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USE OF MULTIVARIATE TECHNIQUES IN A BREEDING PROGRAMME TO ASSIST SELECTION OF SUNFLOWER INBREDS AND HYBRIDS.

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ABSTRACT

In a breeding programme accurate and rapid screening and evaluation of a large number of genotypes is time consuming and difficult and is often complicated by the need to assess simultaneously a range of growth parameters. To assist in selecting genotypes, data relating to ten growth parameters of sunflowers were analysed by computer to define similarity groupings among and between inbred and hybrid lines of sunflower. In this study, similarity groupings were defined amongst 387 inbred lines and 262 hybrid lines grown under irrigation at Narromine in the central-west of N.S.W. The similarity groupings have been compared using canonical co-ordinate analysis to examine patterns of relationships between inbred selections and experimental crosses into tester males. The potential of using multivariate techniques to assist in the systematic evaluation of various growth parameters of sunflower to improve the efficiency of selection among genotypes in a sunflower breeding programme is considered.

INTRODUCTION

In developing sunflower varieties, efficient and objective comparisons and subsequent interpretation of genotypic performance is a major problem. This problem not only relates to the large number of genotypes involved but also to the need to assess simultaneously a number of parameters which characterise specific genotypes.

The rapid analysis and interpretation of large sets of data has been hindered by a lack of suitable statistical procedures. Consequently multivariate methods have generally been used to simplify the analysis of large complex data sets.

Multivariate techniques have been applied in the analysis of genotype x environmental interaction by Byth, Eismann and Lacy (1976). Pattern analysis, which is the accepted term to describe the use of both cluster analysis and ordination, has been used to classify plant introductions of *Stylosanthes* species into morphological-agronomic groups (Burt *et al.,* 1971; Edye *et al.,* 1974b) and the agronomic performance of spaced plants (Edye *et al.,* 1973).

Mungomery *et al.,* (1974) showed that pattern analysis methods were useful alternative means of studying the performance of large sets of soybean cultivars in different environments and Edye (1976) found that both classical statistics and pattern analysis procedures agreed substantially when the data of a small sward trial of *Stylosanthes* species was analysed.

The use of multivariate techniques in a sunflower breeding programme to assist the plant breeders to rapidly screen and evaluate large numbers of inbred and hybrid crosses were investigated.

MATERIALS AND METHODS

From the sunflower nursery planted on 18 August 1977, 387 inbred lines, representing a diverse range of genotypes, were selected and ten (10) growth parameters were recorded for ten (10) space plants for each line. The ten growth parameters are summarised in Table 1. All plants were open-pollinated and then each head was covered with a muslin bag to prevent possible bird damage. After physiological maturity (measured when involucral bracts on head had turned brown), field measurements were recorded. Plants were then cut at ground level and air dried in trays before final dry weight and yield parameters were determined.

Table 1. Characteristics used in the Analysis.

1.	MF	Mean Days to mid-flower
2.	HT	Mean Plant height (cm)
3.	Std	Mean Stem diameter (cm)
4.	HD	Mean Head diameter (cm)
5.	T.D.W.	Mean total above ground vegetative dry weight (gm)
6.	St.D.W.	Mean Stem dry weight (gm)
7.	H.D.W.	Mean Head dry weight (gm)
8.	SWT	Mean Seed weight (gm)
9a.	100	Mean 100 Seed weight (gm) (Inbred analysis only)
b.	OIL	Mean Percentage oil content (Hybrid analysis only)
10.	H.I.	Harvest Index*

*Harvest Index — calculated as Seed weight/Total above ground dry weight.

In the same nursery hand crosses were made using tester males onto selected inbred (A) lines and the resulting hybrid crosses were planted on 7 February 1978. The same procedures described for the inbred analysis were used.

Percentage oil contents were determined using a Newport Mark III nuclear magnetic resonance analyser.

Data Analysis.

The two sets of 387 inbreds and 262 hybrids were classified using the euclidean model of Burr (1968) and the 'incremental sum of squares' fusion strategy (Burr, 1970). Both hierarchies were initially truncated at the 25 groups level. However on examination several of these groups only differed slightly and were bulked leaving a total of 17 groups. The two matrices of intergroup euclidean distances were then subjected to principal co-ordinate analysis (PCOA) (Gower, 1966, 1967). The diagnostic programmes Grouper and Gowecor (Lance *et al.,* 1968) were used to examine the contributions of the ten (10) variables to the classifications, and the relationship to the PCOA vectors.

A canonical co-ordinate analysis (Williams and Lance, 1968) between the two sets of 17 groups was achieved by appeal to the duality established by Gower (1966, 1967) between PCOA analysis using standardised euclidean distance and conventional principal component analysis using the correlation matrix.

RESULTS AND DISCUSSION

Analysis 1 Classification.

The initial classification of the two data sets of inbreds and hybrids are shown in Figure 1(a) and (b). For convenience, the attributes that contributed to the specific fusions are designated and the dendograms have been arranged so that the groups with the greater mean value follow the one direction. By following the course of the dendograms the attribute contribution to the fusion groups narrows from a complex contribution by all ten (10) growth parameters to the specific contribution of single parameters such as seed weight and oil content. For the purpose of this paper the data from the 17 inbred and 17 hybrid groups were examined and found to be sufficiently homogeneous to group into seven (I-VII) fusion groups respectively, with attributes in mean values from fusion group I to fusion group VII.

Table 3. Summary of genetic components of means in 25 crosses of sunflower for twelve quantitative characters.

Genetic components of means
First row : Number of crosses in which significant
Second row : Number of crosses in which magnitude is highest

Character	d	h	i	j	l
Number of leaves	10	12	9	13	12
	Nil	8	2	2	13
Leaf length	11	20	12	11	19
	Nil	8	Nil	Nil	17
Leaf breadth	14	18	13	11	19
	Nil	10	Nil	Nil	15
Petiole length	10	21	13	10	11
	Nil	11	2	2	11
Stem girth	10	19	12	5	16
	Nil	8	Nil	Nil	17
Plant height	16	21	12	15	16
	Nil	12	Nil	3	10
Head diameter	9	22	15	9	12
	Nil	18	Nil	3	4
Head weight	8	21	15	13	19
	Nil	13	1	2	9
Number of seeds	16	21	15	12	18
	Nil	8	Nil	Nil	17
Hundred seed weight	14	20	12	20	19
	Nil	7	Nil	2	16
Seed yield	9	23	12	9	14
	Nil	14	1	Nil	10
S/H estimate	12	11	10	12	11
	Nil	5	1	1	18

As mentioned earlier, there are not many attempts in sunflower to study genetics exclusively. The breeding programmes might have involved the estimation of general and specific combining abilities which do not provide a clear picture of the gene action. In a few recent studies on genetics (Velkov, 1970; Rao and Singh, 1977 and Dua, 1980), only additive and dominance types of gene action were reported for some characters. But, in the present study, the epistasis indicated by the diallel analysis was confirmed by generation mean analysis. So, one suggestion is that until a large number of studies are reported on the genetics of the crop to provide a general idea about its genetic architecture, it is necessary to plan any future genetic study with methods capable of estimating epistasis in addition to additive and dominance estimates. The alternative suggestion possible is to carry out diallel analysis involving parents selected at random (random effects model) from the world germplasm of sunflower so that the results are applicable to the whole germplasm. Though this sounds nice theoretically, its practicability is not definite; the former suggestion hence seems to be appropriate. If the future breeding programmes are preceded by such genetic studies to follow the appropriate breeding procedures depending on the relative importance of additive, dominance and epistatic types of gene action, the new achievements in sunflower breeding could be made faster than in the past.

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LITERATURE CITED

DUA, R.P. 1979. Studies on the stability of genetic parameters for the oil and yield components in sunflower (*Helianthus annuus* L.). *Thesis Abstracts* 5 (2), 94 — 95.

FALCONER, D.S. 1975. *Introduction to quantitative genetics, London, Longman* pp. 365.

HAYMAN, B.I. 1954. The theory and analysis of diallel crosses. *Genetics* 39, 879 — 809.

HAYMAN, B.I. 1958. Separation of epistatic from additive and dominance variation in generation means. *Heredity* 12, 371 — 391.

JINKS, J.L. and JONES, M. 1958. Estimation of components of heterosis. *Genetics* 43, 223 — 234.

PANSE, V.G. and SUKHATME, P.V. 1961. *Statistical methods for agricultural workers, I.C.A.R., New Delhi.* pp. 361.

RAO, N.M. and SINGH, B. 1977. Inheritance of some quantitative characters in sunflower (*Helianthus annuus* L.). *Pantnagar Journal of Research.* 2(2), 144 — 146.

VELKOV, V.N. 1970. Inheritance of stem height in sunflower. *Genetika i Selekcija, Sofia.* 3, 393 — 401. *Plant Breeding Abstracts.* 41, 8607.

Figure 1(a). Hierarchy for the classification of the data for (a) 17 inbred groups.

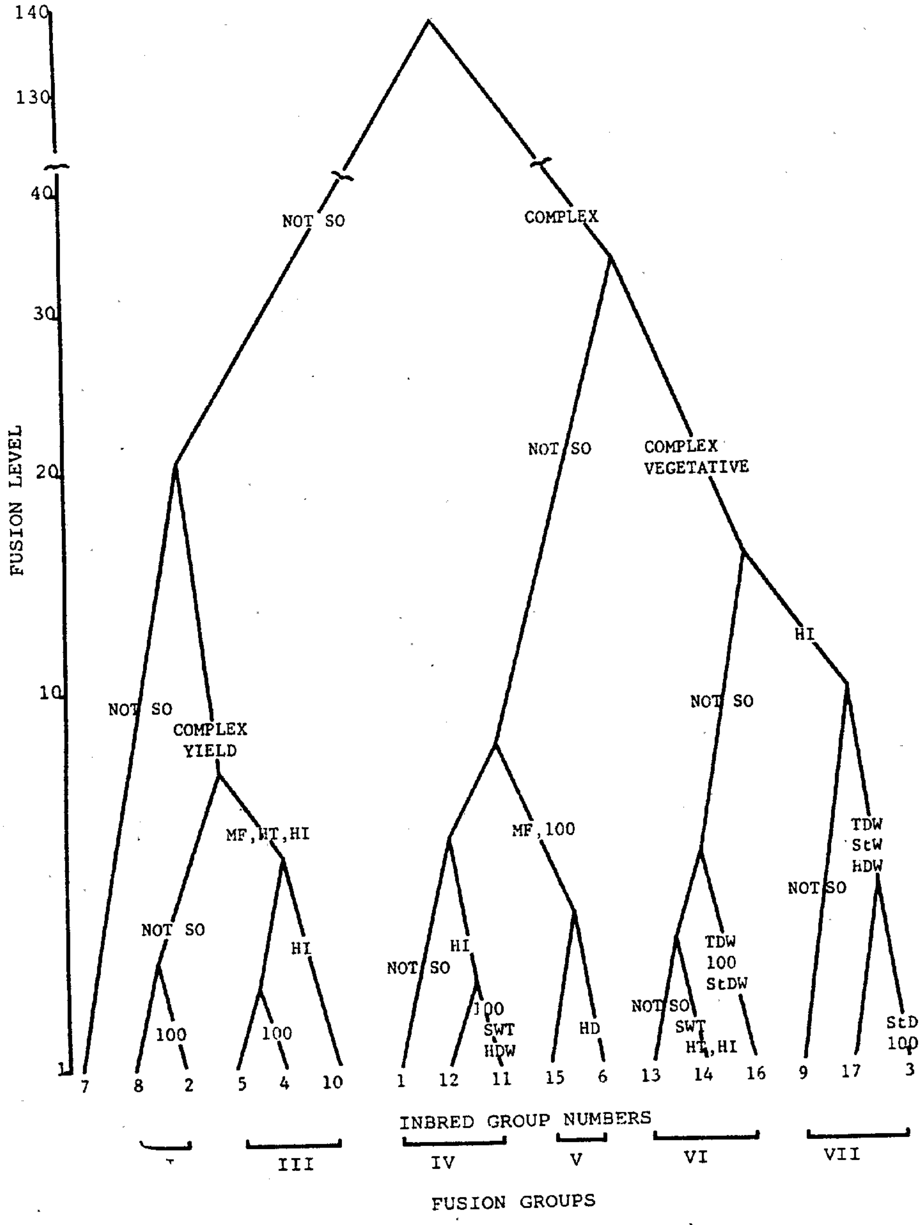
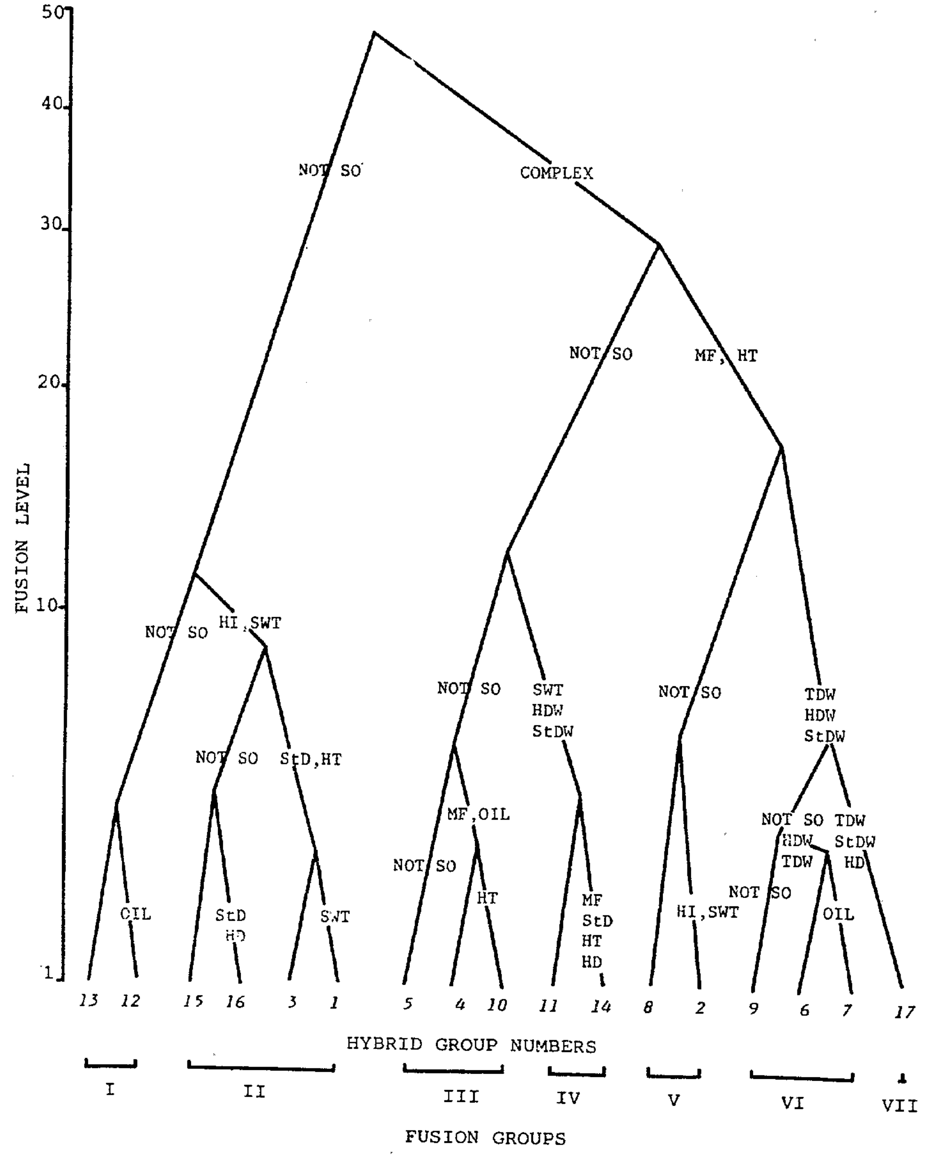


Figure 1(b). Hierarchy for the classification of the data for (b) 17 hybrid groups.



Although the selection trends can be followed on the dendograms the usefulness of the final groupings is difficult to assess without knowing the raw data and genotypes involved. For convenience, group means of five (5) selected parameters and the selection criteria of the seven (7) inbred and seven (7) hybrid fusion groups are presented in Table 2. A brief description of the important characteristics is included.

Table 2. Selection criteria.

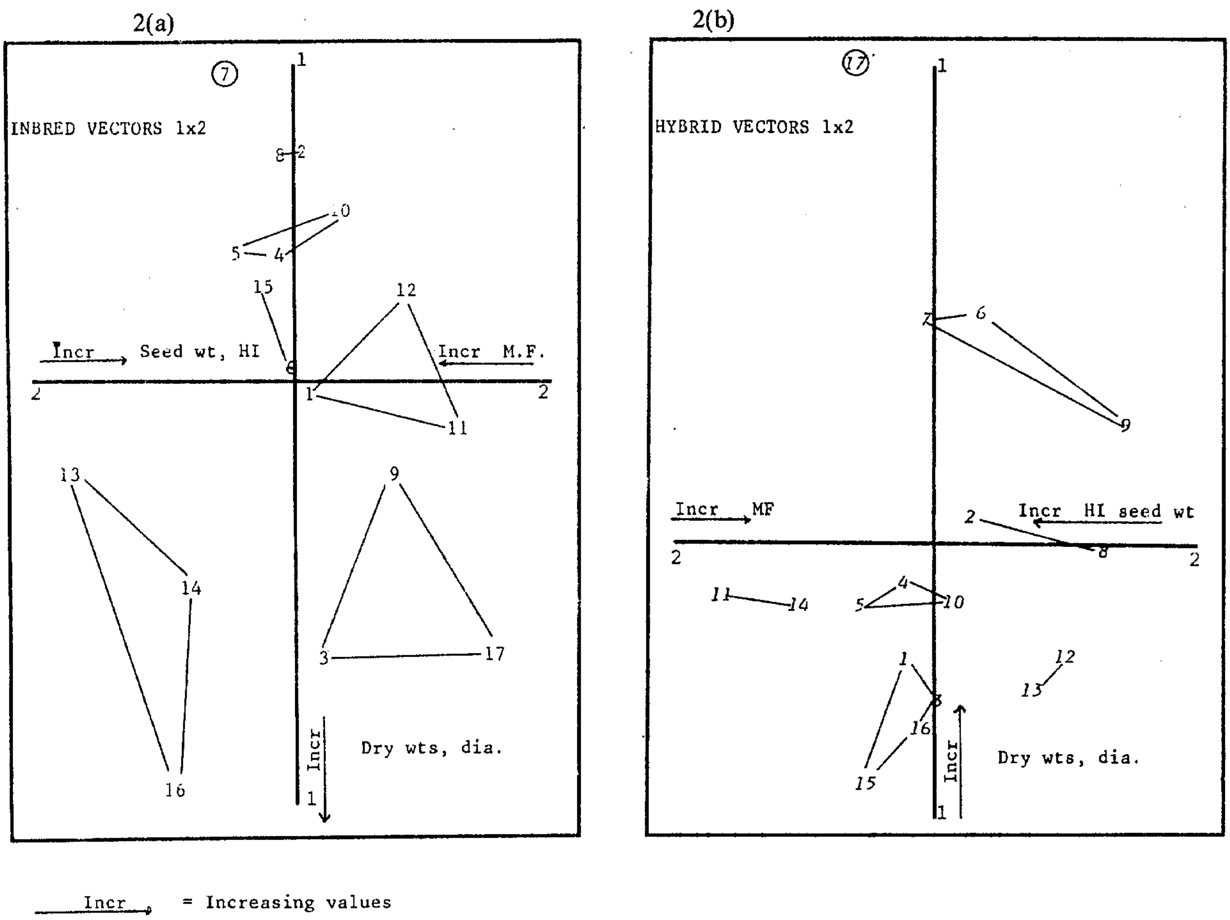
Fusion Group	Days to Mid Flower	Plant Height (cm)	Total Dry Weight (gm)	Seed Weight (gm)	Harvest Index	Comments
(a) inbred fusion groups						
I	90.3	67.1	87.9	13.4	0.16	Selected as very short and early, for possible use in semi-dwarf, short season hybrids, reduced yield potential.
II	88.1	68.4	120.0	21.4	0.18	Short early lines with average yield potential, yield advantage over I due to extra height and vegetative growth.
III	92.1	83.1	149.9	30.0	0.20	Early lines of medium height and yield potential, possible use in midseason-early hybrids with good dryland adaptation and better yield potential than I and II.
IV	92.7	92.9	205.5	42.5	0.21	Mid, midseason early lines of medium height and good yield potential, possible use as hybrids for good dryland and irrigation.
V	101.6	96.3	201.3	36.5	0.19	Similar plant types to IV but later with no yield advantage with delayed flowering. Plant type limiting as plant types in IV of similar maturity hence better seed yield.
VI	107.8	131.8	309.0	31.8	0.10	Tall late lines with large plants but poor seed yields. Photosynthesis being channelled into vegetative growth rather than seed.
VII	99.6	123.5	279.3	61.5	0.22	Tall, midseason-late lines with maximum yield potential, suitable for incorporation into full season, irrigated hybrids.
(b) Hybrid fusion groups						
I	68.7	151.2	121.1	20.7	0.17	Extremely poor heterosis — discard hybrid combinations.
II	66.0	152.3	125.1	39.2	0.31	Short hybrids with poor leaf canopies which reduce yield potential however may be of some use under stress conditions as has a good H.I.
III	66.6	164.4	159.4	48.5	0.30	Similar hybrids to I and II with improved vegetative growth and yield potential, suitable for dryland conditions.
IV	63.1	162.3	211.2	72.3	0.35	Medium height, early hybrids, good yield potential, use under dryland conditions.
V	71.6	208.4	167.2	38.3	0.23	Midseason-tall hybrids with poor vegetative growth which is reducing yield potential, no advantage over VI hybrids.
VI	78.2	220.6	259.8	62.8	0.24	Tall, late hybrids with good plant types and yield potential for use under good dryland and irrigation.
VII	70.0	180.0	416.5	59.5	0.14	Medium maturity hybrids with large plant types and average seed yields.

Examination of the inbred fusion groups means presented in Table 2a clearly demonstrates the similarities and/or the differences between the seven (7) inbred fusion groups. The same trend is seen in Table 2b for the hybrid fusion groups. The initially large and diverse range of inbred genotypes have been classified into meaningful agronomic groups. The classification has been particularly useful in that a plant breeder can easily pull out specific plant types with different growth, yield and quality parameters.

Analysis 2 — Ordination.

The main Gower principal co-ordinate vectors for the 17 inbred and 17 hybrid groups are presented in Figures 2(a) and (b). In the inbred analysis the first three vectors accounted for 66.3%, 18.6%, 9.7% respectively or 94.6% of the total variation. The first three hybrid vectors accounted for 55.8%, 19.5% and 15.8% respectively or 91.1% of the total variation.

Figure 2. The main Gower principal co-ordinate vectors for (a) 17 inbred and (b) 17 hybrid groups.



Correlation coefficients between the first three vectors and the original attributes using Gowecor (Lance *et al.*, 1968) are presented in Tables 3(a) and (b). Vector 1 separated the inbred and hybrid groups on plant dry weights and stem/head diameters, whilst vector 2 separated the groups on seed weight, harvest index and days to mid flower. The projection of the inbred and hybrid groups onto vectors 1 and 2 have been joined to indicate how these plots were grouped in the hierarchical classification in Figure 1.

Table 3a. Attribute values for characters used in inbred analysis.

Vector 1		Vector 2		Vector 3	
Attribute	Value	Attribute	Value	Attribute	Value
6	−.972	10	.895	9	−.667
5	−.965	8	.745	1	.432
3	−.936	1	−.481	2	.381
7	−.918	7	.372	10	.308
4	−.913	9	.197	3	.179
2	−.897	5	−.188	8	.148
1	−.699	4	.140	4	−.133
9	−.665	6	−.139	5	−.132
8	−.628	3	−.137	6	−.083
10	.269	2	−.052	7	−.055

Table 3b. Attribute values for characters used in hybrid analysis.

Vector 1		Vector 2		Vector 3	
Attribute	Value	Attribute	Value	Attribute	Value
5	.977	1	.706	9	.708
6	.975	10	−.653	10	.579
3	.916	8	−.582	8	.576
4	.910	2	.485	2	.433
7	.842	7	−.483	1	.387
2	.631	9	.377	4	−.166
8	.558	4	−.199	7	.144
1	.526	3	.177	5	−.118
10	−.414	6	−.039	6	−.107
9	−.367	5	−.019	3	−.051

No major discrepancy between the classification and the ordination analyses is apparent for either sets of fusion groups. However the spatial arrangement of the groups in the ordination analyses helps to understand the strength of the similarities and/or differences between fusion groups.

3. Comparison between Inbred and Hybrid groups.

In an attempt to see if it is possible to record growth parameters of inbreds in a spaced plant trial and predict with any degree of accuracy their performance in hybrid combinations a canonical correlation analysis between the principal component vectors of the inbred and hybrid groups was made.

Although there was a high canonical correlation between the principal component vectors of the two sets of fusion groups ($R_{i,h}$ = 0.99, 0.99 and 0.99 for the first three vectors respectively) the correlation for these principal component vectors depended almost entirely on vegetative parameters. There was only a small degree of similarity in genotype between corresponding linked fusion groups of inbreds and hybrids. This lack of similarity in genotype may be due to the initial large variation in genotypes and to differences in heterosis of experimental crosses from related genotypes, e.g.

When related to inbred genotypes within one or more inbred fusion groups are crossed onto a tester male, the resultant hybrids may fall into several hybrid fusion groups, especially as the contribution of the various growth parameter measured may vary between the inbred and the hybrid fusion groups.

CONCLUSION

Both the classification and ordination procedures presented above appear to be very useful tools in a sunflower breeding programme as they help to simplify the assessment and classification of large numbers of genotypes. The procedure would also lend itself to be used in conjunction with either crop modelling or field trials to assess the potential of specific genotypes.

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LITERATURE CITED

BURR, E.J. 1968. *Australian Computer Journal* 1:97 — 99.

BURR, E.J. 1970. *Australian Computer Journal* 2: 98 — 103.

BURT, R.L., EDYE, L.A., WILLIAMS, W.F., GROF, B. and NICHOLSON, C.H.L. 1971. *Australian Journal of Agricultural Research* 22:737 — 757.

BYTH, D.E., EISEMANN, R.L. and DELACY, I.H. 1976. *Heredity* 37:216 — 230.

EDYE, L.A., BURT, R.L., WILLIAMS, W.T., WILLIAMS, R.J. and GROF, B. 1973. *Australian Journal of Agricultural Research* 24:511 — 525.

EDYE, L.A., BURT, R.L., NICHOLSON, C.H.L., WILLIAMS, R.J. and WILLIAMS, W.T. 1974b. *C.S.I.R.O. Australian Division Tropical Agronomy Technical Papers.* No. 15.

EDYE, L.A. 1976. *Pattern Analysis in Agricultural Science.* pp. 181 — 193.

GOWER, J.C. 1966. *Biometrita* 53:325 — 338.

GOWER, J.C. 1967. *The Statistician* 17: 13 — 28.

LANCE, G.N., MILNE, P.W. and WILLIAMS, W.T. 1968. *Australian Computer Journal.* 1:178 — 181.

MUNGOMERY, V.E., SHORTER, R. and BYTHE, D.E. 1974. *Australian Journal of Agricultural Research.* 25:59 — 72.

WILLIAMS, W.T. and LANCE, G.N. 1968. *Statistician* 18.

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STRATIFIED MASAL SELECTION ON SUNFLOWER AS A BREEDING METHOD FOR SYNTHETIC VARIETIES FOR FORAGE OR GRAIN.

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ABSTRACT

Mexico is not considered as an important country in the world production of sunflower; however, Mexico has large acreage in the northern semi-arid regions of the country with possibilities of sunflower production. After several years of research we have formed the C.V. TECMON-1 for grain and TECMON-51 for forage, both varieties have been formed by masal stratified selection and is derived from the same local variety. With the same breeding method, we have formed TECMON-2 *(Resistant to Homeosoma electellum)* and TECMON-3 with germplasm from Rumania, Czechoslovakia, Australia and Canada.

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