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THE YIELD STABILITY OF MAIZE GENOTYPES ACROSS INTERNATIONAL ENVIRONMENTS: FULL SEASON TROPICAL MAIZE

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SUMMARY

Evaluation of the yield stability of a group of CIMMYT tropical maize populations across international environments, measured by the performance of varieties derived from them, showed that the populations Mezcla Tropical Blanca, La Posta and Amarillo Dentado produced the most stable varieties across environments. Mezcla Tropical Blanco and Amarillo Dentado produced selections with good stability in both low and high yielding environments while La Posta produced varieties with better performance in favourable environments. 'Across-site' varieties were not consistently more effective than 'site-specific' varieties in improving yield stability. Varieties selected for some specific population–environment combinations have been very stable in other areas of the world.

J. Crossa, B. Westcott y C. Gonzalez: *Estabilidad de rendimiento de genotipos de maíz en distintos medios ambientes internacionales: Maíz tropical de plena estación.*

RESUMEN

La evaluación de la estabilidad de rendimiento de un grupo de poblaciones de maíz tropical de CIMMYT en distintos medios ambientes internacionales, usando como medida el rendimiento de variedades derivadas de éstas, demostró que las poblaciones Mezcla Tropical Blanca, La Posta y Amarillo Dentado produjeron las variedades más estables en distintos medios ambientes. La Mezcla Tropical Blanca y Amarillo Dentado produjeron selecciones con buena estabilidad en medios ambientes de rendimiento tanto bajo como alto, mientas que La Posta produjo variedades de mejor rendimiento en ambientes favorables. Las variedades plantadas en varias localidades no demostraron consistencia en cuanto a una mayor eficacia en el mejoramiento de la estabilidad de rendimiento que lo obtenido para variedades en localidad específica. Las variedades seleccionadas para algunas combinaciones específicas de población-ambiente han sido muy estables en otras zonas del mundo.

INTRODUCTION

CIMMYT's maize improvement work involves the continuous development and improvement of tropical (full and intermediate season), sub-tropical and quality protein gene pools and populations. In Mexico, CIMMYT has a network of experimental stations located so as to represent the environments found in other important maize-growing areas of the developing world. These differing environments permit CIMMYT to carry out preliminary stages of germplasm

improvement for a wide range of production circumstances. In addition to Mexico's environmental diversity, its climate permits CIMMYT breeders to conduct two crop improvement cycles a year at its lowland and intermediate altitude stations.

The gene pools are broadly based, a wide range of materials being brought together for particular combinations of altitude and climate. These materials are selected for yield potential, height, maturity, lodging, disease and insect resistance until they are able to contribute superior new germplasm to the populations. This approach aims to generate populations for developing countries, leading to open-pollinated varieties having white or yellow, flint or dent grain, early, intermediate or late maturity, and a yield potential and stability equal or superior to the best local cultivars.

One of the main concerns of the programme is to produce genetic material that will perform well under different environmental conditions, especially where inputs are low and various forms of environmental stress are a problem. The objectives of this study were therefore to examine the yield stability of some maize populations measured by the performance of the varieties derived from them and to identify specific sites where stable selections have been made.

MATERIALS AND METHODS

The CIMMYT maize improvement method and its international testing system

Full details of the CIMMYT population improvement programme are provided by Paliwal and Sprague (1982) and Vasal *et al.* (1982). Multi-locational testing plays a major role in the system. CIMMYT's maize populations enter the international progeny testing trials (IPTTs) once they are judged to have reached a level of development sufficiently high to offer superior germplasm for some part of the developing world. Half of the populations are tested internationally each year, each population being tested every other year. CIMMYT selects 250 full-sib families from each population being tested and sends seed to collaborators at six sites worldwide, chosen to provide suitable environments for the particular population in question. Each collaborator evaluates these 250 families in comparison with the six best locally available hybrids or varieties as checks using a 16 X 16 simple lattice design. The ten best families are chosen on the basis of their yield potential, agronomic type, days to flowering, resistance to diseases and insects and absence of lodging and rots.

At CIMMYT's stations in Mexico, remnant seed from these ten best entries from each test site is grown and the ten families are intercrossed in all possible combinations. The recombined seed of this family intermating is then bulked to produce an experimental variety. Some experimental varieties are identified by the test site, year and population. Thus 'Kisanga 7729' refers to the ten best families selected by CIMMYT staff from population 29 grown in a 1977 IPTT at Kisanga, Zaire. If the site name is followed by a number in brackets, this refers to a selection of ten families made by the national programme staff.

Thus 'Santa Rosa (3) 7624' is the third variety selected in 1976 from population 24 by staff at Santa Rosa, Nicaragua. Finally, an 'Across' variety, such as 'Across 7843' is a variety created from the ten families which performed best across all six sites where the IPTT was grown. About 25 to 30% of the best families selected on the basis of across-site performance are used to reconstitute the population for the next cycle of improvement.

Experimental varieties from each population are assembled into experimental variety trials (EVTs) which are widely tested the following year at 20 to 80 sites throughout the developing world. At each of these sites, co-operators evaluate the experimental varieties against their best locally available check varieties and hybrids, using a randomized complete block design with four replicates.

This international maize testing system, with national programme staff acting as full partners, continues to grow in size. CIMMYT (1981) saw their population improvement programme as being essentially based on this testing by co-operators, its success depending on the quality of the trials and data. As national programmes develop their own sets of gene pools and advanced populations, they improve their capacity to use CIMMYT germplasm to meet the varietal requirements of local farmers.

Genetic material

A brief description of the full season tropical maize populations is given here. For each population, current details of the component germplasm and the countries where progeny tests have been conducted are given in CIMMYT (1981).

Population 21: Tuxpeno-1. This is a tropical lowland population with white dent grain, late maturity, excellent standability and relatively short plant type. It is fairly tolerant of most foliar diseases and performs well in most tropical lowlands. Since 1977, it has been improved specifically for resistance to fall armyworm (*Spodoptera frugiperda*).

Population 22: Mezcla Tropical Blanca. This population is adapted to tropical areas. It has a white dent or semi-dent grain and late maturity. It performs well in the tropical regions of Mexico, central America, northern south America, east and west Africa and India. Since 1980 it has been subjected to selection for downy mildew resistance by CIMMYT's Asian Maize Regional Programme in co-operation with Thailand's National Programme at Kasetsart University, Suwan Station.

Population 24: Antigua-Veracruz 181. This is a tropical lowland population with yellow semi-dent grain. It is of intermediate plant height and maturity and performs well in the lowland tropics of south America, central America, Mexico, southeast Africa and Asia. The emphasis is on improving its resistance to fall armyworm.

Population 25: Blanco Cristalino-3. This is adapted to lowland tropical and sub-tropical areas. It has a white flint to dent grain and late maturity. It has

been selected for stem borer (*Diatraea saccharalis*) resistance. It performs well in the tropical lowlands of Mexico, Africa and parts of Asia.

Population 27: Amarillo Cristalino-1. This is a tropical lowland population with yellow flint grain. It is of intermediate plant size and medium to late maturity. It performs well in the lowland tropics of south America, the Caribbean, India and southeast Asia. It is being improved for borer resistance.

Population 28: Amarillo Dentado. This is a tropical lowland population with late maturity, relatively tall plants and yellow dent grain. It gives high yields and performs well in the tropical lowlands of Mexico, central America, south America and parts of Asia. Special attention is being given to plant height reduction. Since 1980 it has been subjected to selection for downy mildew resistance by CIMMYT's Asian Maize Regional Programme in co-operation with Thailand's National Programme at Kasetsart University, Suwan Station.

Population 29: Tuxpeno Caribe. This is a tropical lowland population with white dent grain and late maturity. High yield potential has been demonstrated in Mexico, central America, Egypt and parts of Africa and Asia. The emphasis is on reducing plant height.

Population 36: Cogollero. This is a lowland tropical and sub-tropical population with semi-dent grain, intermediate to late maturity and tall plants. It performs well in central America, lowland south America and parts of Asia. A reduction in plant height is being given special emphasis.

Population 43: La Posta. This is a tropical lowland population with white dent grain. Tall and late, its high yield potential has been verified in the lowlands of south America, central America, Mexico, the humid tropics of west and central Africa and parts of east Africa. Emphasis is on streak resistance and reduced plant height in a co-operative programme with the International Institute for Tropical Agriculture (IITA), Nigeria.

Trials data and statistical analysis

White-grained varieties selected from populations 21, 22, 25, 29 and 43 are grown in experimental variety trial (EVT) 12, while yellow-grained varieties from populations 24, 27, 28 and 36 are grown in EVT 13. Varieties from populations 26 and 35 were included in EVT 13 only in 1979, and one derived from population 73 was included in EVT 12 only in 1983. The yield data which are analysed here came from some of the experimental variety trials conducted in the five years 1979–83. The data values were retrieved from the CIMMYT maize computer system.

The method of stability assessment used has been described by Westcott (1987). The analysis for one year's trials in an EVT is based on the sequential accumulation of the environments according to their rank order, the sites being ranked in descending order according to their overall means. The two sets of sites outside the lower and upper quartiles of the sample of site means are examined in turn. For each set, the analysis is performed in cycles, each successive cycle including one more site. Thus, for the low yielding sites, the first

cycle (called L1) involves the analysis of the lowest yielding site, the second cycle (L2) involves analysing the two lowest yielding sites and so on, the lowest yielding site of those remaining being added at each cycle. Similarly, cycles H1, H2, etc. involve the highest yielding site, the two highest yielding sites, and so on.

Each cycle produces a two-dimensional picture, in which the first two principal co-ordinates are plotted for each variety. Neglecting information in the third and later principal co-ordinates can somewhat distort the revealed relationship between varieties but such distortion can be reduced by superimposing the minimum spanning tree. This also provides a natural centre for the picture (Westcott, 1987). The stable varieties are simply the ones consistently furthest from the centre and their identification is generally immediate. To avoid a large number of figures, the results from the present analysis are described in words. However, a sequence of four pictures corresponding to L4, L12, H4 and H12 of EVT 13 in 1979 (Fig. 1a, b, c and d) is included for illustrative purposes.

RESULTS

Stability analysis of EVTs in 1979

Stability analyses performed by Westcott (1987) on EVT 12 showed Across 7622, Dholi 7622 and Poza Rica 7843 to be the most stable varieties in low yielding sites (Poza Rica 7843 also being stable in favourable environments). Poza Rica 7822 and La Maquina 7843 performed well in both the L and H cycles.

In EVT 13, 16 selections were evaluated at 47 different locations and analyses were performed on the 12 lowest and 12 highest yielding sites. The two highest yielding varieties overall, Across 7728 and Sete Lagoas 7728 (Table 1), showed remarkable stability in the L cycles. A variety derived from population 35, Tocumen (1) 7835, performed well in L3–L12 and Across 7736 (ranked

Table 1. *Varieties in experimental variety trial (EVT) 13 in 1979 ranked in descending order of mean yield (t ha^{-1}) over all sites*

Rank	No.	Variety	Country of origin	Mean yield
1	4	Across 7728		4.63
2	3	Sete Lagoas 7728	Brazil	4.56
3	2	La Maquina 7827	Guatemala	4.46
4	8	Poza Rica 7824	Mexico	4.42
5	1	Poza Rica 7827	Mexico	4.40
6	6	Across 7736		4.36
7	5	Suwan 7736	Thailand	4.27
8	11	Across 7726		4.18
9	7	Dholi 7624	India	4.15
10	10	Suwan 7726	Thailand	4.12
11	9	Sete Lagoas 7726	Brazil	4.11
12	15	Across 7627		4.07
13	14	Tocumen (1) 7835	Panama	4.05
14	12	Santa Cruz (1) 7835	El Salvador	3.97
15	13	Poza Rica 7835	Mexico	3.88
16	16	Across 7635		3.60

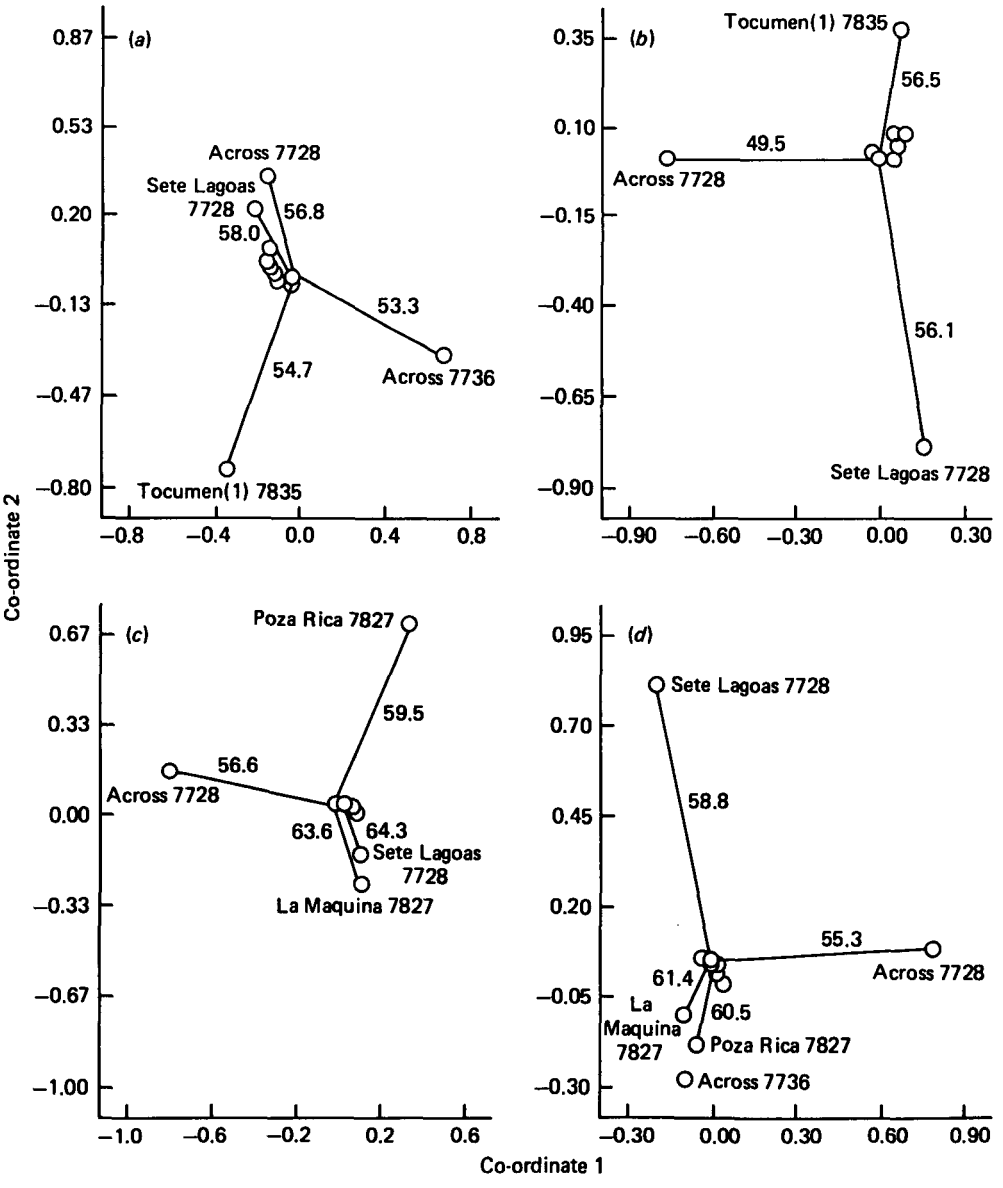

Fig. 1. Plot of similarity distances (Westcott, 1987) among varieties relative to the first two principal coordinates in (a) cycle L4, (b) cycle L12, (c) cycle H4 and (d) cycle H12 of the analysis of the EVT 13 (1979).

sixth overall) was an outlying point in L1-L4. The analysis over the four lowest yielding sites (L4) is presented in Fig. 1a; Across 7736 and Tocumen (1) 7835 are the remotest points followed by Across 7728 and Sete Lagoas 7728 closer to the centre. From L5 onwards only Across 7728, Sete Lagoas 7728 and Tocumen (1) 7835 are outlying points. The analysis over the twelve lowest yielding sites (L12) (Fig. 1b) showed these same three varieties as outlying items in the diagram. In summary, the analyses of the low yielding sites showed

that only Across 7728, Sete Lagoas 7728 and Tocumen (1) 7835 can be considered stable, as they are the ones that stayed far from the centre in most of the L cycles; Across 7736 is not considered stable since it appeared far from the centre only in L1-L4.

Analysis of the high yielding sites showed Across 7728, Poza Rica 7827 (ranked fifth overall), Sete Lagoas 7728 and La Maquina 7827 (ranked third overall) as being the remotest points in most of the H cycles. However, Sete Lagoas 7728 and La Maquina 7827 appeared closer to the centre in H1-H9 (Fig. 1c shows cycle H4) and from H10 to H12 Poza Rica 7827 moved closer to the centre and Sete Lagoas 7728 was located further from the centre (Fig. 1d illustrates cycle H12). Across 7736 was an outlying point only in H8, H10 and H12.

Stability analysis of EVTs in 1980

In EVT 12, while Cotaxtla 7822 and Across 7822 were stable in both low and high yielding locations, Ilonga 7822 showed good stability in low and Across 7843 in high environmental conditions.

Stability analyses performed on ten low and ten high yielding environments of EVT 13 conducted in 1980 at 41 sites indicated that Across 7824 (ranked fifth overall, Table 2) was the outlying point in most of the L and H cycles (and so represented the most stable variety). Ferkessedougou 7928 and La Maquina 7928, selections made in population 28 during 1979, were stable at high and low yielding sites, respectively (the former throughout all H cycles and the latter from L3 to L10). Variety Cd. Obregon 7936 (fourth overall) performed rather erratically in L cycles, but appeared as a remote point in L1, L2, L4, L5 and in L7 to L9. Sete Lagoas 7824 (tenth overall) showed signs of stability in unfavourable environments as it appeared far from the centre in L5

Table 2. *Varieties in EVT 13 in 1980 ranked in descending order of mean yield (t ha^{-1}) over all sites*

Rank	No.	Variety	Country of origin	Mean yield
1	9	Ferkessedougou (1) 7928	Ivory Coast	5.27
2	10	Ferkessedougou 7928	Ivory Coast	5.15
3	11	La Maquina 7928	Guatemala	5.15
4	14	Cd. Obregon 7926	Mexico	5.06
5	5	Across 7824		5.03
6	13	Guanacaste (1) 7928	Costa Rica	5.03
7	12	Poza Rica 7928	Mexico	4.98
8	16	Across 7728		4.92
9	7	Pichilingue 7827	Ecuador	4.88
10	4	Sete Lagoas 7824	Brazil	4.86
11	15	Poza Rica 7936	Mexico	4.82
12	8	Across 7827		4.80
13	6	Guanacaste 7827	Costa Rica	4.70
14	2	Pichilingue 7824	Ecuador	4.56
15	3	Suwan 7824	Thailand	4.55
16	1	Guanacaste 7824	Costa Rica	4.54
17	17	Across 7627		4.45

to L10. Analyses on favourable environments also showed Pichilingue 7827 to be stable over all H cycles.

Stability analysis of EVTs in 1982

The mean yield and rank of the varieties involved in EVT 12 tested at 50 locations in 1982 are shown in Table 3. Analyses on the 13 lowest yielding sites showed Poza Rica 8022 and La Maquina 8022 (ranked second and fourth overall, respectively) to have a clear pattern of stability in most L cycles. Across 7622 was also stable in low yielding environments, although it gradually moved out from the centre in cycles L1 to L5, did not appear stable in L11, and afterwards appeared again as a remote point. La Maquina 8022 was consistently outlying in all H cycles, followed closely by Ferkessedougou (1) 8022 (third overall) and Across 8043 (fifth overall). Poza Rica 8022 showed signs of stability under favourable environmental conditions especially in H1, H2 and H13.

Principal co-ordinate analyses performed on twelve low yielding sites in EVT 13 suggested that Poza Rica 8027, Across 7928, Across 7936 and Across 7728, (ranked sixth, fourth, third and second overall, respectively, Table 4) were the most stable. However, in L1, Piura (1) 7936 and Across 7728 were far from the centre; in L2, Piura (1) 7936, Across 7936 and Across 7928 were remote points; and in L3, Across 7936, Piura (1) 7936 and Across 7728 were the furthest points, followed by Across 7928 and Poza Rica 8027. From L4 onwards, the stability pattern of these varieties is clear, except in L4 where Across 7728 appeared very close to the centre. Piura (1) 7936 performed well only in L1 to L5. Two varieties with good stability in L cycles, Across 7928 and Across 7728, also performed well in all H cycles. The highest yielding variety over all sites, Pichilingue 7928, showed a very stable performance over the twelve high yielding environments.

Table 3. *Varieties in EVT 12 in 1982 ranked in descending order of mean yield (t ha^{-1}) over all sites*

Rank	No.	Variety	Country of origin	Mean yield
1	7	Guaymas (1) 8022	Honduras	5.49
2	4	Poza Rica 8022	Mexico	5.49
3	8	Ferkessedougou (1) 8022	Ivory Coast	5.48
4	5	La Maquina 8022	Guatemala	5.44
5	16	Across 8043		5.41
6	17	Across 7622		5.37
7	3	Chuquisaca (1) 7822	Bolivia	5.35
8	13	San Andres 8043	El Salvador	5.35
9	2	Across 7921		5.33
10	9	Across 8022		5.31
11	12	Across 7929		5.28
12	6	Santa Rosa 8022	Nicaragua	5.28
13	11	El Paraiso 7929	Honduras	5.25
14	15	Cotaxtla (INIA) 8043	Mexico	5.23
15	18	Across 7729		5.18
16	1	Los Diamantes (1) 7921	Costa Rica	5.17
17	14	Los Diamantes (1) 8043	Costa Rica	5.16
18	10	Across 7925		4.86

Table 4. *Varieties in EVT 13 in 1982 ranked in descending order of mean yield (t ha^{-1}) over all sites*

Rank	No.	Variety	Country of origin	Mean yield
1	9	Pichilingue 7928	Ecuador	4.75
2	13	Across 7728		4.71
3	12	Across 7936		4.66
4	10	Across 7928		4.66
5	5	Guaymas 8027	Honduras	4.45
6	6	Poza Rica 8027	Mexico	4.45
7	8	Suwan 8027	Thailand	4.43
8	1	Nayarit (Fansa) 8024	Mexico	4.43
9	7	Tocumen 8027	Panama	4.39
10	11	Piura (1) 7936	Peru	4.34
11	3	Chirigui (2) 8024	Panama	4.32
12	2	Chirigui (1) 8024	Panama	4.32
13	14	Across 7627		4.07
14	4	Satipo (1) 7827	Peru	3.94

Stability analysis of EVTs in 1983

Varieties derived from populations 21, 22, 29, 43 and 73 were included in EVT 12. Twelve low and twelve high yielding sites out of a total of 46 locations were considered for further analyses. Ferkessedougou 8129 (ranked second overall, Table 5) was a remote point in all L cycles; Poza Rica 8129 (ranked sixth overall) presented a clear pattern of stability from L3 to L12 and the top ranking variety, Santa Rosa 8073, was stable over the L cycles from L5 onwards. Two other varieties, Ferkessedougou (1) 8129 and Rattray-Arnold (1) 8121, did not do badly in general; they showed remote points in L7-L12 and in L2-L4, respectively. On the other hand, Gandajika 8022 was the best in H cycles, followed by Kwadaso 8043 (eighth overall). The third ranking variety, Ilonga 8043, was also located in remote positions in H1 and in H6-H12.

EVT 13 was conducted at 52 locations, and a total of 13 low and 13 high yielding sites were used in principal co-ordinate analyses. Muneng 8128 and Londrina 8136 (Table 6) ranked sixth and thirteenth, respectively, were

Table 5. *Varieties in EVT 12 in 1983 ranked in descending order of mean yield (t ha^{-1}) over all sites*

Rank	No.	Variety	Country of origin	Mean yield
1	12	Santa Rosa 8073	Nicaragua	5.07
2	8	Ferkessedougou 8129	Ivory Coast	5.06
3	10	Ilonga 8043	Tanzania	5.00
4	13	Across 7622		4.98
5	6	Gandajika 8022	Zaire	4.97
6	7	Poza Rica 8129	Mexico	4.97
7	9	Ferkessedougou (1) 8129	Ivory Coast	4.94
8	11	Kwadaso 8043	Ghana	4.94
9	4	Rattray-Arnold (1) 8121	Zimbabwe	4.88
10	14	Across 7729		4.88
11	5	Across 8121		4.83
12	1	Jardinopolis 8121	Brazil	4.81
13	3	Poza Rica 8121	Mexico	4.80
14	2	Omonita (1) 8121	Honduras	4.52

Table 6. *Varieties in EVT 13 in 1983 ranked in descending order of mean yield (t ha^{-1}) over all sites*

Rank	No.	Variety	Country of origin	Mean yield
1	12	Guarare (1) 8128	Panama	4.70
2	14	Ferkessedougou (1) 8128	Ivory Coast	4.55
3	11	Guarare 8128	Panama	4.53
4	19	U.P. Los Baños (1) 8136	Philippines	4.50
5	17	Across 8128		4.48
6	15	Muneng 8128	Indonesia	4.47
7	21	Poza Rica 8136	Mexico	4.42
8	10	La Molina (2) 8128	Peru	4.41
9	13	Ferkessedougou 8128	Ivory Coast	4.39
10	8	La Molina 8128	Peru	4.38
11	16	Suwan 8128	Thailand	4.35
12	6	U.P. Los Baños 8027	Philippines	4.34
13	20	Londrina 8136	Brazil	4.34
14	9	La Molina (1) 8128	Peru	4.33
15	23	Across 7728		4.31
16	18	U.P. Los Baños 8136	Philippines	4.30
17	7	Across 8027		4.22
18	3	Across 8024		4.20
19	5	Iboperenda 8027	Bolivia	4.16
20	2	Iboperenda 8024	Bolivia	4.10
21	22	Across 7627		3.95
22	4	Pichilingue (1) 7827	Ecuador	3.63
23	1	Pichilingue (1) 7824	Ecuador	3.56

found to be the most stable, although they followed different patterns. Londrina 8136 performed very well in L1, L2, L4 and L5; from L5 to L10 both showed remote points; while over the last three L cycles, only Muneng 8128 continued to give a stable performance. Ferkessedougou (1) 8128 (second overall) showed signs of stability in L7-L9, L11-L13 and H3-H13. The highest yielding variety over all environments, Guarare (1) 8128, presented remote points only in the low cycles L3-L5 and L7-L9, though it clearly showed very good stability over all the H cycles. It was followed closely by Across 8128, but only after H4.

DISCUSSION AND CONCLUSIONS

Mezcla Tropical Blanca (population 22) produced four stable varieties in EVT 12 (1982) and one in EVT 12 (1983). La Posta (population 43) gave rise to three stable varieties (one in EVT 12 in 1982 and two in EVT 12 in 1983). Eleven selections from Amarillo Dentado (population 28) showed a generally good stability pattern in EVT 13 from 1979 to 1983; six were stable in both low and high yielding environments. A few selections made from Amarillo Cristalino-1 (population 27) and Cogollero (population 36) also showed good stability across environments.

The results suggest that Mezcla Tropical Blanca, La Posta and Amarillo Dentado have produced the most stable varieties. Paliwal and Sprague (1982) have already mentioned the good performances of some varieties derived from these populations (Across 7822, Across 7728) at several locations and their

considerable degree of adaptation which allows them to perform well under differing environmental conditions.

Mezcla Tropical Blanca has a very broad genetic base and has performed well in various tropical regions around the world; selections from this population have shown good stability in both low and high yielding environments. Population Amarillo Dentado, which includes Tuxpeno, Caribbean and Brazilian germplasm and showed good progress in each cycle of selection, has again produced varieties with good stability under both favourable and unfavourable environmental conditions.

La Posta, which contains Tuxpeno germplasm and has shown relatively good progress in each selection cycle, tends to produce varieties that perform better under favourable environmental conditions.

The results show that across-site selection is not consistently more effective than site-specific selection in improving stability. However, in some trials across-site varieties have been fairly stable at both low and high yielding sites (Across 7728, Across 7736, Across 7822, Across 7824 and Across 7928). Across 7928 was stable in EVT 13 in 1979 and 1982.

The fact that some populations produce stable varieties and others do not suggests that a broad genetic base does not in itself assure stability. However, there are indications that varieties from some specific population-environment (site, year) combinations have been very stable in other areas around the world. This is the case for varieties produced from Mezcla Tropical Blanca, La Posta and Amarillo Dentado when evaluated in Poza Rica, La Maquina or Ferkessedougou.

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