USE OF YIELD STABILITY IN BREEDING SUNFLOWER FOR ZAMBIAN ENVIRONMENTS.

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SUMMARY

Stability analysis was carried out on experimental data to identify and characterise stable varieties of sunflower (Helianthus annuus) in the Zambian environments in order to select breeding populations with wider adaptability. Data was obtained from field experiments conducted at five locations over three years (1983-1985). Genetic material used included sets of 25 hybrids derived from six breeding populations of both tropical and temperate origins. Seed yield was measured and used as the variable in all statistical analyses. Stable varieties were identified to have consistent yields across the locations in any given year. Such varieties were not necessarily those with highest mean yields, rather had strong tendencies to yield higher than the location mean yield. Stability analysis was seen as a useful tool in the breeding programme when a wide range of environments is considered for cultivation of the crop, as is the case in Zambia.

INTRODUCTION

In Zambia rainfall constitutes the principal source of water for cultivation of most crops including sunflower (Helianthus annuus). Unfortunately the fluctuations in distribution and amounts associated with the rain season make it difficult for a given crop variety to give reliable seed yields due to significant genotype by environment interactions (Annual Research Report, 1984). In the presence of these interactions, genotypes performed differently from location to location and season to season. Inconsistencies of this nature may be due to alterations in the ranking of genotypes from one environment to another or changes in the differences between the genotypes, with ranking unchanged (Allard and Bradshaw, 1964). Sprague (1963), interpreted these inconsistencies to mean that genotypes were variably suited to specific environments. In Zambia, yield fluctuations result of variations in factors such as climatic and soil conditions, management levels in the farming community and significances of disease attacks. To ensure stable food production under such environments through provision of appropriate cultivars, plant breeders have suggested using yield stability as a useful criterion in the development of varieties (Sihna et al., 1986; Eberhart and Russel, 1966; Finlay and Wilkinson, 1963; Francis and Kannenberg, 1978.). Unlike in other crops such as wheat (Keim and Kronstad, 1978), maize (Francis and Kannenberg, 1978) yield stability in sunflower has not been widely used in developing stable varieties. This paper reports research results from a sunflower breeding programme in Zambia using yield stability as an additional selection criterion in the development of varieties suitable for the various climatic and farming conditions typical of the country.

MATERIALS AND METHODS

Inbred lines used as male parents of the hybrids evaluated were derived from six breeding populations through recurrent selection. Breeding population "A" is the oldest population and of tropical background. It is a complex population of elite material from seven cycles of selection and material from the disease resistance programme. It is characterised by tall vigorous plants and improved tolerance to Alternaria and Septoria leaf diseases. Breeding population "B" is of temperate origin and is composed of material derived from the high oil content Russian germplasm. It is characterised by short plants and moderate susceptibility to drought stress associated with boron deficiency. Breeding population "C" is a newer population of tropical background created from K030A (Kenyan open pollinated variety) and some material from population "A" and surrounding countries. It is characterised by susceptibility to stem lodging. Breeding population "D" is a population created by crossing a temperate tester with elite material from population "A" in 1977. The population has undergone six cycles of selection for leaf diseases. Breeding population "F" is mostly a temperate population created by crossing population "D" with some exotic material. It is characterised by multibranches and high oil content. A cytoplasmic male sterile line of wide genetic base, FSa3, derived from Vniimk 8931, was used as a tester for populations of tropical background; an inbred line of tropical origin, FSc1, was used as a tester for populations of temperate background. Male S2 lines with superior combining ability for seed yield were selected at 10% selection pressure from each population. Hybrids from these lines crossed with their respective testers were evaluated against recommended commercial varieties (checks) in Primary Variety Trials at four locations and further inbred. A total of 25 good yielding hybrid varieties, including checks, were subjected to further evaluation in the Preliminary Variety Trials. Results from these trials were used for this paper.

Hybrids were evaluated over 10-12 locations for three years in order to broaden the range of environmental conditions. The experimental set up was a 5x5 balanced lattice square design with three replications. No effort was made to separate hybrids on the basis of parental background in the trials. Plots were 3m x 6 m with a harvest area of 8.1m^2. Recommended cultural practices were followed throughout the growing season.

Only analysis concerning seed yield will be discussed here. Analysis of variance was calculated at each location in each year as well as combined analysis across locations within a year with locations considered random. Stability analysis for each of the year followed the method of Finlay and Wilkinson (1963), with no combined analysis across years. This was necessitated by the changes in entries being tested from the 1983/84 season to the 1985/86 season. Only the sites with homogenous error mean square were considered. The analysis was conducted without data transformation. The coefficient of determination (r^2) rather than the mean square due to deviation from regression was used as a measure of the fit. The overall standard error (SE) of the slope (b) was computed using a pooled sum of product of the deviates. Another stability parameter, the coefficient of variation (CV) of a variety yields across locations was also calculated (Francis and Kannenberg, 1978).

RESULTS

The range of environments on which the regression has been computed is presented in table 1. The wide amplitude encountered during the 83/84 season is mostly a result of drought stress and soil fertility variation. During the following two seasons, water supply was rarely limiting but the incidence of leaf diseases was prevalent at a number of sites.

Table 1: Environmental index across years and locations represented by the mean seed yield (Q/Ha) of the site.

	TRIAL LOCATIONS											
SEASON	MAGOYE	NANGA	MT. MAKULU	G.VALLEY	MSEKERA	MASUMBA	MPONGWE	KABOMPO	MUFULIRA	MALASHI	MBALA	MEAN
83/84		23.96	22.05	17.92		14.03	26.65		8.96		8.51	17.44
84/85		17.88	23.09	16.51	21.40	17.96	29.04	16.28				20.31
85/86	16.56	25.78	16.14		20.30			13.82	14.91	20.79	21.13	18.68

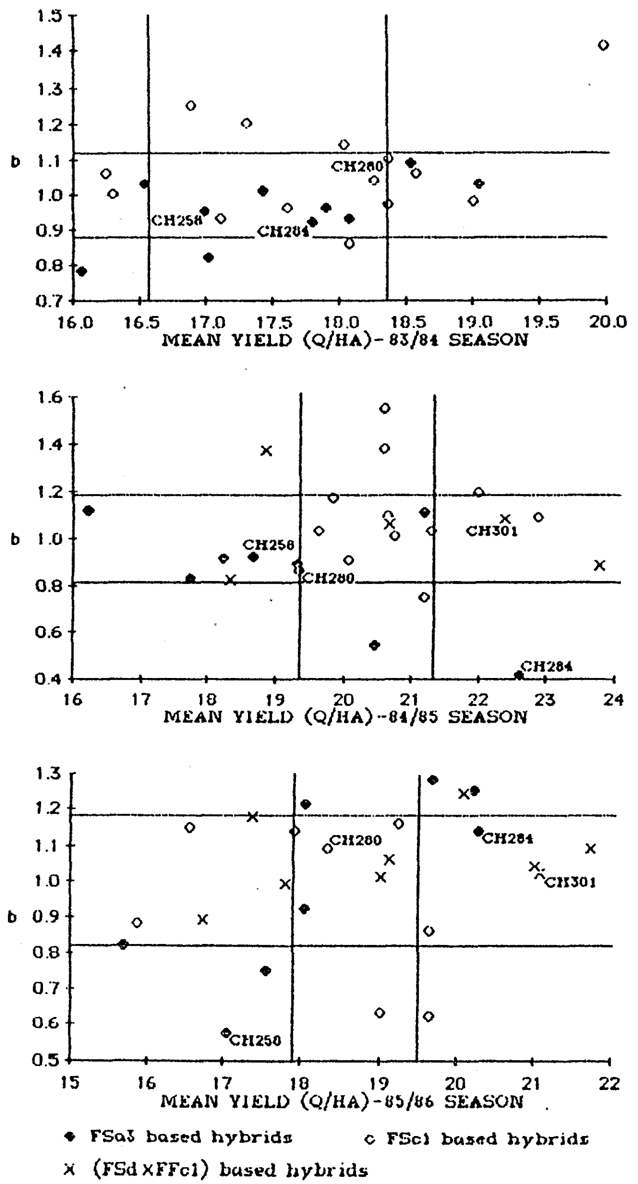
The results of the regression analysis are presented in table 2. Higher r^2 and CV values were recorded during the 83/84 season. The new varieties CH284 and CH301 displayed a relatively low CV across years together with a higher overall mean.

Table 2: Mean seed yields, coefficients of determination, regression coefficients and coefficients of variation of sunflower genotypes grown in 1983-1986.

		OVERALL MEAN (Q/HA)			r^2			b			CV		
PEDIGREE	CODE	83/84	84/85	85/86	83/84	84/85	85/86	83/84	84/85	85/86	83/84	84/85	85/86
FSa3xC78/207	CH258	16.99B	18.69C	17.06C	0.95	0.87	0.59	0 95	0.92	0.57	41.3	24.4	17.3
xA83/346		17.43B			0.98			1.01			42.3		
xA83/289	CH285	18.54A	20.48B	15.70C	0.95	0.51	0.74	1.09	0.54	0.82	43.3	16.9	24.3
xA83/289 (sib)	CH295		17 76C			0 76			0.83			24.7	
xA83/257		16.06C			0.94			0.78			36.1		
xA83/326	CH281	18.08B	21.20B	20.23A	0 98	0.81	0.94	0.93	1 11	1.25	37.7	26.8	25.5
xA83/326 (sib)	CH291		18.26			0.74			0.91			26.7	
xA83/331	CH284	17 80B	22.63A	20.30A	0.95	0.29	0.88	0.92	0 41	1.14	38.4	15.5	24.0
xA83/205		17.90B			0 90			0.96			39.2		
xA83/231		17.02B			0 86			0.82			37 5		
xA83/364		16.54B			0 90			1.03			47.5		
xC82/321		19.05A			0.97			1.03			39.6		
xD83/401			19.33B			0.73			0.89			25.0	
xD83/385			16.23C			0.89			1.12			33.8	
xA84/772	CH321			18.05B			0.75			1.21			31.1
xA84/848	CH323			19.69A			0.92			1.28			27.2
xZ320	CH325			18.05B			0.91			0.92			21.4
xZ321	CH326			17.55C			0.70			0.75			20.6
FSc1xB81/022	CH280	18.37A	19.37B	18.36B	0.93	0.74	0.86	1 10	0.86	1.09	44.9	23.7	25.7
FSc1(SR)xB81/022	CH290		20.09B			0.87			0.90			22.2	
FSc1xB79/719	CH278	18.07B	19.87B		0.89	0.83		0.86	1.17		36.5	29.6	
FSc1(SR)xB79/719	CH288		19.65B			0.80			1.03			26.9	
FSc1xZ265	CH270	17.31B			0.94			1 20			51.4		
xZ274	CH279	16.24C			0.91			1.06			49.4		
xB81/016		16.30C			0.90			1 00			46.6		
xB82/019		19.98A			0.97			1.41			51.6		
xB82/032	CH282	16.89B			0.98			1.25			53.8		
xB83/669	CH286	18.57A	20.62B		1.00	0.97		1.06	1.55		41.2	35.3	
xB83/643		17.64B			0.78			0.96			44 5		
xB83/710		18.37A			0.97			0.97			38.9		
xB83/648		17.11B			0 81			0 93			43.4		
xB83/789		18.03B			0.96			1.14			46.6		
xB83/853	CH287	18.26B	20 70B		0.90	0.83		1.04	1.01		43.3	24.5	
xB83/873	CH283	19.01A	21.20B		0.91	0.74		0.98	0.75		38.8	18.8	
FSc1(SR)xB84/747	CH296		20 62B	19.03B		0.87	0.76		1.38	0.63		33.1	15.2
xB84/707	CH297		22.88A			0.87			1.09			23.6	
xB84/695	CH298		21.31A			0.74			1.03			25.8	
xB84/683	CH299		22.01A			0.69			1.19			30.0	
xB84/579	CH306		20.65B			0.93			1.10			25.5	
xB84/642	CH308			19.67A			0.70			0.86			20.9
xB84/623	CH309			17.91B			0.66			1.14			31.5
xB84/665	CH311			19.67A			0.69			0.62			15.2
xF84/442	CH327			16.56C			0 83			1 15			30.7
xF84/420	CH328			19.26B			0.81			1.16			26.7
xF84/466	CH329			15.88C			0 79			0.88			24.8
(FSdxFFc1)xB83/873	CH301		22 39A	21 10A		0.97	0.89		1.08	1 02		22.5	20.4
xB83/853	CH302		18.86C			0.89			1 37			35.5	
xB83/669	CH303		20 70B			0.86			1.06			25.4	
xB83/789	CH304		18.35C			0.76			0.82			23.5	
xB83/643	CH305		23.80A	19.14B		0.61	0.78		0.88	1.06		21.9	25.1
xB84/579	CH312			21.75A			0.94			1.09			20.8
xB84/685	CH313			16.75C			0.77			0.89			24.3
xB84/642	CH314			21.02A			0.71			1.04			23.7
xB84/669	CH316			19.03B			0.79			1.01			23.9
xB84/623	CH317			17.81C			0.71			0.99			26.6
xB84/747	CH318			17.37C			0.89			1.18			28.9
xB84/665	CH319			20.09A			0.87			1.24			26.5
Pioneer 72044		10.43C			0.75			0.51			40.8		

In figure 1, the central class interval on X and Y axes is of 2 SE. It appears that the relation between yield and stability (b) varies across the seasons. However, the group of three way crosses introduced since the 84/85 season shows yield variability and generally good stability (b=1). The general yield improvement realised during these 3 years is made apparent by the relative position to the checks CH258 and CH280.

Figure 1. The relation of yield and stability of 25 hybrids grown in Zambia.



DISCUSSION

It is difficult to reconcile in this study the three concepts of stability defined as: good regression, b=1, and low CV (Lin et al.,1986). The difficulty arises primarily from the multiplicity of the stress factor in Zambia and the unpredictability of the environmental index.

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