15.1
POLAV	23.4	12.2	12.6	6.8	5.3	12.9	17.6	11.7	12.5
VERPE	11.1	17.5	1.1	11.4	11.3	11.5	19.5	16.8	12.3
CAPBP	14.2	4.4	15.0	5.8	3.3	7.7	13.8	10.4	8.6
POLPE	14.8	8.2	1.7	0.2	0.6	12.7	6.1	5.7	8.4
ELYRE	14.5	7.1	13.2	6.1	7.6	4.7	11.4	16.2	7.7
VERAR	2.8	1.3	19.1	8.2	8.6	7.5	7.8	4.2	7.5
TRIIN	7.4	4.8	8.8	7.3	7.3	6.8	5.9	4.6	6.7
PLAMA	6.5	1.3	1.7	.	0.6	7.2	6.9	4.2	5.0
LAMPU	5.1	8.2	1.1	2.2	4.0	6.5	7.8	0.6	4.9
MATMT	11.4	4.6	2.0	3.6	11.6	3.8	5.7	2.8	4.4
POLLA	3.4	0.6	1.1	.	0.3	7.9	2.6	0.2	4.3
LAMAM	4.2	17.7	.	0.9	0.3	5.0	1.6	0.4	3.6
GAEBI	3.4	.	1.7	.	.	5.6	3.3	1.3	3.4
URTUR	16.5	4.0	.	.	.	3.6	1.6	1.3	3.0

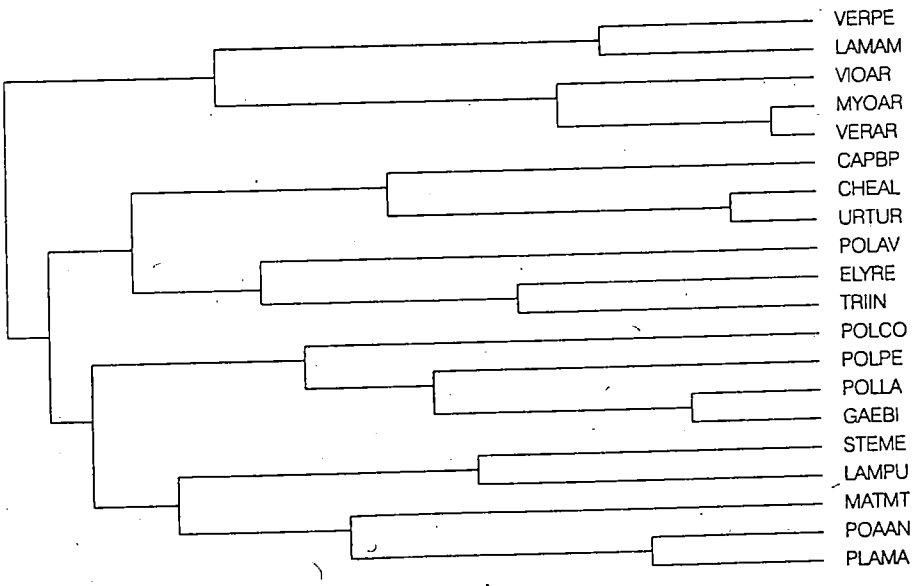

FIGURE 1. A cluster analysis on frequencies of weed species. The most similar weed species are clustered together. Bayer codes (1) are used for names of weed species.

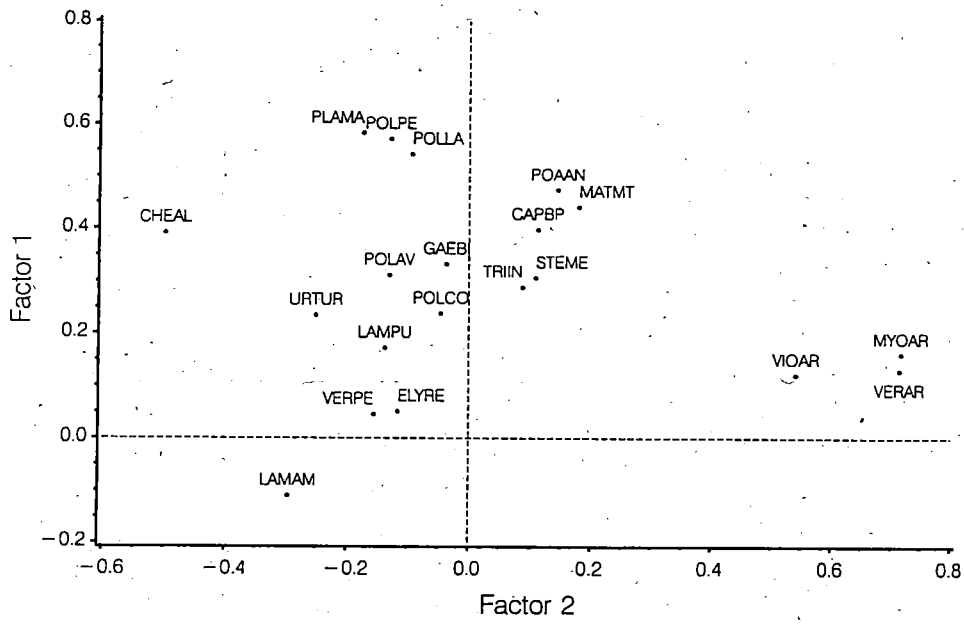

FIGURE 2. Factor pattern of frequencies of weed species. Relationship between factor loadings for the first two factors. Bayer codes (1) are used for names of weed species.

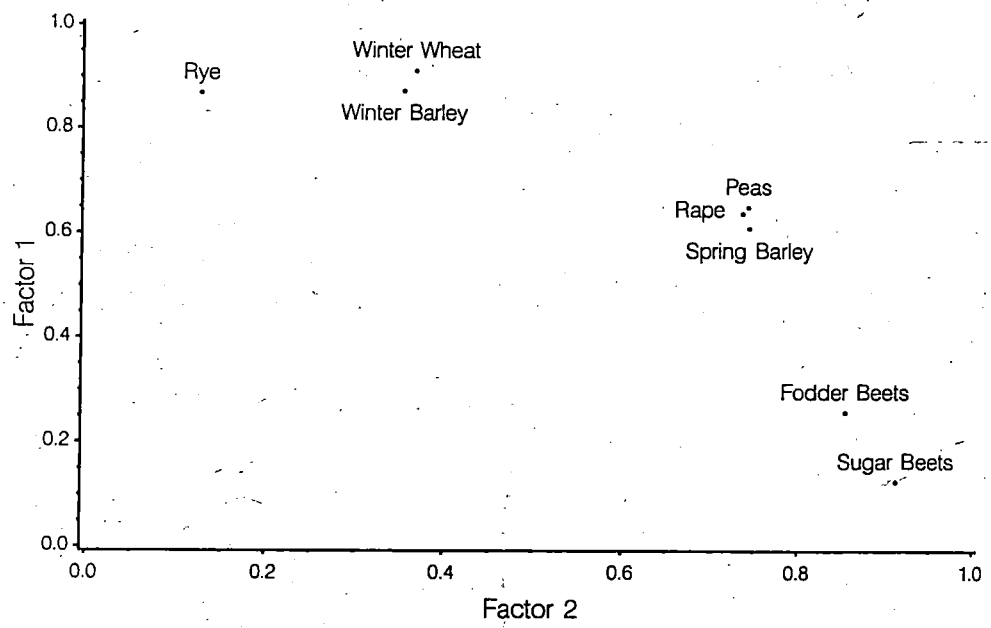

FIGURE 3. Factor pattern of crops based on the frequencies of weed species within each crop. Relationship between factor loadings for the first two factors.

Chenopodium album L. (CHEAL) and *Urtica urens* L. (URTUR) regularly occur together, one reason being that both are common weeds of beet crops and both are also favoured by soils high in nitrogen.

Galeopsis bifida Boenne. (GAEBI) and *Polygonum lapathifolium* L. (POLLA) are clustered together because both species thrive in soils with a high amount of organic matter, which in turn is correlated with the water holding capacity of the soil (2).

The factor analyses showed that four factors are needed to explain the variation among these species. Figure 2 shows the distribution of the weed species on the first two factors, which together explain a significant part of the variation. *M. arvensis* (MYOAR) and *Veronica arvensis* (VERAR) are placed close together as in the cluster analysis, while both are also placed near *Viola arvensis* Murr. (VIOAR). All three species are typical winter annuals with high frequencies in winter crops, which would explain why there is a high probability of finding them in the same field. The most typical summmer annuals are placed farthest away from the above mentioned species. Although we lose some information by using a factor analysis it clearly indicates that the life span and hence the duration of the growing season play a decisive role in determining which weed species occur together.

Figure 3 is based on a factor analysis conducted from the standpoint of the crop rather than the weed species. As a result the pattern is clearer, with the winter and summer annual crops falling into separate groups with high similarity of the weed flora. Rye, which is grown on sandy soils, and beets, which are weak competitors early in the season, appear to lie on the periphery of the two main groups.

Conclusion

Cluster and factor analyses of the frequencies of 20 weed species in eight crops provide useful methods for detecting patterns in their distribution.

These patterns are closely connected with both the life span of the plants and soil properties. However, in the present study, several weed species occur together even though no explanation is available at present.

More complex analyses, such as multivariate analysis of variance, canonical correspondence analysis (CCA) and detrended CCA, are needed in order to investigate the impact of soil properties on weed communities.

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