the sorghum meal price as low as possible, but some commented that too low a price may signal a lower quality product to consumers.

More market education will be required. Correspondingly, Power Foods took advantage of the national trade fair and the agricultural show to advertise its products.

Further information on this work can be obtained from J. A. B. Kiriwaggulu, Marketing Development Bureau, Ministry of Agriculture, PO Box 2, Dar es Salaam, Tanzania.

Stratification of Pearl Millet Testing Sites in the SADC Region

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Introduction

Maximization of crop productivity requires accurate selection and targeting of cultivars for appropriate production areas. The number and location of testing sites are critical factors that affect the efficiency of and potential gains from breeding. The selected testing sites must be representative of the conditions of target production areas. Within a large region such as SADC, knowledge of underlying production zones within the region could help not only in choosing appropriate testing sites, but also in objective targeting of cultivars for production (Peterson 1992). The availability of long-term yield data from regional trials conducted in the SADC region over the past decade provides a unique opportunity to identify intra-regional production zones based on grouping of previously used testing sites with respect to their similarities in cultivar response to varying production conditions.

Plant breeders, over the years, often change both the genotypes and the locations in regional trials. Unlike the well-designed balanced genotype x location x year (GLY) investigations, where genotypes and locations remain the same over years, the analysis of regional trials is statistically more difficult due to highly unbalanced GLY data. Statistical techniques, developed over the last decade to stratify testing sites according to similarities in cultivar response, attempt to account for this imbalance in GLY data basically through averaging of location proximity matrices across years. This approach minimizes the influence of missing data and short-term weather events or rare disease epidemics on relative relationships among the testing sites (Peterson 1992).

Based on this basic approach, Peterson (1992) and Peterson and Pfeiffer (1989) applied factor analysis on the average correlation matrix to stratify international winter wheat testing sites using 17 years of trial data. The average correlation matrix was derived from the correlation matrices from individual trial years, the correlations within a year being computed between cultivar yields for pairs of locations. DeLacy et al. (1990) used the pattern analysis technique (Williams 1976) to stratify Australian cotton testing sites based on 6 years' data. They computed squared Euclidean distance (SED) between locations for each year and averaged the SEDs across years to produce a single average dissimilarity matrix for site classification. The individual years' dissimilarity matrices were either simply averaged or weighted by the number of genotypes grown in different years to obtain the single average dissimilarity matrix.

The objective of this research was to stratify the pearl millet testing sites in the SADC region based on available historical yield data from regional trials. This information allowed the identification of key benchmark testing sites representative of the underlying production zones in the SADC region. The site-stratification so obtained will also help to effectively use and target exchange of germplasm and information.

Materials and methods

Data from 90 pearl millet multi-environment trials (MET) conducted at 25 sites over 9 years, was split into two sets: Set 1 (1989/90 to 1992/93) included introductory genetic materials. Set 2 (1994/95 to 1998/99) included advanced genetic materials. Sequential Retrospective (SeqRet) pattern analysis was applied to stratify the test sites according to their similarity of genotype-yield differentiation patterns. This methodology is outlined in DeLacy et al. (1990). The SeqRet package and its manual are available at the website http://pig.ag.uq.edu.au/qgpb.

Results and discussion

Site stratification analysis from Set 1 and Set 2 partitioned the testing sites into six and five groups with R^2 values of 76% and 79% respectively. Analysis of the cumulative dataset (1989/90 to 1998/99) clustered the 25 sites into six

Table 1. Biophysical characteristics of SADC pearl millet test sites

Site	Country	Soil type	SWHC	pH	Drainage	Longi-tude	Lati-tude	Altitude (m)	Annual rainfall (mm)	First month	Min temp (°C)	Max temp (°C)	LGP (months)
Sebele (seb)	Botswana	M/F	H	6.4	MWD	26.0	-24.6	976	495	11	12	28	2
Maun (mau)	Botswana	C	M	6.6	WD	23.4	-20.0	898	445	12	15	31	3
Kasinthula (kas)	Malawi	F	M	6.6	PPD	34.8	-16.1	122	793	12	19	32	4
Ngabu (nga)	Malawi	F	H	7.3	ID	34.9	-16.5	115	760	11	19	32	4
Umbeluzi (umb)	Mozambique	M	H	6.4	WD	32.3	-26.0	64	667	12	17	29	5
Bagani (bag)	Namibia	C	VL	6.4	ID	20.7	-18.1	1049	551	12	14	30	4
Katima (kat)	Namibia	C	VL	6.4	ED	24.3	-17.6	966	682	12	13	30	4
Mahanene (mah)	Namibia	C/M	M	6.4	WD	15.2	-17.5	1110	505	11	13	29	3
Mashare (mash)	Namibia	M	M	6.6	ID	20.2	-17.9	1061	568	1	14	31	4
Ogongo (ogo)	Namibia	C	VL	6.4	SED	14.6	-17.9	1225	403	1	12	26	3
Okashana (oka)	Namibia	C	VL	8.5	WD	16.5	-18.3	1097	446	1	15	31	3
Hombolo (hom)	Tanzania	C/M	M	5.4	MD	35.9	-6.0	1019	562	12	16	30	4
Ilonga (ilo)	Tanzania	F	M	5.7	WD	37.0	-6.8	914	978	11	16	28	6
Ukiriguru (uki)	Tanzania	C/M	M	5.4	ID	33.0	-2.7	1239	952	11	17	28	7
Kaoma (kao)	Zambia	C	VL	6.4	ED	24.4	-14.4	1041	967	11	14	29	5
Longe (lon)	Zambia	C	L	4.8	WD	24.9	-14.9	1124	930	11	13	29	5
Simulumbe (sim)	Zambia	C	L	4.3	ED	23.8	-14.6	1017	968	11	15	29	5
Panmure (pan)	Zimbabwe	M	M	6.4	MWD	31.6	-17.3	1037	817	11	13	27	5
Kadoma (kad)	Zimbabwe	F	H	6.3	MWD	29.9	-18.3	1107	735	12	14	28	5
Lucydale (luc)	Zimbabwe	C	M	6.4	MD	28.5	-20.4	1416	591	11	12	25	4
Makoholi (mak)	Zimbabwe	M	M	6.4	MWD	30.8	-19.8	1111	628	12	13	26	5
Matopos (mat)	Zimbabwe	F	H	6.4	MD	28.5	-20.4	1416	591	11	12	25	4
Muzarabani (muz)	Zimbabwe	M	H	6.4	MWD	31.0	-16.4	427	665	12	17	32	3

Soil type: M = Medium, F = Fine, C = Coarse
SWHC = Soil water-holding capacity; H = High, M = Medium, L = Low, VL = Very low
Drainage: WD = Well drained, ID = Imperfectly drained, MD = Moderately drained, MWD = Moderately well drained, PD = Poorly drained; ED = Excessively drained, SED = Somewhat excessively drained
LGP = Length of growing period.

groups with R^2=76% and captured the major patterns of site similarities found in Set 1 and Set 2 (Fig. 1, Table 1). Based on the plant breeders' experience gained from running many years of MET, the cumulative dataset was more informative in judging the relevance of site-stratification results. Despite a highly imbalanced historical pearl millet MET dataset, SeqRet pattern analysis provided an objective basis for stratifying the test sites and thus choosing an optimum number of sites for future testing of genotypes.

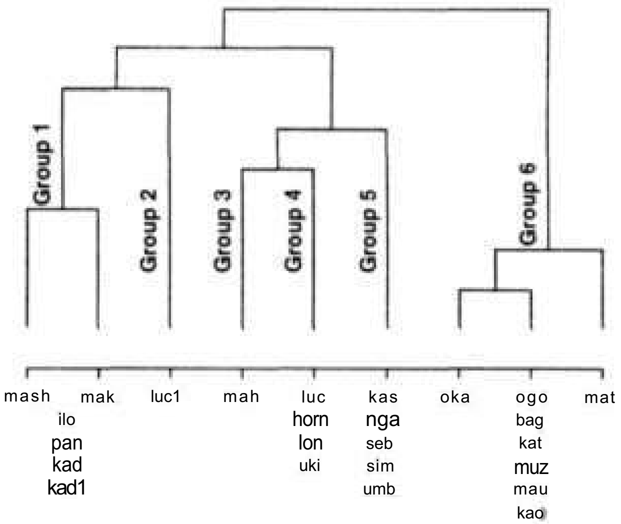

Figure 1. Dendrogram of cumulative classification of sites (1989/90 to 1998/99) based on grain yield (site codes shown in Table 1)

Conclusions

The results obtained from the cumulative dataset imply that further testing can be restricted to a few benchmark sites picked from each of the six groups representing six production zones within the SADC region. NARS scientists have expressed interest in using the SeqRet pattern analysis procedure to analyze their own MET data for national site stratification.

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Development of Sorghum Varieties through Participatory Plant Breeding in Malawi

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Introduction

In conventional plant breeding, farmers are invited to the research station once a year to evaluate new improved cultivars. Participatory plant breeding (PPB) uses a different approach — farmers are more closely involved in technology development, working with the breeder from an early stage in the breeding process. This farmer participation increases the chances of adoption of cultivars thus developed, and thus increases the expected returns from investments in plant breeding.

The Department of Agricultural Research, Ministry of Agriculture and Irrigation, Malawi, initiated a project during the 1997/98 season in which PPB was used in sorghum breeding for the first time. The objective of this work was to develop diversified sorghum populations and lines that incorporate farmer-preferred plant and grain traits.

Activities for the 1997/98 season were conducted at Kasinthula Research Station with 25 farmers (men and women) and at Ngabu Research Station with 20 farmers. These farmers evaluated 55 sorghum genotypes, and identified 8 genotypes as possessing traits they preferred most (Chintu 1998). During the 1998/99 season, PPB activities involved 23 farmers at Chitala and 16 farmers at Kasinthula. The farmers evaluated 101 genotypes and selected 20. However, farmers differed in traits that they considered most valuable (Chintu 1999).