MIDALTITUDE MAIZE BREEDING:

POPULATIONS, INBREDS AND HYBRIDS FROM THE IITA-NCRE-CAMEROON PROGRAM

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Maize Research Program

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OBJECTIVE

The objective of this report is to summarize the development of the IITA-Cameroon midaltitude maize breeding program, and to present results of evaluations of the genetic material carried out in Nigeria, Cameroon, and Zimbabwe in 1991.

INTRODUCTION

Maize breeding in the tropics is divided into the following altitude strata: 1. Lowland, 0-1000 meters above sea level, 2. Midaltitude, 1000-1600m, 3. Transition, 1600-2000m, and 4. Highland, >2000m. The division is based on genotype x environment (GxE) interactions explained by temperature effects on both plant physiology and predominance of particular pathogen complexes. In West Africa, most of the midaltitude zone is found in western and central Cameroon and the Jos Plateau of Nigeria. A major portion of eastern and southern Africa are midaltitude.

Prior to 1986, no core international center staff (IITA or CIMMYT) had been posted in Africa for midaltitude maize breeding. Varietal development had occurred in some national programs (especially Zimbabwe), occasionally with bilateral assistance and expatriote staff (Kenya, Zaire, Zambia, Malawi, Tanzania and Cameroon), however, much of the best work centered on proprietary hybrids, unavailable to other countries.

In 1979, IITA began a modest midaltitude breeding program at Jos, Nigeria, occupying less than 25% of one breeding position. Eastern and southern African midaltitude materials were combined with lowland streak resistant lines and populations to form the Midaltitude Streak Resistant population (MSR), and to initiate extraction of inbred lines. The first cycle of international full sib family testing in MSR occured in 1983, with varieties available for testing in 1984.

In January 1984 the author was transferred from IITA Ibadan to the IITA-USAID-Cameroon bilateral National Cereals Research and Extension (NCRE) Project, based in the Western Highlands of Cameroon. The objectives were to both develop the national midaltitude maize breeding program, and to expand the international midaltitude germplasm base. This report centers on progress toward the second objective.

SELECTION OF PARENTAL GERMPLASM

Varietal constraints identified through the TLU (on farm Testing and Liason Unit) and other sources indicated a need for the following open pollinated varietal types: 1. late maturing, white and yellow flinty grain with high yield and improved storability, and 2. early maturing, white and yellow flinty grain for an early season food source and for sale on higher priced early markets.

The wide range of soil types and fertility in the region indicated a need to focus some varietal development on tolerance to acid, phosphorus fixing soils. On the other hand, the increasing commercial (large and small farm) sector needed the uniformity and high yield that only hybrids can provide. Since there was no hybrid seed company in the country, these farms were importing hybrid seed, principally from Zimbabwe and Kenya.

A wide range of germplasm was obtained from tropical, subtropical, and tropical mid and high altitude programs around the world for 1984 testing in Cameroon. These included hybrids from Kenya, Zimbabwe, and Dekalb Seed Co., and open pollinated populations from CIMMYT, Tanzania, Kenya, Costa Rica, Guatemala, Brazil, and Thailand. These were added to two varieties already introduced by the project from Zaire and varieties from the MSR population, as well as 714 segregating inbred lines from the Jos program.

Most populations and hybrids were tested across seven sites in three provinces, ranging from 1000 to 2000m. These initial trials indicated the existence of an adaptation break point at approximately 1600m altitude, above which is found a limited area of intense cultivation, primarily in the N.W. Province. The majority of the growing area is concentrated in the much larger midaltitude stratum.

POPULATION FORMATION

The High Altitude Population (HAP) was formed in response to on farm trials which indicated that the midaltitude variety which was being extended in the transition zone was not performing better than the local farmer variety, i.e. an improved variety targeted to the higher altitude area was necessary. The Acid Tolerant Population (ATP) was formed principally to introduce acid tolerant germplasm from other countries, but is also filling the need for a late maturing, flinty yellow grain variety. The Early White population (EW) responds to the need for an early maturing white flinty grain variety. Population descriptions and status of improvement follow:

1. High Altitude Population (HAP).

Objective: Provide varieties for high (transition) altitudes (1600-2000m)

Composition:

Material	Source
Highland Hybrids	Kenya
Pool9a	CIMMYT
V301,V304	Guatemala
MSR	IITA
Dekalb 690	Dekalb
SR52, ZS206	Zimbabwe
Ndu Local	Cameroon

Status: Three cycles recombination followed by two cycles half-sib family selection (3 locations, 2 replications, approximately 350 families) were completed. HAP has been tested as a variety since 1989. Resistance to Phaeosphaeria maydis, a leaf spot prevalent in the area but only recently identified, is required.

2. MSR (IITA-Ibadan based Midaltitude Streak Resistant population).
Objective: Provide white grained, late maturing, streak resistant varieties for the midaltitudes.

Composition:	Material	Source
	ZCA, ECEM-573, SR52	Zambia
	48 S1's	Zimbabwe
	Katumani, H614, 7801	Kenya
	7880, 7621, 7696	Tanzania
	BACOA, BACOB	Cameroon
	Tlat 7844	CIMMYT
	U.S. Cornbelt x Midalt.	U.S./IITA

Status: Five cycles of international full sib family selection have been completed, with one site in Cameroon each cycle. Varieties from the population have been in testing since 1985, but none yet recommended in Cameroon.

3. Acid Tolerant Population (ATP).
Objective: Provide yellow flint grained varieties tolerant to acid soils of midaltitude zone.

Composition:	Material	Source
	ESAL QYF3, Q5VF1	Brazil
	CMS 36 SAFRI	CIMMYT/Brazil
	HE1066, 1049	Limagrain
	Suwan 1	Thailand
	Across 7728	CIMMYT
	COCA	Cameroon
	Shaba	Zaire
	MSR	IITA

Status: Three recombinations followed by four cycles of half sib family selection have been completed: two locations with two reps/location of approximately 300 families are tested each cycle. ATP needs improvement for Puccinia sorghi resistance, as parents are primarily lowland materials. Selection for streak resistance was made at Ibadan in 1991.

4. Early White Population.
Objective: Provide early maturing, white grained varieties for the midaltitudes.
Composition: CIMMYT subtropical Population 34
Early maturing lines extracted from MSR in Cameroon.

Status: Three cycles of full sib and half sib family recurrent selection were completed in Population 34 itself, followed by testcrossing early MSR inbreds onto 34. Selected testcrosses **per se** were recombined to form the population, which is being tested as a variety. Disease resistance, ear tip cover, earliness, and flinty grain are principal selection criteria. Early White was reselected for streak resistance at Ibadan in 1991.

In addition, three germplasm donor populations have received more limited improvement attention: IITA-EMSR, CIMMYT-43SR (Tuxpeno), and CIMMYT-32 (Eto). All three were cycled through inbreeding and **per se** line testing with subsequent reconstitution of the populations from S2 or S3 lines, in order to improve disease resistance for midaltitude adaptation. The latter two are being used in crosses for inbred extraction.

The two populations introduced from Zaire in 1982 (Kasai and Shaba) were carried on through advanced on-station and on-farm testing, and were released while other material was under development. Kasai, a short plant type population (Tuxpeno x Eto, recombined) preferred by farmers on fertile soils at 1000-1300m, was eventually converted to streak resistance at IITA. Shaba (Tuxpeno x Eto x H632 x SR52, recombined) performed well on the Adamaoua plateau, which is similar in climate and soils to its region of development, Shaba province of Zaire. It is not sufficiently resistant to Puccinia sorghi for use in the wetter Western Highlands.

Specialty varieties received some attention in germplasm development: MSR and the varietal synthetics were used as recurrent backcross parents in the transfer of the sh and su2 genes to midaltitude backgrounds in Cameroon. The resulting MSR-sh (BC3) and MSR-su (BC2) sweetcorn populations were selfed and recombined under streak virus at Ibadan in 1991A and B seasons; seed was returned to Cameroon and placed in long term storage in Ibadan.

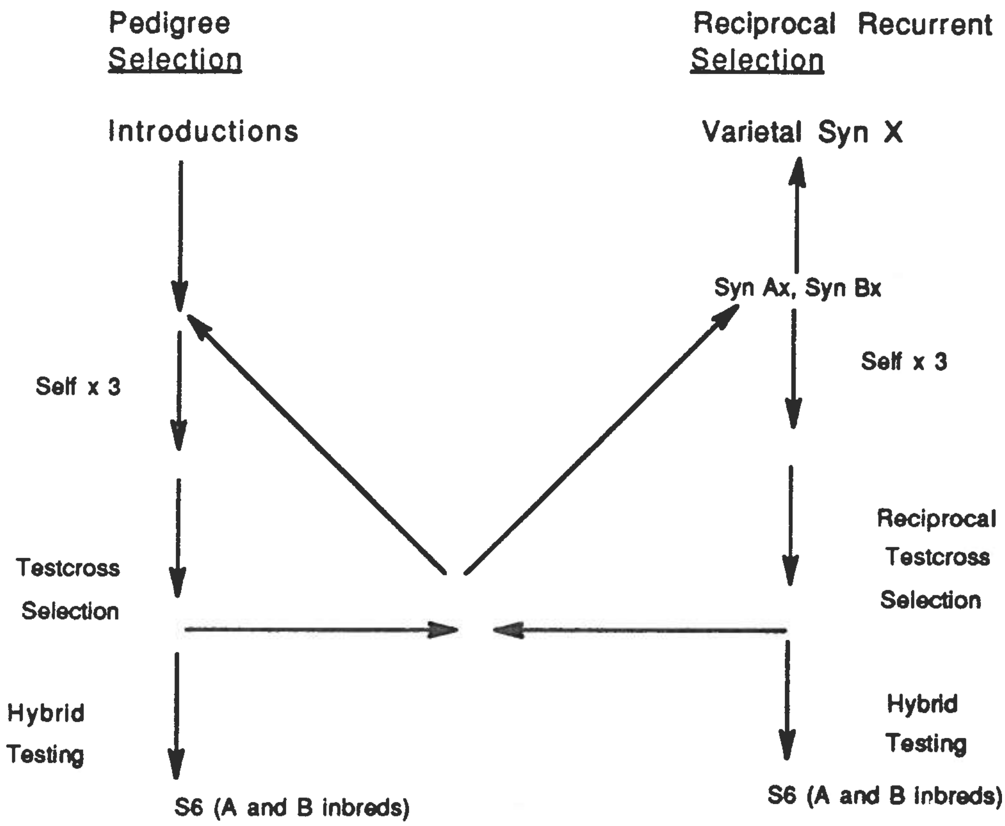
A less successful attempt to obtain midaltitude adapted popcorn lines by backcross continues. U.S. popcorn inbreds and single cross parents of double cross hybrids were crossed with MSR. A series of backcrosses, selfing, and reverse backcrosses had very limited success in combining popcorn grain characteristics with midaltitude adaptation. The equivalent of BC1S1 (popcorn as recurrent parent) was selected and selfed in Jos under heavy turcicum leaf blight in 1991. A diallel cross series among the BC lines was tested in Cameroon, and was re-formed in Nigeria for 1992 testing.

INBRED DEVELOPMENT

A major part of the Cameroon midaltitude program consists of a modified form of the Eberhart comprehensive breeding program, designed to systematically produce inbred lines for use in both hybrid and open pollinated synthetic varieties (Figure 1). This was the first use of the Eberhart approach in the international research centers.

Figure 1

Modified Comprehensive
Breeding System



1. New inbreds, hybrids, and variety synthetics (Syn X above) are available each year.
2. Introductions are accomodated, and enter recurrent selection as inbred derivatives.
3. Inbreds are recycled for improved per se performance though reciprocal synthetics (Syn A and Syn B above).

An initial group of 714 segregating lines was brought from the IITA Jos program in 1984. The prevalence of *P. sorghi* rust and other adaptation factors at the Cameroon nursery sites required severe selection among and within lines **per se**. Testcrosses and hybrids were formed from the best lines for testing in 1985 and 1986. Of the original 714 lines, three remain currently in the program and are designated by an alphabetical prefix (M131, C70, and Z28). All subsequent lines were developed by selfing from populations, synthetics, and crosses in Cameroon.

In 1986, sixteen of the original lines were divided into two heterotic groups, based on results of single cross hybrid trials. Intermating within groups was initiated to form the heterotic source synthetics AW and BW, (A1 and B1). Subsequent cycles were designated as A2 and B2, A3 and B3, etc. Selfing was initiated directly from these synthetics, from MSR, and from MSR crossed onto introductions from eastern and southern Africa. Lines were testcrossed at S3 stage to two reciprocal single cross testers, selected for combining ability in multilocational trials, and advanced to single cross hybrid trials. Inbreds selected at the testcross or single cross stage were used to reconstitute the reciprocal synthetics annually, designated as "cycles". The reciprocal synthetics were crossed onto introductions from Kenya, Zimbabwe, Tanzania, CIMMYT, and the U.S.; resultant lines are being tested along with the new lines from the synthetics **per se**. The frequency of acceptable lines extracted from the synthetics (recycled lines) is higher than that obtained from populations and crosses of populations onto introductions (Everett, Agron. Abstracts, 1988). In order to maintain this higher frequency, only S4 or more advanced inbreds selected for combining ability are incorporated into the synthetics.

With each "cycle" of inbred selection, a varietal synthetic is formed using inbreds from both heterotic groups. After three recombinations, the new synthetic is tested in the standard open pollinated variety trial. It was found that the performance of these varietal synthetics (the latest being Syn4) was better than the conventionally developed o.p. varieties in most traits, eliminating the requirement to maintain a separate selection program for population improvement in the late, white grained midaltitude classification.

EVALUATION OF PROGRESS

With my transfer back to Ibadan in 1991, evaluation of progress of the Cameroon midaltitude breeding program was initiated, both for purposes of documentation, and to determine adaptation of the material to a wider range of midaltitude environments. The latter is essential to incorporating it into the international testing program and to merging it with the Jos based breeding program. The opportunity was also taken to select within populations, and among and within lines for resistance to streak virus, as the facilities for leafhopper rearing had not been developed in Cameroon despite persistent attempts to obtain them through NCRE.

Evaluation trials were run in several forms, covering most of the materials developed over the seven years of the program. Lacking a "transition zone" (1600-2000m) site in Nigeria, the HAP was not included. Evaluations were made of 1. open pollinated varieties, 2. cycles of selection of six populations, 3. single cross hybrids, 4. testcrosses, and 5. inbred lines.

Trial and nursery sites in 1991 are listed with trials in Table 1. The Cameroon sites were managed by N. Beninati, J. Etandu and I. Tabi, as part of the ongoing NCRE midaltitude breeding program. The Nigerian sites were managed from Ibadan. In Zimbabwe, Pioneer International (Barry McCarter) and CIMMYT (Kent Short) breeders planted and managed the trials. The author was able to visit the trials in Zimbabwe but not Cameroon. A brief description of the sites, including 1991 site management constraints follows; more detailed characterization of the soils of the Cameroon sites can be found in the IITA internal paper "Soils of the Cameroon Highlands: Observations and Suggested Research", L. A. Everett.

Foumbot: 1000m altitude on fertile volcanic ash derived soil in West Province, Cameroon. The occasional epidemic of lowland rust, Puccinia polysora, was especially heavy in 1991, reducing yield of susceptible entries, especially the check ZS206 from Zimbabwe. Plant stands were reduced more than usual (perhaps by the pervasive mole crickets at the site).

Nfonta: Also known as Bambui Plain, 1300m altitude on acid, Phosphorus fixing soil derived from an old volcanic outflow plain in Northwest Province, Cameroon. Hazards often include the African rootworm (Buphonella spp.), requiring treatment at or soon after planting with Dursban. There were no constraints specific to 1991 noted. The dominant disease is often Diplodia macrospora, but is not ususally yield limiting.

Babungo: 1200m altitude on moderately fertile colluvial soil in N.W. Province. Substantial stand losses, in part due to the African rootworm, were noted. The inbred trial was discarded due to damage.

Mbang Mbirni: 1200m altitude on probable volcanic outflow plain in Adamaoua Province, Cameroon. Fertilizer Sulfur is required at this site. Yields can vary considerably depending on rainfall distribution and field position (erosion scalping has removed the fertile topsoil in some areas on the upper slopes). In 1991 yields were high at this site.

UTC: 1350m altitude on acid soil of Jos Plateau, Nigeria. Fertility has been improved by repeated applications of P on this commercial farm, but Zn deficiency was noted in leaf tissue sample analyses later run at IITA. Principal constraints in 1991 were cutworms and erosion at planting which considerably reduced stands of the first plantings (nursery and advanced hybrid and o.p.

trials). All the advanced trials at UTC were reduced to 3 row plots, sacrificing one guard row for seedling transplanting to fill missing hills, however, variability for yield on the single harvested row was high. The cutworms had previously been misidentified as army worm (an occasional problem later in the season), resulting in considerable stand losses on the commercial farm and research plots due to inappropriate choice of insecticide. After identifying the pest as cutworm, I was able to prevent damage to later plantings with locally available insecticide, however, the Dursban, which, mixed with Lindane, was effective at the high altitude sites in Cameroon where cutworm is a major constraint, was not available in Jos. The absence of terraces on the UTC farm, combined with heavy rains at planting, requires the installation of temporary diversion ditches at approximately 30m contour intervals during planting, a practice not previously followed. We developed this technique on similar slopes at Babungo and Mbang Mbirni in Cameroon. The dominant disease present was Exserohilum turcicum leaf blight, at a pressure higher than that seen in Cameroon. Grey leaf spot, Cercospora zeae-maydis, (isolated by Dr. K. Cardwell) was prevalent on some inbred lines, and, to a minor extent on some hybrids. Ear rots were moderate to light.

WAMCO: 1250m altitude on moderately fertile, but poorly drained soil of Jos Plateau. The principal constraint in 1991 was reduced stands due to misapplication or (probable) defective composition of Stomp herbicide applied by the commercial farm to the research plots. The same herbicide applied on the BARC farm required discarding of all research plots on the main field. At both UTC and WAMCO, the number of plots with low stands was reduced by transplant redistribution of seedlings within plots (prior to thinning). Dominant leaf diseases present at WAMCO were Diplodia macrospora and E. turcicum. These two leaf blights are easily confused, and the presence of Diplodia had not been previously recognized at Jos. It was not possible to separate scores of these mixed blight infections, so a composite blight score was given at WAMCO. Severe ear rots were observed at this site, perhaps caused by Diplodia moving from the leaves into the stem, and on into the ear; Diplodia was later isolated from ear samples (Dr. K. Cardwell). The principal ear rots in Cameroon originate from the tips of poorly covered ears, a minor source of ear rots in Jos, as maturity occurred near the end of the rainy season. No P. sorghi was present at either Jos site. Physoderma maydis infections were intense on some genotypes, especially at WAMCO.

Pioneer: 1500m altitude on the ART farm near Harare, Zimbabwe. This is a professionally managed research farm on fertile soil.

Glendale: 1200m on a private farm approximately 40km from Harare.

Rattray-Arnold: 1300m altitude research farm of the Zimbabwe Seed Coop. Professionally managed and on fertile soil. The Glendale and Rattray-Arnold trials were managed by CIMMYT.

Table 1 Trial and nursery sites, 1991

	Site								
	Cameroon				Nigeria		Zimbabwe		
Trial Type	Foumbot	Nfonta	Babungo	Mbang	UTC	WAMCO	Pioneer	Glendale	Rattray
Advanced O.P.	X	X	X	X	X	X			
Advanced Hybrid	X	X	X	X	X	X			
Prelim. Hybrid	X		X	X	X	X			
Testcrosses	X	X				X			
Cycles of Popns.	X	X	X	X	X	X	X	X	X
Inbred Trial			X*		X	X			
Inbred Nursery	X				X				

*Trial discarded

RESULTS

Open Pollinated Varieties

The open pollinated variety trials were a continuation of the midaltitude National Variety Trials (NVT) reconstituted annually in Cameroon. They are divided into one early (NVT-E) and one late (NVT-L) set. The design is four row plots, four replications per site.

The **NVT-E** consisted of four entries: 1. Kasai, an intermediate maturity check included in both the NVT-L and NVT-E as comparison of early with late variety yields. 2. BACOA, an intermediate maturity yellow dent-flint developed at Bambui Station prior to the NCRE project. 3. Early White, developed by the IITA-NCRE program as described above. 4. EMSR (Cameroon version), an early maturing population developed at Jos during the same period as Early White, but from different source materials. This was selfed and selected as S2's in Foumbot, and the resultant S3/S2 families were recombined to re-form a more disease resistant version of the population. 5. EMSR (Jos version), an entry which was included only at the Jos sites in an expansion of the trial.

Results are presented in Tables 2-5. Maturity differences were evident between the two intermediate and two early populations, with a difference of four days to silk. Moisture at harvest was lower with EMSR. Ear rots were less in the intermediate populations, compared to the early populations. Yield differences were non-significant across five sites, however, Kasai ranked first (as observed in previous years), the exceptions being in the highly variable UTC trial, and at Foumbot (no explanation). Stalk lodging was least in Kasai and Early White, with BACOA lodging most, also a result consistent over years. In the five entry trial at the Jos sites, among the early entries the EMSR reselected in Cameroon showed significantly less ear rot than the Jos based EMSR and than Early White. At WAMCO the mixed leaf blight score was equal for Early White and the reselected EMSR, and significantly better than the Jos EMSR. The intense S2/S3 selection in EMSR for plant health in Cameroon was apparently effective across regions. Given the different genetic origins of Early White and EMSR, as well as relative strengths of each, combining the two could be advantageous in increasing the genetic variability without sacrificing plant or ear quality. On farm trials and surveys in Cameroon are indicating that these improved early populations need to be shifted to an even shorter maturity span to match the local early varieties.

The **NVT-L** trial consisted of eleven entries: Kasai, Shaba, two cycles of ATP, one varietal selection from ATP, COCA (developed at Bambui Station prior to NCRE), varietal synthetics 3 and 4, one variety from each of two cycles of MSR, and the Zimbabwe hybrid ZS206 as check.

Results are shown in tables 6-9. Table 6 presents the across site results: locations to be included for each trait were selected based on sufficient trait expression and data reliability at the site. Lodging, for example, was not sufficiently high at some

Table 2 **Early mid-altitude variety trial, 1991, characters across locations in Cameroon and Nigeria (Plateau State)**

Entry	Characters							
	Days to silk	Plant Height cm	Ear Height cm	Ear Aspect (1-5)	Ear Rot (1-5)	*Puccinia polysora* (1-5)	Moisture %	Yield Mg/ha
Kasai	72.4	229	112	1.7	2.0	2.0	33.2	7.45
BACOA	71.7	245	132	2.3	2.1	3.6	29.8	6.34
Early White	68.1	224	108	2.2	2.8	2.4	30.5	7.11
EMSR (C)[1]	67.8	224	111	2.4	2.5	1.7	27.3	7.07
LSD .05	1.3*	9.7*	7.4*	0.3	0.4*	0.5*	1.1*	ns
No. locations	5	5	5	5	5	2	5	5

* Variety x Location interacton as error
1 EMSR reselected as S2's and recombined in Cameroon.

Table 3 **Early mid-altitude variety trial, 1991, Characters across locations, Plateau State, Nigeria**

Entry	Characters							
	Days to Silk	Plant Height cm	Ear Height cm	Ear Aspect (1-5)	Ear Rot (1-5)	Stalk Lodging %	Moisture %	Yield Mg/ha
Kasai	73.8	223	113	2.0	1.9	4.1	30.6	7.69
BACOA	72.0	239	129	3.0	2.1	22.6	25.7	7.43
Early white	70.6	218	109	2.8	2.8	2.5	26.1	7.19
EMSR (c)[1]	69.3	213	108	3.0	2.3	15.5	23.7	7.82
EMSR[2]	68.8	208	111	3.0	2.9	15.3	23.8	7.24
LSD .05	1.3	12.2	9.9	0.3	0.4	15.7	1.4	n.s
No. locations	2	2	2	1	2	1	2	2

1 EMSR reselected as S2's and recombined in Cameroon
2 EMSR, IITA source

Table 4 **Early mid-altitude variety trial, 1991, UTC, Plateau State, Nigeria**

Entry	Characters						
	Days to silk	Plant Height cm	Ear Height cm	Ear Rot (1-5)	*E. turcicum* (1-9)	Moisture %	Yield Mg/ha
Kasai	74.3	224	114	1.5	3.5	33.4	8.43
BACOA	72.3	248	136	2.0	4.3	28.3	8.67
Early White	70.8	215	106	2.4	3.5	29.1	8.33
EMSR (C)[1]	69.0	219	109	2.0	2.5	26.3	8.89
EMSR[2]	68.3	213	113	2.5	3.3	26.7	8.62
LSD .05	2.1	17	13	0.7	ns	2.7	n.s

1 EMSR reselected as S2's and recombined in Cameroon
2 EMSR, IITA source

Table 5 **Early mid-altitude variety trial, 1991, WAMCO, Plateau State, Nigeria.**

Entry	Characters								
	Days to silk	Plant Height cm	Ear Height cm	Ear Aspect (1-5)	Ear Rot (1-5)	Blight[3] (1-9)	Stalk Lodging %	Moisture %	Yield Mg/ha
Kasai	73.3	223	113	2.0	2.3	2.8	4.1	27.8	6.94
BACOA	71.8	230	123	3.0	2.3	3.8	22.6	23.1	6.19
Early White	70.5	220	112	2.8	3.0	3.3	2.5	23.2	6.11
EMSR (C)[1]	69.5	208	106	3.0	2.5	3.3	15.5	21.0	6.76
EMSR[2]	69.3	203	110	3.0	3.3	4.3	15.3	20.9	5.87
LSD .05	1.9	20	ns	0.3	0.5	0.8	15.8	1.9	0.63

1 EMSR reselected as S2's and recombined in Cameroon
2 EMSR, IITA source
3 *Exserohilum turcicum* plus *Diplodia macrospora*

locations to include in the analysis, and plant height data were not accurately taken at some others. Yield is presented for five of the six sites, omitting Foumbot, which showed considerably different yield rankings than other sites due to the epidemic of lowland rust, (see P. polysora scores for ZS206 and COCA, table 6). The top yield was registered by the single cross check. Syn4 significantly outyielded all other open pollinated varieties, the first time this has occurred with the late maturing o.p. trials in Cameroon. Syn3 and Syn4 were both excellent for most traits observed (plant height, ear height, lodging resistance, and leaf diseases). Given that Syn4 is streak resistant, and has been divided into both white and yellow versions, it should be rapidly advanced for release in Cameroon. In Nigeria, the performance of Syn4 should be qualified by observations on ear rot at WAMCO farm: the NVT-L was harvested before the end of the rains (with the NVT-E), when rots had not completely developed. Scores at this site for Syn4 included as a check in hybrid trials harvested later, indicated more ear rot than desirable. Given that all the inbred components for Syn3 and Syn4 had been selected exclusively in Cameroon, with different ear rot organisms, it can be expected that inbreds selected in Jos, should produce synthetics (now in recombination) with improved resistance to the ear rot pressure at WAMCO. (The problem did not surface at UTC.) Alternatively, given the rare event of finding a superior o.p. (ref. the case of TZB-Gusau and the delay in converting it to SR), selection within Syn4 for ear rot resistance at WAMCO should be considered.

The ATP entries performed similarly to each other: the population is tall with primarily yellow flint grain and good yield. It, like COCA, was developed primarily on an acid, P fixing soil, and is targeted to that situation. Improvement could be made to plant structure (especially ear position, next highest after COCA) without altering the robust growth habit required to tolerate acid soils. Selfing/selection would be appropriate to improve leaf disease resistance.

COCA, while ranking fourth in yield across the five sites, continues to display unacceptable plant structure, combined with poor root and stalk lodging resistance (note Table 7). Most of the parentage of COCA is of mid-high altitude East African origin, so it has an adaptation range higher than most of the other midaltitde varieties. Its best use would be as a parent in crosses with lower altitude adapted material, like Kasai and Population 32, for extraction of lines and perhaps population formation. Kasai, the shortest and earliest variety in the trial, continues to show the best lodging resistance. Shaba, maintained since 1985 on the Adamaoua Plateau, with very little disease pressure, had the highest blight scores at Jos. This, in addition to insufficient P. sorghi resistance observed in previous years at Bansoa (West Province, Cameroon), indicates that Shaba **per se** should not be released in the Cameroon Western Highlands nor in Jos. It has been difficult, however, to identify a variety superior to Shaba on the Adamaoua Plateau (see NCRE annual reports). The MSR entries did not do well in these trials in 1991: it would be advisable to

Table 6 **Late Mid-altitude variety trial, 1991, characters across locations in Cameroon and Nigeria (Plateau State).**

Entry	Days to silk	Plant Height cm	Ear Height cm	Plant Aspect (1-5)	Ear Aspect (1-5)	Ear Rot (1-5)	Rust[1] (1-5)	Blight[2] (1-9)	Root Lodging %	Stalk Lodging %	Moisture %	Yield[3] Mg/ha
ZS 206	74.4	263	136	1.6	1.0	2.4	3.5	2.4	14.7	17.6	28.8	8.13
Syn 4	74.3	265	138	1.6	1.8	2.1	3.0	2.3	16.7	13.9	28.1	7.66
Shaba	74.9	259	134	2.0	1.8	2.3	2.6	3.5	19.6	11.6	29.9	7.08
ATP 89	75.9	265	141	2.0	1.6	1.7	2.5	2.8	17.2	15.4	27.9	7.04
COCA	73.9	264	150	2.4	2.2	2.5	3.5	2.8	35.1	30.1	26.0	7.04
ATP 90	73.8	261	145	2.0	1.7	1.7	2.5	3.0	20.3	10.9	27.8	6.95
EVATP89	74.5	268	148	2.2	1.7	1.7	2.5	2.6	22.4	10.1	27.9	6.90
Syn 3	75.2	251	130	1.7	1.8	2.1	2.4	3.1	13.7	18.4	28.5	6.81
Kasai	73.7	230	118	1.9	2.2	2.4	2.4	2.9	15.5	7.8	28.2	6.79
Bab MSR89	74.3	249	140	2.4	1.9	2.2	2.5	3.4	20.1	18.3	27.0	6.67
Fbt MSR 87	75.3	249	127	1.9	1.7	2.5	2.9	3.1	23.7	14.3	26.9	6.40
LSD .05	1.2*	13	10	0.4	0.3*	0.3	0.5	0.6	9.8	7.9	1.3	0.46
No. locations	4	3	3	5	6	6	2	2	3	2	6	5

* Variety x Location interaction as error.
1 Rust primarily *Puccinia polysora* at rated sites (Foumbot and Nfonta, Cameroon).
2 Blight *Exserohilum turcicum* at UTC, mixed *E. turcicum* and *Diplodia macrospora* at WAMCO, Plateau State.
3 Yield adjusted for plants at harvest via covariance analysis.

Table 7 Late Mid-altitude variety trial, 1991, characters across locations at Plateau State, Nigeria.

Entry	Days to silk	Plant Height cm	Ear Height cm	Plant Aspect (1-5)	Ear Aspect (1-5)	Ear Rot (1-5)	Blight[1] (1-9)	Root Lodging %	Stalk Lodging %	Moisture %	Yield[2] Mg/ha
ZS 206	76.3	263	138	1.0	1.1	2.1	2.4	1.9	17.6	22.9	8.65
Syn 4	76.0	251	130	1.3	2.1	2.0	2.3	3.1	13.9	22.3	8.19
COCA	75.8	267	151	2.3	2.3	2.5	2.8	11.5	30.1	20.3	7.58
ATP 89	77.5	259	136	1.8	2.1	1.9	2.8	3.1	15.4	22.2	7.55
ATP 90	74.8	264	141	1.8	2.4	1.8	3.0	1.8	10.9	23.2	7.44
Syn 3	77.3	254	133	1.8	2.0	2.4	3.1	5.0	18.4	23.7	7.42
Shaba	75.0	263	139	2.0	2.3	2.6	3.5	6.2	11.6	23.5	7.32
EVATP89	76.0	269	144	1.8	2.0	1.8	2.6	3.7	10.1	22.0	7.29
Kasai	74.3	234	121	1.5	2.8	2.1	2.9	2.7	7.8	22.5	7.08
Bab MSR89	76.5	254	138	2.0	2.4	2.0	3.4	6.9	18.3	21.0	7.00
Fbt MSR 87	77.5	244	124	1.8	2.3	2.6	3.1	3.8	14.3	20.9	6.72
LSD .05	2.1	18	11	0.7	0.5	0.5	0.6	5.7	7.9	2.0	0.88
No. locations	1	1	1	1	2	2	2	1	2	2	2

1. Blight *Exserohilum turcicum* at UTC, and *E. turcicum* plus *Diplodia macrospora* at WAMCO
2. Yield adjusted for plants at harvest via covariance analysis.

Table 8 **Late Mid-altitude variety trial, 1991, at UTC Farm, Plateau State, Nigeria.**

Entry	Characters								
	Days to silk	Plant Height cm	Ear Height cm	Ear Aspect (1-5)	Ear Rot (1-5)	Leaf[1] Blight (1-9)	Stalk Lodging %	Moisture %	Yield[2] Mg/ha
ZS 206	76.3	263	138	1.0	2.0	2.5	27.2	16.3	9.29
Syn 4	76.0	251	130	2.0	2.0	2.5	11.9	15.6	9.20
Syn 3	77.3	254	133	2.0	2.0	3.5	20.1	16.1	8.32
Shaba	75.0	263	139	2.3	2.3	3.3	10.2	17.2	8.30
ATP 89	77.5	259	136	2.5	2.0	3.0	14.1	15.0	8.19
ATP 90	74.8	264	141	2.8	1.8	2.8	13.2	16.3	8.19
COCA	75.8	267	151	2.3	2.3	3.0	27.0	13.6	8.02
EVATP89	76.0	269	144	2.5	1.8	3.0	11.7	16.0	7.47
Kasai	74.3	234	121	2.8	2.3	3.0	5.3	16.5	7.46
Bab MSR89	76.5	254	138	2.5	2.0	4.0	19.2	14.6	7.31
Fbt MSR 87	77.5	244	124	2.3	2.3	3.3	13.7	14.5	7.20
LSD .05	2.1	18	11	0.6	n.s	0.7	11.8	n.s	1.24

1. Leaf blight = *Exserohilum turcicum*.
2. Yield adjusted for plants at harvest by covariance analysis over UTC and WAMCO.

Table 9 **Late Mid-altitude variety trial, 1991, WAMCO Farm, Plateau State, Nigeria.**

	Characters							
Entry	Plant Aspect (1-5)	Ear Aspect (1-5)	Leaf[1] Blight (1-9)	Root Lodging %	Stalk Lodging %	Ear Rot (1-5)	Moisture %	Yield[2] Mg/ha
ZS 206	1.0	1.3	2.3	1.9	8.0	2.3	29.4	8.00
Syn 4	1.3	2.3	2.0	3.1	15.9	2.0	29.0	7.18
COCA	2.3	2.3	2.5	11.5	33.2	2.8	26.9	7.13
EVATP89	1.8	1.5	2.3	3.7	8.6	1.8	28.0	7.12
ATP 89	1.8	1.8	2.5	3.1	16.8	1.8	29.5	6.90
Kasai	1.5	2.8	2.8	2.7	10.4	2.0	28.6	6.70
Bab MSR89	2.0	2.3	2.8	6.9	17.4	2.0	27.4	6.70
ATP 90	1.8	2.0	3.3	1.8	8.7	1.8	30.1	6.69
Syn 3	1.8	2.0	2.8	5.0	16.8	2.8	31.3	6.51
Shaba	2.0	2.3	3.8	6.2	13.1	3.0	29.7	6.35
Fbt MSR 87	1.8	2.3	3.0	3.8	14.9	3.0	27.3	6.24
LSD .05	0.7	0.7	0.9	5.7	9.7	0.9	ns	1.24

1. Leaf blight, mixture of *Exserohilum turcicum* and *Diplodia macrospora.*

2. Yield adjusted for plant stand by covariance analysis over UTC and WAMCO.

include the Across sites version of the latest cycle of MSR in these trials, as experience and theory indicate that it would probably be the most consistent performer.

One conclusion which can be drawn from the two NVT trials is that the international midaltitude EVT should include a wider range of varietal sources, and that the entries from one population should probably not exceed two, probably the latest two Across site selections. Varieties formed based on two replications at one site could be returned to the cooperator at that site but not included in the international trial.

A second conclusion is that some form of the comprehensive breeding system to produce both inbreds and superior open pollinated synthetics (e.g. Syn3 and Syn4) has been effective in Cameroon, and would likely be useful in the broader midaltitude program, improving both the organization and performance of the germplasm.

Hybrids

All hybrids tested were single crosses. They were divided into two advanced (selected in 1990) and four preliminary sets. The advanced sets contained 18 entries each, and were planted in four row plots, four replications per site. The preliminary sets contained 56 entries each, and were planted in two row plots, three replications per site. Covariance analysis was used to adjust yields for variable plant stands.

Results across sites are presented in tables 10-21. Selections based on rapid summaries of field observations at harvest (allowing immediate nursery plantings for formation of selected crosses) are starred in the tables. Selections based on later data analyses across all sites in Cameroon and Nigeria are underlined in the tables: the delay in analysis prevented re-formation of these hybrids in time for Jos 1992 plantings. Selections made in Cameroon are presented in the 1991 NCRE Annual Report: these hybrids were prepared in Cameroon for planting again in 1992. They differ from the Jos based selections, in large part because of the different ear rot species and mode of entry. Husk cover, ear aspect, and ear rot criteria dominated the Jos selection process, usually eliminating the top yielding hybrids. Scores of two or less are desirable for these traits.

Of the 213 preliminary hybrids, 40% ranked higher in yield than the trial averages of ZS206 (Zimbabwe Seed Coop), the best commercial midaltitude hybrid known. However only 7% of the entries yielded more than 15% above Syn4. Of the 7%, half contained the inbred 88069, which has ZS206 as one parent. However, 88069, like ZS206, is both yellow and has poor ear tip cover (in crosses). In the advanced trials, 88069x87036 was again a top yielder in 1991 (one ton/ha higher than the next entry), with excellent plant type. It is, however, unacceptable **per se** since it is a yellow by white hybrid, and had poor tip cover in Nigeria. Given the hybrid's unusually high yield and good plant characteristics, the inbred parent 88069 should be rapidly converted to white grain and improved for tip cover.

Table 10 Cameroon advanced hybrids Set 1, across locations in Cameroon and Nigeria (Plateau State).

No.	Entry Name	Days Silk	Plant Height cm	Ear Height cm	Husk Cover 1-5	Ear Aspect 1-5	Ear Rot 1-5	Root Lodge %	Puccinia polysora 1-5	Leaf Blight 1-9	Physo derma 1-9	Moist. %	Yield Mg/ha
12	89274 X 89293	73	257	141	1.7	1.6	2.3	8	5.0	3.0	3.9	26.4	9.75
1	88069 X 88091	74	259	131	2.8	1.4	2.0	4	3.8	2.9	2.4	28.3	9.66
*9	89223 X 89258	73	249	129	1.3	1.5	1.6	7	4.0	2.1	5.0	25.7	9.31
16	M131 X 88099	74	255	136	2.1	2.1	2.4	11	3.3	4.4	2.6	27.4	9.03
*8	89223 X 88099	73	257	131	1.5	1.1	1.7	8	2.5	2.6	2.6	25.6	8.95
2	88069 X 89207	75	258	126	2.3	2.0	2.6	4	4.3	3.6	3.3	29.0	8.83
13	89274 X 89302	71	226	120	1.5	2.5	2.2	4	5.0	2.0	5.4	26.2	8.82
15	Z28 X 89293	76	254	137	2.4	1.9	2.8	13	3.8	3.8	3.1	28.5	8.70
*11	89223 X 89260	71	239	127	1.1	1.6	1.5	6	3.8	2.1	4.1	24.9	8.65
3	87366 X C70	75	236	116	1.7	1.4	1.8	5	2.5	3.9	3.1	27.3	8.60
4	ZS206	72	265	132	2.5	1.6	2.7	6	5.0	2.9	3.8	26.7	8.57
14	Z28 X 89242	75	254	130	1.0	1.8	2.7	4	3.0	3.6	2.6	26.0	8.46
17	88091 X C70	74	269	131	1.8	1.2	1.8	19	3.8	3.9	3.5	26.7	8.37
5	87366 X 89311	75	244	119	1.8	1.5	2.1	20	3.0	3.3	2.6	28.1	8.18
10	SYN4	73	258	132	1.4	2.7	2.5	10	4.2	2.6	3.9	26.6	8.13
6	87366 X 89199	75	247	123	1.4	1.5	2.2	7	3.3	4.8	2.3	28.4	8.03
7	87366 X 89243	76	255	125	1.0	1.8	2.5	28	3.3	4.4	2.3	29.4	7.99
	Mean	74	252	129	1.7	1.7	2.2	10	3.7	3.4	3.3	27.1	8.71
	LSD.05	2	10	7	0.5	0.3	0.4	9	0.7	1.7	0.9	1.7	0.78
	No. Locs.	6	6	6	6	6	6	2	1	2	2	6	6

Table 11 Cameroon advanced hybrids Set 1, across locations in Nigeria (Plateau State).

No.	Entry Name	Days Silk	Plant Height cm	Ear Height cm	Husk Cover 1-5	Ear Aspect 1-5	Ear Rot 1-5	Root Lodge %	Leaf Blight 1-9	Physo derma 1-9	Grain Texture 1-9	Yield Mg/ha
1	88069 X 88091	74	252	130	3.9	1.4	2.3	4	2.9	2.4	3.8	9.97
12	89274 X 89293	75	260	139	2.4	1.5	2.4	6	3.0	3.9	6.3	9.57
*9	89223 X 89258	74	247	128	1.4	1.5	1.8	1	2.1	5.0	5.1	8.86
13	89274 X 89302	72	221	118	2.0	2.8	1.8	1	2.0	5.4	5.8	8.85
15	Z28 X 89293	75	243	133	2.5	1.6	2.9	3	3.8	3.1	5.3	8.80
14	Z28 X 89242	75	250	128	1.0	1.8	2.8	4	3.6	2.6	5.9	8.51
*11	89223 X 89260	70	230	122	1.1	1.6	1.8	2	2.1	4.1	5.3	8.49
2	88069 X 89207	76	242	118	3.3	2.1	2.6	1	3.6	3.3	5.3	8.40
*8	89223 X 88099	74	249	129	2.0	1.1	1.6	5	2.6	2.6	6.3	8.26
18	8535-23	75	248	131	1.5	1.9	1.8	7	5.4	3.1	6.1	8.20
3	87366 X C70	73	227	111	2.0	1.6	2.1	1	3.9	3.1	3.8	7.94
4	ZS206	72	249	124	2.6	1.6	2.5	3	2.9	3.8	7.8	7.93
17	88091 X C70	74	256	129	2.3	1.4	2.4	21	3.9	3.5	3.0	7.90
10	SYN4	73	245	126	1.4	2.9	2.5	7	2.6	3.9	5.3	7.84
16	M131 X 88099	76	250	133	3.1	2.4	2.5	13	4.4	2.6	5.5	7.83
6	.'366 X 89199	75	241	123	1.3	1.4	2.8	5	4.8	2.3	2.8	7.51
5	87366 X 89311	74	237	116	2.5	1.8	2.6	14	3.3	2.6	2.1	7.37
7	87366 X 89243	75	242	121	1.0	2.3	3.4	16	4.4	2.3	3.8	6.73
	Mean	74	244	125	2.1	1.8	2.3	6	3.4	3.3	4.9	8.28
	LSD.05	4	11	9	0.8	0.5	0.7	12	1.7	0.9	1.2	1.53
	No. Locs.	2	2	2	2	2	2	1	2	2	2	2

Table 12 Cameroon advanced hybrids Set 2, across locations in Cameroon and Nigeria (Plateau State).

No.	Entry Name	Days Silk	Plant Height cm	Ear Height cm	Husk Cover 1-5	Ear Aspect 1-5	Ear Rot 1-5	Puccinia polysora 1-5	Leaf Blight 1-9	Physo derma 1-9	Moist. %	Yield Mg/ha
11	88069 X 87036	76	261	125	2.1	1.6	2.3	3.5	2.3	2.9	27.2	9.97
9	88094 X M131	75	259	132	2.1	1.5	2.5	3.3	4.4	3.1	26.4	8.93
7	ZS206	73	263	131	2.3	1.7	2.7	5.0	2.8	3.1	26.0	8.74
15	89277 X 89293	76	257	139	1.7	2.0	2.7	3.8	3.4	3.0	27.7	8.74
2	89258 X C70	75	252	126	2.0	2.1	2.3	3.5	2.6	4.1	26.1	8.56
16	89182 X 88099	73	250	128	2.6	2.1	2.3	3.0	3.3	3.4	27.1	8.42
3	89258 X 89182	72	239	117	1.5	1.8	2.0	3.0	2.1	3.6	26.0	8.40
8	89302 X 89293	75	239	121	1.6	1.6	2.2	4.8	2.9	4.8	27.3	8.39
*6	89302 X 88099	76	239	126	2.0	2.0	1.5	3.0	2.9	2.8	26.3	8.39
17	89310 X C70	78	258	129	1.3	1.8	2.5	4.3	3.4	4.9	29.3	8.29
5	89260 X 88099	72	262	139	2.0	2.1	2.0	3.3	2.1	3.3	25.2	8.13
10	87014 X M131	78	256	130	1.7	2.1	2.2	3.3	5.1	2.4	28.2	8.12
1	89246 X C70	78	273	137	1.3	1.8	2.5	3.0	3.8	3.3	25.2	7.97
12	87366 X 88030	75	257	128	1.1	2.1	2.1	3.0	5.0	2.5	27.0	7.74
14	SYN4	75	258	130	1.5	2.5	2.5	4.3	2.9	3.8	27.3	7.73
4	89258 X 89248	76	260	126	2.0	2.2	2.3	4.0	2.8	4.4	24.5	7.69
	Mean	75	255	129	1.8	1.9	2.3	3.6	3.2	3.4	26.7	8.39
	LSD.05	2	9	7	0.5	0.4	0.5	0.7	1.6	1.2	1.6	0.78
	No. Locs.	6	6	6	6	6	6	1	2	2	6	6

Table 13 Cameroon advanced hybrids Set 2, across locations in Nigeria (Plateau State).

No.	Entry Name	Days Silk	Plant Height cm	Ear Height cm	Husk Cover 1-5	Plant Aspect 1-5	Ear Aspect 1-5	Ear Rot 1-5	Root Lodge %	Stalk Lodge %	Leaf Blight 1-9	Grain Texture 1-9	Yield Mg/ha
11	88069 X 87036	76	246	123	3.1	1.1	1.9	2.0	2	2	2.3	5.1	9.70
15	89277 X 89293	77	251	136	2.3	1.4	1.8	2.6	7	7	3.4	4.8	8.95
7	ZS206	74	255	130	2.6	1.1	1.6	2.4	7	11	2.8	8.0	8.86
*6	89302 X 88099	75	240	124	2.6	1.0	2.1	1.1	7	18	2.9	6.1	8.78
9	88094 X M131	74	257	134	3.4	1.6	1.9	2.6	9	14	4.4	4.3	8.59
13	8556-6	75	263	147	2.0	3.4	2.5	2.5	29	29	4.0	3.5	8.58
2	89258 X C70	76	252	127	2.8	1.0	2.4	2.3	6	7	2.6	4.1	8.41
8	89302 X 89293	76	234	120	1.9	1.0	1.6	2.0	6	5	2.9	3.3	8.31
17	89310 X C70	78	247	126	1.4	1.0	1.9	2.5	11	15	3.4	6.3	8.24
5	89260 X 88099	72	260	139	4.0	2.4	2.4	2.0	10	19	2.1	6.0	8.13
18	8535-23	77	249	130	1.4	1.5	2.5	2.3	7	11	5.6	6.1	8.10
3	89258 X 89182	73	230	114	1.8	1.0	2.1	2.3	14	8	2.1	2.5	7.83
14	SYN4	75	245	127	2.0	1.1	2.6	2.6	3	11	2.9	5.1	7.80
10	87014 X M131	78	246	129	2.0	1.0	2.5	2.4	22	49	5.1	4.4	7.77
16	89182 X 88099	73	247	128	3.4	1.0	2.7	2.8	13	13	3.3	5.0	7.73
12	87366 X 88030	76	248	126	1.1	1.1	2.3	2.3	10	12	5.0	3.4	7.20
1	89246 X C70	79	267	[illegible]	1.4	1.8	2.4	3.4	20	23	3.8	5.6	7.04
4	89258 X 89248	77	251	126	2.3	1.4	2.5	2.6	18	29	2.8	3.5	6.26
	Mean	76	249	129	2.3	1.4	2.2	2.4	11	16	3.4	4.8	8.13
	LSD.05	2	12	9	0.5	0.5	n.s.	0.9	15	21	1.5	1.0	1.25
	No. Locs.	2	2	2	2	2	2	2	1	2	2	2	2

Table 14 Cameroon midaltitude hybrids Set 1, across locations in Cameroon and Nigeria (Plateau State).

No.	Entry Name	Days Silk	Plant Height cm	Ear Height cm	Husk Cover 1-5	Ear Aspect 1-5	Ear Rot 1-5	Root Lodge %	Stalk Lodge %	Leaf Blight 1-9	Physo derma 1-9	Moist %	Yie Mg/h
37	88069 X 90323	74	251	123	3.1	2.2	2.0	8	3	2.2	3.7	27.5	10.
3	M131 X 89274	72	255	133	1.9	2.1	2.3	2	18	2.8	4.2	22.9	10.0
36	88069 X 90314	72	236	112	2.2	2.1	2.4	4	1	2.0	3.7	26.0	10.0
33	88069 X 89274	73	262	134	2.5	2.3	2.1	5	17	2.2	3.3	25.6	10.0
38	88069 X 90332	75	257	123	2.1	2.3	2.1	1	2	1.7	2.5	26.6	9.9
40	88069 X 89365	74	246	118	3.0	1.9	2.2	7	3	2.0	2.7	23.8	9.8
39	88069 X 89343	75	250	121	2.0	2.3	2.5	15	3	3.7	3.0	24.4	9.7
55	M131 X 89258	72	254	125	2.3	1.9	2.3	16	21	2.5	3.0	23.3	9.6
35	88069 X 90313	74	249	117	2.6	1.7	2.6	2	1	2.8	4.2	27.1	9.5
46	89302 X 90314	72	234	123	1.7	1.9	2.0	16	1	2.0	4.2	23.7	9.4
14	Z28 X 89223	72	258	131	1.5	1.3	1.8	3	11	2.0	2.5	21.6	9.3
23	Z28 X 87036	76	268	133	1.4	1.6	1.8	18	5	2.2	2.3	25.2	9.2
*43	89302 X 89291	72	242	121	2.9	1.1	2.1	6	11	2.2	2.8	23.9	9.2
11	89293 X 90323	74	256	130	2.0	1.9	2.1	8	9	3.2	2.5	25.7	9.2
50	ZS206	71	264	132	2.4	1.6	2.5	44	11	2.3	2.7	22.4	9.2
47	89302 X 90323	74	233	114	1.9	1.9	2.0	2	3	2.8	4.8	25.4	9.1
34	88069 X 90301	71	253	120	2.5	2.0	1.9	22	3	3.0	3.0	23.3	9.1
15	Z28 X 89274	71	253	133	1.7	1.9	2.5	3	12	3.2	3.2	24.5	9.0
*2	M131 X 89223	73	257	126	1.3	1.6	1.8	8	10	3.0	3.5	21.3	9.0
52	89302 X 87036	71	241	122	1.3	1.9	1.9	5	3	2.3	3.5	22.8	9.0
4	M131 X 90301	72	258	131	1.7	1.9	2.1	10	29	4.3	3.2	20.4	9.0
1	M131 X C70	74	268	139	1.6	1.9	2.3	12	37	5.8	3.5	22.9	9.0
7	M131 X 90323	75	257	127	1.7	2.0	2.1	9	19	5.0	3.3	26.6	9.0
32	88069 X 89293	74	250	125	3.3	1.9	3.1	3	2	3.3	3.8	25.1	8.9
16	Z28 X 90301	71	256	138	1.8	1.9	2.6	5	9	3.8	2.5	22.4	8.9
*12	89293 X 89365	76	251	127	1.8	1.7	1.5	7	5	2.5	3.0	24.3	8.9
5	M131 X 90313	76	253	136	1.6	1.8	2.5	8	10	3.7	3.2	24.2	8.9
19	Z28 X 90323	74	253	129	1.4	1.7	1.9	3	7	2.5	2.7	27.2	8.9
26	87366 X 89274	70	252	131	1.7	2.5	1.7	28	8	2.8	3.0	25.4	8.8
*20	Z28 X 90332	76	262	131	1.4	1.5	1.7	1	3	2.0	2.5	26.6	8.8
*17	Z28 X 90313	75	245	124	1.8	1.7	2.4	3	1	2.8	2.2	26.2	8.8
56	89258 X 89293	72	256	130	2.1	1.9	1.9	11	18	3.2	3.2	23.0	8.8
13	Z28 X 88094	73	273	133	2.1	1.5	2.7	16	8	3.5	2.7	23.3	8.8
28	87366 X 90323	73	251	122	1.7	2.1	1.9	8	8	4.7	2.5	28.7	8.6
10	ZS206	71	260	126	2.3	1.7	2.7	12	8	2.7	3.2	25.0	8.6
*22	Z28 X 89365	75	254	128	2.0	1.5	2.2	12	1	2.3	2.8	23.9	8.6
27	87366 X 90313	74	243	124	1.7	1.8	2.1	8	13	5.2	3.0	25.3	8.5
42	89302 X 89223	71	236	119	1.3	1.6	1.7	2	2	1.8	5.0	23.0	8.5
9	89293 X 89291	71	268	147	3.4	1.9	2.5	9	16	2.5	3.0	24.8	8.4
21	Z28 X 89343	75	249	128	1.3	1.8	2.1	14	3	2.8	2.8	22.8	8.4
18	Z28 X 90314	73	242	121	1.3	1.7	2.1	18	1	2.2	2.5	26.1	8.4
24	87366 X 88094	72	273	136	1.7	1.7	1.8	13	25	4.7	2.2	25.8	8.3
49	89302 X 89343	72	237	115	1.3	1.9	1.8	6	4	3.3	3.5	23.4	8.3
*51	89302 X 89365	72	240	118	1.8	2.0	1.9	5	7	1.8	2.8	23.3	8.3
53	89302 X 89277	70	238	129	1.4	2.7	2.2	4	7	2.5	3.8	23.2	8.3
48	89302 X 90332	74	236	115	1.2	2.0	1.8	5	2	1.5	3.2	24.2	8.3
44	89302 X 90301	71	228	120	1.3	2.2	2.2	9	5	2.0	3.0	21.7	8.2
29	87366 X 89343	71	243	121	1.3	2.1	1.8	26	9	4.5	2.5	27.8	8.2
*45	89302 X 90313	73	236	124	1.8	2.0	2.3	8	3	2.0	5.2	23.0	8.2
41	C70 X 89302	73	242	122	1.6	1.9	2.1	11	4	2.8	4.2	23.4	8.1
25	87366 X 88099	72	260	136	1.3	1.7	1.6	19	27	5.5	2.3	24.2	8.1
31	87366 X 89365	74	245	118	1.4	1.9	1.7	23	12	2.7	2.2	24.1	8.0
6	M131 X 90314	75	249	124	1.3	2.7	2.7	19	3	3.3	1.8	24.5	8.0
30	SYN4	72	251	125	1.5	2.9	2.8	24	7	2.8	3.0	23.2	7.9
54	89302 X 8931	73	233	121	1.8	2.1	2.3	15	10	2.2	5.3	24.2	7.5
8	C70 X 89293	73	262	128	1.3	2.3	3.2	12	15	4.3	3.5	22.2	7.5
	Mean	73	250	126	1.8	1.9	2.2	11	9	3.0	3.2	24.2	8.8
	LSD.05	2	10	10	0.5	0.4	0.5	16	13	1.4	1.0	2.3	0.8
	No. Locs.	5	5	5	5	5	5	1	2	2	2	5	[illegible]

Table 15 Cameroon midaltitude hybrids Set 1, across locations in Nigeria (Plateau State).

No.	Entry Name	Days Silk	Plant Height cm	Ear Height cm	Husk Cover 1-5	Ear Aspect 1-5	Ear Rot 1-5	Root Lodge %	Stalk Lodge %	Leaf Blight 1-9	Physoderma 1-9	Grain Texture 1-9	Yield Mg/ha
36	88069 X 90314	76	216	107	3.2	2.0	2.2	4	1	2.0	3.7	3.3	9.13
3	M131 X 89274	75	248	131	2.3	2.0	2.3	2	18	2.8	4.2	4.3	8.96
33	88069 X 89274	77	248	128	3.2	3.2	2.0	5	17	2.2	3.3	6.8	8.85
37	88069 X 90323	77	236	118	4.3	2.8	2.2	8	3	2.2	3.7	3.5	8.77
55	M131 X 89258	77	248	127	3.0	2.0	2.3	16	21	2.5	3.0	3.2	8.70
38	88069 X 90332	79	248	119	2.3	2.8	2.0	1	2	1.7	2.5	4.0	8.63
50	ZS206	76	261	132	2.7	1.7	2.2	44	11	2.3	2.7	7.8	8.37
35	88069 X 90313	78	233	112	3.2	2.0	2.7	2	1	2.8	4.2	4.8	8.33
40	88069 X 89365	78	228	112	4.0	2.2	2.3	7	3	2.0	2.7	3.8	8.19
23	Z28 X 87036	78	264	137	1.5	1.8	2.3	18	5	2.2	2.3	5.2	8.12
14	Z28 X 89223	76	244	127	1.7	1.5	2.2	3	11	2.0	2.5	6.2	8.10
47	89302 X 90323	78	220	113	2.3	2.0	2.3	2	3	2.8	4.8	3.5	8.08
4	M131 X 90301	76	246	131	2.3	2.0	2.0	10	29	4.3	3.2	3.8	8.06
*46	89302 X 90314	77	220	112	1.8	1.8	2.0	16	1	2.0	4.2	4.7	7.96
39	88069 X 89343	81	230	110	2.2	2.5	2.7	15	3	3.7	3.0	5.2	7.91
5	M131 X 90313	80	246	130	2.0	1.8	2.5	8	10	3.7	3.2	4.5	7.86
*17	Z28 X 90313	79	236	123	2.0	1.7	2.5	3	1	2.8	2.2	6.2	7.85
15	Z28 X 89274	75	253	137	1.7	2.0	2.0	3	12	3.2	3.2	5.8	7.85
*20	Z28 X 90332	79	252	128	1.7	1.7	2.0	1	3	2.0	2.5	3.8	7.79
19	Z28 X 90323	79	240	124	1.7	1.7	2.5	3	7	2.5	2.7	4.5	7.78
*2	M131 X 89223	77	253	126	1.7	1.5	1.8	8	10	3.0	3.5	4.3	7.76
26	87366 X 89274	74	234	123	1.7	2.8	2.0	28	8	2.8	3.0	4.0	7.68
32	88069 X 89293	78	238	117	4.2	2.0	3.2	3	2	3.3	3.8	5.0	7.67
34	88069 X 90301	77	236	119	3.2	2.3	2.0	22	3	3.0	3.0	6.0	7.56
10	ZS206	75	254	128	2.5	1.8	2.5	12	8	2.7	3.2	7.2	7.55
*43	89302 X 89291	75	233	119	2.7	1.3	1.8	6	11	2.2	2.8	6.0	7.50
18	Z28 X 90314	78	231	118	1.5	1.5	2.5	18	1	2.2	2.5	4.2	7.38
7	M131 X 90323	80	241	121	1.8	2.2	2.2	9	19	5.0	3.3	3.0	7.33
52	89302 X 87036	75	219	111	1.5	2.3	2.3	5	3	2.3	3.5	4.2	7.33
11	89293 X 90323	77	243	127	2.3	2.0	2.5	8	9	3.2	2.5	3.8	7.32
56	89258 X 89293	76	245	122	2.8	2.2	2.2	11	18	3.2	3.2	3.3	7.29
44	89302 X 90301	75	218	111	1.3	2.2	2.2	9	5	2.0	3.0	5.5	7.29
27	87366 X 90313	78	234	119	2.0	2.0	2.5	8	13	5.2	3.0	3.7	7.26
*51	89302 X 89365	77	230	116	2.2	2.0	2.2	5	7	1.8	2.8	3.5	7.24
42	89302 X 89223	75	221	113	1.7	2.0	1.8	2	2	1.8	5.0	5.2	7.19
*22	Z28 X 89365	80	241	123	2.2	1.7	2.2	12	1	2.3	2.8	4.8	7.15
16	Z28 X 90301	76	248	133	1.7	2.2	3.3	5	9	3.8	2.5	6.3	7.13
9	89293 X 89291	75	267	162	4.0	2.0	3.0	9	16	2.5	3.0	3.2	7.10
48	89302 X 90332	78	210	103	1.2	2.3	2.2	5	2	1.5	3.2	4.0	7.09
53	89302 X 89277	75	221	118	1.3	3.3	2.0	4	7	2.5	3.8	6.5	7.09
1	M131 X C70	78	259	136	1.7	2.2	2.5	12	37	5.8	3.5	4.3	7.05
*45	89302 X 90313	78	220	115	2.0	2.5	2.0	8	3	2.0	5.2	6.5	7.04
13	Z28 X 88094	77	273	141	2.3	1.8	2.7	16	8	3.5	2.7	5.8	7.01
*12	89293 X 89365	80	233	123	2.2	1.7	1.8	7	5	2.5	3.0	3.7	6.98
28	87366 X 90323	78	237	122	2.0	2.7	2.7	8	8	4.7	2.5	2.8	6.93
21	Z28 X 89343	79	242	126	1.3	2.0	2.2	14	3	2.8	2.8	4.2	6.88
6	M131 X 90314	78	233	116	1.5	2.7	2.3	19	3	3.3	1.8	2.8	6.84
41	C70 X 89302	77	223	117	1.5	2.2	2.0	11	4	2.8	4.2	6.2	6.75
49	89302 X 89343	76	220	112	1.3	2.2	2.0	6	4	3.3	3.5	3.2	6.73
24	87366 X 88094	77	265	138	1.8	2.0	2.2	13	25	4.7	2.2	2.2	6.63
29	87366 X 89343	75	230	118	1.5	2.3	2.0	26	9	4.5	2.5	3.5	6.63
31	87366 X 89365	77	239	118	1.8	1.8	1.7	23	12	2.7	2.2	2.8	6.55
54	89302 X 8931	75	222	108	2.0	2.0	2.0	15	10	2.2	5.3	3.3	6.46
30	SYN4	77	235	118	1.5	3.0	3.2	24	7	2.8	3.0	4.5	6.32
25	87366 X 88099	76	257	136	1.8	2.3	2.2	19	27	5.5	2.3	2.7	6.08
8	C70 X 89293	73	254	128	1.5	3.0	3.7	12	15	4.3	3.5	4.5	4.94
	Mean	77	239	122	2.1	2.1	2.3	11	9	3.0	3.2	4.5	7.46
	LSD.05	3	13	13	0.7	0.5	0.8	16	13	1.4	1.0	1.4	1.18
	No. Locs.	2	2	2	2	2	2	1	2	2	2	2	2

Table 16 Cameroon midaltitude hybnds Set 2, across locations in Cameroon and Nigeria (Plateau State)

No.	Entry Name	Days Silk	Plant Height cm	Ear Height cm	Husk Cover 1-5	Ear Aspect 1-5	Ear Rot 1-5	Root Lodge %	Stalk Lodge %	Leaf Blight 1-9	Physo derma 1-9	Moist. %	Yield Mg/ha
17	90113 X M131	75	273	139	1.8	1.7	2.5	*11	10	2.8	2.7	23.4	9.65
*47	90147 X 89365	75	266	135	1.2	1.3	1.5	2	7	2.2	2.3	23.1	9.43
8	89258 X 87036	72	265	133	1.1	2.3	1.7	10	6	1.8	3.5	25.6	9.39
1	89258 X 88094	71	264	135	2.9	1.8	2.2	11	12	2.0	3.0	23.4	9.35
*13	89260 X 90323	72	251	128	1.8	2.1	1.7	3	3	1.5	4.0	25.4	9.34
23	90117 X M131	76	268	140	2.7	1.9	1.9	1	3	2.7	2.2	25.7	9.26
*21	90113 X 89343	74	263	135	1.4	1.6	1.8	6	4	1.8	4.0	25.2	9.20
2	89258 X 88098	72	262	132	1.8	1.8	1.9	14	13	2.0	3.7	23.5	9.18
6	89258 X 90314	72	254	131	2.1	2.1	1.9	8	4	1.8	3.8	25.8	9.12
4	89258 X 89274	70	261	135	2.1	2.5	1.9	5	8	1.5	5.8	24.5	9.12
9	89258 X 89183	71	257	133	1.7	1.8	1.9	3	6	1.7	3.7	26.1	9.02
53	90156 X 89291	69	250	130	2.4	2.1	1.9	17	32	2.7	2.5	23.9	8.93
20	90113 X 90323	75	260	136	2.1	1.7	2.3	1	6	2.3	3.3	25.0	8.92
7	89258 X 89343	72	257	133	1.4	1.8	1.9	15	15	2.3	3.5	24.3	8.87
*22	90113 X 87036	75	268	137	1.3	1.9	1.8	6	1	2.0	3.3	25.1	8.86
27	90117 X 90313	76	256	131	2.4	1.7	2.1	1	6	2.2	2.7	25.8	8.84
29	90117 X 90323	75	254	127	2.3	1.9	1.7	7	2	2.7	2.8	24.7	8.82
49	ZS206	71	268	139	2.1	1.6	2.7	4	8	2.7	3.2	24.4	8.82
51	90156 X C70	74	262	132	1.2	2.1	1.8	37	8	2.0	3.8	25.3	8.80
44	90147 X 88098	72	258	137	1.1	1.6	1.9	6	16	3.3	2.5	24.0	8.72
30	90117 X 89365	74	259	126	1.7	1.8	1.8	5	2	1.7	2.7	24.5	8.71
54	90156 X 90313	73	245	126	1.5	2.2	2.1	0	2	1.8	2.7	25.1	8.66
10	ZS206	71	265	141	2.3	1.5	2.7	19	15	2.8	2.8	23.7	8.66
*14	89260 X 89343	70	258	140	1.5	1.8	1.5	12	3	1.7	3.8	23.3	8.60
33	90135 X 89274	72	261	130	1.6	1.9	1.9	4	2	2.3	3.2	24.6	8.59
18	90113 X 89223	74	271	137	1.2	1.8	2.7	8	1	1.5	3.8	25.2	8.58
26	90117 X 89291	72	259	130	3.7	2.3	3.0	17	10	3.3	2.7	24.8	8.57
35	90135 X 89365	77	259	126	1.5	1.3	1.6	17	0	1.7	3.0	23.7	8.56
16	89260 X 89246	73	264	140	1.9	1.5	1.5	3	11	1.7	4.3	22.2	8.55
3	89258 X 88099	72	257	131	2.5	2.2	1.8	10	31	2.0	3.3	23.1	8.51
5	89258 X 90301	71	261	133	1.7	1.7	1.8	9	2	2.2	3.0	24.2	8.50
*42	90143 X 89343	71	258	134	1.1	1.7	2.1	5	7	2.5	3.3	23.5	8.50
15	89260 X 89183	70	250	132	1.7	2.3	1.7	18	3	1.7	4.0	25.2	8.48
41	90143 X 90323	72	249	132	2.3	2.1	2.4	14	2	2.0	3.7	24.9	8.44
45	90147 X 89274	70	261	137	1.8	2.3	2.4	2	8	3.7	3.3	23.8	8.42
12	89260 X C70	71	265	136	1.8	2.0	1.8	15	3	2.2	3.5	22.3	8.38
37	90143 X 88094	71	261	130	2.9	1.9	2.3	5	4	2.8	3.3	23.9	8.35
56	90156 X 87036	71	247	126	1.3	2.3	2.1	3	2	1.8	2.7	24.4	8.30
11	89258 X 89246	73	271	137	1.9	1.9	1.9	6	26	2.2	3.2	21.8	8.29
38	90143 X 88099	70	254	128	3.1	1.9	2.2	4	10	2.5	3.7	24.7	8.27
36	90143 X M131	74	248	125	2.0	1.8	2.1	12	9	2.3	3.5	23.7	8.22
40	90143 X 90313	73	246	127	1.7	1.9	2.5	4	3	2.7	3.8	24.6	8.22
46	90147 X 90301	72	254	130	1.3	1.9	1.9	0	8	4.2	2.7	21.4	8.17
55	90156 X 90323	72	240	119	1.3	2.7	1.7	11	2	1.7	2.2	25.9	8.17
24	90117 X 88094	73	270	132	3.1	2.0	2.5	5	4	3.0	2.5	25.5	8.13
52	90156 X 88099	72	251	128	1.8	2.1	2.1	4	23	2.3	2.8	24.5	8.11
43	90147 X C70	76	257	134	1.0	1.9	2.4	1	9	4.0	3.8	23.7	8.00
25	90117 X 89242	72	252	129	1.5	1.9	2.7	15	3	3.3	2.5	25.1	7.98
32	90135 X 88098	73	263	134	1.2	1.9	1.5	4	3	2.7	3.0	25.0	7.96
28	SYN4	72	258	131	1.6	2.8	2.7	11	10	1.8	2.8	24.4	7.93
39	90143 X 89274	70	256	134	1.9	2.5	2.5	9	10	2.5	5.5	24.0	7.79
50	90156 X 88091	71	256	129	1.8	2.0	1.8	8	16	2.3	2.5	24.9	7.77
19	90113 X 90301	74	259	134	1.5	1.9	2.5	7	5	2.2	2.8	23.3	7.74
31	90135 X C70	76	268	133	1.2	1.8	2.0	4	0	2.8	3.7	24.8	7.73
48	90156 X 89293	74	252	131	1.4	2.4	2.5	11	14	3.0	3.5	24.9	7.63
34	90135 X 90301	73	262	135	1.2	1.7	1.7	0	1	2.5	2.3	21.7	7.56
	Mean	73	259	132	1.8	1.9	2.1	8	8	2.3	3.3	24.3	8.55
	LSD.05	2	11	10	0.5	0.5	0.5	14	14	1.4	1.3	2	0.81
	No. Locs.	5	5	5	5	5	5	1	2	2	2	5	5

Table 17 Cameroon midaltitude hybrids Set 2, across locations in Nigeria (Plateau State).

No.	Entry Name	Days Silk	Plant Height cm	Ear Height cm	Husk Cover 1-5	Ear Aspect 1-5	Ear Rot 1-5	Root Lodge %	Stalk Lodge %	Leaf Blight 1-9	Physoderma 1-9	Grain Texture 1-9	Yield Mg/ha
17	90113 X M131	78	271	141	2.3	1.8	2.7	*11	10	2.8	2.7	5.0	8.90
8	89258 X 87036	77	262	133	1.0	2.7	1.7	10	6	1.8	3.5	5.5	8.84
23	90117 X M131	80	262	133	3.3	2.0	2.2	1	3	2.7	2.2	5.2	8.67
*47	90147 X 89365	80	258	132	1.5	1.5	1.8	2	7	2.2	2.3	4.0	8.48
4	89258 X 89274	74	262	133	3.0	3.0	2.2	5	8	1.5	5.8	5.7	8.44
1	89258 X 88094	75	257	128	3.3	2.3	2.3	11	12	2.0	3.0	4.2	8.44
*13	89260 X 90323	77	242	124	2.3	2.5	1.7	3	3	1.5	4.0	3.7	8.38
27	90117 X 90313	80	250	129	2.5	1.8	2.3	1	6	2.2	2.7	6.3	8.15
49	ZS206	75	261	130	2.1	1.5	2.5	4	8	2.7	3.2	8.0	8.12
26	90117 X 89291	76	248	131	4.7	2.5	3.3	17	10	3.3	2.7	7.5	8.05
*21	90113 X 89343	78	253	130	1.6	1.8	1.7	6	4	1.8	4.0	5.5	8.01
20	90113 X 90323	80	251	133	2.3	1.8	2.2	1	6	2.3	3.3	6.2	8.00
6	89258 X 90314	76	242	120	2.7	2.2	1.8	8	4	1.8	3.8	4.5	7.99
9	89258 X 89183	75	243	121	2.0	2.2	2.2	3	6	1.7	3.7	3.2	7.93
2	89258 X 88098	76	258	131	2.3	2.3	2.0	14	13	2.0	3.7	6.0	7.92
10	ZS206	75	255	124	2.5	1.5	2.2	19	15	2.8	2.8	8.0	7.89
18	90113 X 89223	78	260	133	1.3	2.0	2.8	8	1	1.5	3.8	6.5	7.89
*22	90113 X 87036	79	255	130	1.2	2.3	1.8	6	1	2.0	3.3	6.7	7.89
30	90117 X 89365	77	243	121	2.3	1.7	2.0	5	2	1.7	2.7	5.7	7.84
5	89258 X 90301	75	248	125	2.2	2.0	1.8	9	2	2.2	3.0	5.8	7.81
29	90117 X 90323	79	246	120	3.0	2.2	2.0	7	2	2.7	2.8	6.7	7.72
33	90135 X 89274	76	258	131	1.8	2.2	1.7	4	2	2.3	3.2	5.7	7.71
15	89260 X 89183	75	243	127	2.3	3.0	1.8	18	3	1.7	4.0	2.7	7.67
44	90147 X 88098	75	262	136	1.0	1.8	2.0	6	16	3.3	2.5	5.5	7.64
*14	89260 X 89343	76	253	133	1.7	2.2	1.5	12	3	1.7	3.8	3.7	7.62
25	90117 X 89242	76	252	128	1.5	2.2	3.0	15	3	3.3	2.5	6.3	7.60
41	90143 X 90323	77	238	131	3.2	2.3	2.5	14	2	2.0	3.7	4.8	7.59
12	89260 X C70	76	254	132	2.5	2.5	1.8	15	3	2.2	3.5	4.8	7.49
51	90156 X C70	78	257	128	1.3	2.7	2.3	37	8	2.0	3.8	4.0	7.46
45	90147 X 89274	75	262	137	1.8	2.7	2.7	2	8	3.7	3.3	5.3	7.42
46	90147 X 90301	76	249	131	1.5	1.8	2.3	0	8	4.2	2.7	5.3	7.40
32	90135 X 88098	77	254	128	1.3	2.0	1.8	4	3	2.7	3.0	6.0	7.39
7	89258 X 89343	78	248	127	1.7	2.2	2.2	15	15	2.3	3.5	3.5	7.38
54	90156 X 90313	76	235	122	1.8	2.3	2.5	0	2	1.8	2.7	7.0	7.38
52	90156 X 88099	76	241	126	2.3	2.0	2.3	4	23	2.3	2.8	4.5	7.32
40	90143 X 90313	78	233	123	2.3	2.2	3.0	4	3	2.7	3.8	7.0	7.30
3	89258 X 88099	76	254	133	3.2	2.5	1.8	10	31	2.0	3.3	5.2	7.24
*42	90143 X 89343	76	243	120	1.0	1.7	2.0	5	7	2.5	3.3	4.3	7.17
24	90117 X 88094	77	260	132	3.5	2.2	2.7	5	4	3.0	2.5	7.0	7.16
19	90113 X 90301	78	247	131	1.7	2.0	2.7	7	5	2.2	2.8	6.0	7.16
16	89260 X 89246	78	260	139	2.0	2.0	1.7	3	11	1.7	4.3	3.0	7.15
53	90156 X 89291	74	236	122	2.7	2.5	2.0	17	32	2.7	2.5	4.8	7.11
34	90135 X 90301	77	247	128	1.5	2.0	2.0	0	1	2.5	2.3	5.5	7.11
35	90135 X 89365	80	247	123	2.0	1.8	2.2	17	0	1.7	3.0	5.3	7.05
38	90143 X 88099	75	243	122	4.2	2.3	2.3	4	10	2.5	3.7	6.8	7.01
36	90143 X M131	79	234	119	2.7	1.8	2.0	12	9	[illegible]	3.5	3.0	6.93
55	90156 X 90323	74	225	108	1.7	3.0	1.8	11	2	1.7	2.2	3.8	6.92
11	89258 X 89246	78	258	129	1.7	2.3	2.3	6	26	2.2	3.2	3.5	6.91
31	90135 X C70	80	265	134	1.3	1.8	2.5	4	0	2.8	3.7	6.0	6.83
37	90143 X 88094	75	249	127	3.3	2.3	3.0	5	4	2.8	3.3	5.7	6.82
56	90156 X 87036	75	240	119	1.5	2.7	2.2	3	2	1.8	2.7	4.0	6.80
43	90147 X C70	80	253	130	1.0	2.2	2.8	1	9	4.0	3.8	4.8	6.76
50	90156 X 88091	75	245	123	2.5	2.2	2.0	8	16	2.3	2.5	2.0	6.57
28	SYN4	77	241	123	1.8	3.2	3.0	11	10	1.8	2.8	5.5	6.48
39	90143 X 89274	74	244	126	2.7	3.0	2.2	9	10	2.5	5.5	4.0	6.44
48	90156 X 89293	78	235	120	1.3	2.7	2.7	11	14	3.0	3.5	3.7	6.04
	Mean	77	250	128	2.2	2.2	2.2	8	8	2.3	3.3	5.2	7.53
	LSD.05	2	15	14	0.8	0.8	n.s.	14	14	1.4	1.3	1.1	1.31
	No. Locs.	2	2	2	2	2	2	1	2	2	2	2	2

Table 18 Cameroon midaltitude hybrids Set 3, across locations in Cameroon and Nigeria (Plateau State).

No.	Entry Name	Days Silk	Plant Height cm	Ear Height cm	Husk Cover 1-5	Ear Aspect 1-5	Ear Rot 1-5	Root Lodge %	Stalk Lodge %	Leaf Blight 1-9	Physo derma 1-9	Moist. %	Yield Mg/ha
35	90204 X 89293	73	261	133	2.8	1.5	2.6	10	9	4.5	2.7	24.4	9.38
55	90219 X 88094	72	277	135	1.5	1.4	2.1	1	11	3.7	2.0	25.2	9.26
44	90204 X 89365	74	252	125	2.0	1.5	2.1	0	7	2.3	1.7	23.1	9.26
45	90204 X 87036	73	254	123	1.8	2.3	2.1	14	5	2.3	2.7	24.2	9.22
*13	90183 X 89365	74	270	131	2.1	1.7	2.2	8	2	1.8	1.8	27.0	9.19
23	90194 X 89274	70	259	133	2.0	2.9	2.0	0	2	3.0	2.7	22.4	9.18
48	90210 X 89274	72	266	139	1.5	2.8	2.0	1	5	2.0	4.0	25.6	9.17
5	90183 X 89293	73	271	137	2.6	1.8	2.3	0	9	3.2	1.8	24.4	9.13
27	90194 X 87036	73	264	126	2.2	2.1	1.9	14	1	2.5	2.5	26.3	9.12
24	90194 X 90313	75	243	118	2.2	1.9	2.1	0	2	3.7	2.2	24.7	9.07
11	90183 X 90313	73	254	129	2.5	1.8	2.6	2	3	2.3	1.8	26.7	9.04
*12	90183 X 90332	74	268	129	1.1	1.7	1.7	3	6	1.7	2.3	27.3	9.01
6	C70 X 90183	74	275	138	1.7	2.0	2.7	4	7	3.8	2.2	26.1	8.98
1	M131 X 90176	73	276	138	1.3	1.9	1.6	9	7	3.8	3.3	21.8	8.96
8	90183 X 89242	73	258	133	1.2	1.8	2.3	4	4	2.2	1.8	24.4	8.95
53	M131 X 90219	76	260	128	1.3	1.6	1.9	0	46	4.3	2.2	27.1	8.88
9	90183 X 89291	72	272	142	2.1	1.7	2.2	35	21	2.5	1.8	25.8	8.87
52	90210 X 89343	75	262	126	1.3	2.4	2.1	11	6	4.2	3.3	24.4	8.86
2	90176 X 88094	70	271	136	1.4	1.4	1.3	3	5	3.3	3.7	22.6	8.85
50	ZS206	71	267	130	1.8	1.6	2.5	2	14	3.2	2.7	23.5	8.83
21	90194 X 88099	71	250	121	2.7	3.3	2.1	3	18	4.2	2.2	22.7	8.82
46	90210 X 88099	74	264	137	2.6	2.7	2.0	7	14	3.8	3.2	22.9	8.82
10	ZS206	72	261	130	1.9	1.5	2.5	11	14	2.8	2.7	23.6	8.82
56	90219 X 88099	73	258	134	1.8	1.4	1.8	6	31	3.8	3.0	26.0	8.79
7	90183 X 88099	72	263	135	2.5	1.9	2.0	8	26	2.7	1.8	25.2	8.78
29	90201 X 88094	71	263	136	2.2	1.8	2.4	12	11	4.0	1.8	25.0	8.67
28	M131 X 90201	74	258	127	1.7	2.1	2.5	9	34	4.3	2.2	23.7	8.64
*4	90176 X 90323	72	262	134	1.4	2.0	1.3	3	3	4.2	3.7	24.3	8.61
25	90194 X 90323	74	237	113	2.2	1.7	2.1	1	4	4.2	2.3	26.5	8.60
26	90194 X 89343	73	248	121	1.3	2.3	2.1	1	2	4.2	2.2	22.4	8.58
30	SYN4	73	256	130	1.7	2.6	2.5	2	8	3.0	2.8	23.5	8.57
41	90204 X 90314	72	235	112	1.7	2.4	2.7	3	1	2.7	3.2	25.0	8.56
36	C70 X 90204	73	259	130	1.7	1.9	2.2	18	5	4.5	3.3	23.8	8.56
37	90204 X 88094	72	258	125	2.5	1.9	2.1	2	5	4.5	2.3	24.7	8.48
42	90204 X 90323	74	229	113	1.9	2.4	2.7	3	8	4.0	2.2	27.0	8.44
38	90204 X 88099	72	265	130	2.6	2.1	2.4	6	25	4.8	3.0	24.9	8.44
54	C70 X 90219	76	267	136	1.1	1.9	2.5	1	16	5.8	3.2	27.3	8.42
43	90204 X 90332	75	262	136	1.7	2.3	1.9	0	4	3.0	2.7	26.0	8.41
32	90201 X 89274	70	252	132	1.9	2.4	2.9	11	10	2.3	3.0	24.3	8.33
34	90201 X 89343	73	253	128	1.5	2.2	2.7	2	6	5.0	2.5	22.7	8.28
*17	90188 X 90323	76	253	123	1.1	1.8	1.9	0	2	3.3	3.2	25.9	8.24
51	90210 X 90323	78	243	119	1.9	2.2	1.8	7	5	3.0	2.5	29.1	8.09
31	90201 X 89223	71	250	121	1.4	2.2	2.5	3	6	2.8	2.2	23.3	8.08
39	90204 X 89242	73	254	130	1.6	2.1	2.8	3	9	4.0	2.3	23.1	8.05
14	M131 X 90188	76	262	133	1.3	1.9	[illegible]	1	15	4.2	2.2	24.5	8.00
47	90210 X 89223	75	269	133	1.3	1.9	2.0	2	5	2.8	3.3	24.5	7.99
33	90201 X 90313	71	238	118	1.7	2.4	3.1	4	1	4.2	2.7	22.3	7.99
18	90188 X 89343	73	256	126	1.1	2.2	2.1	1	3	3.5	2.8	24.3	7.99
49	90210 X 90313	76	245	119	2.0	2.2	2.3	3	1	3.3	3.3	27.4	7.94
22	90194 X 89223	71	246	120	1.5	2.0	2.0	1	1	2.7	2.7	21.7	7.93
20	C70 X 90194	73	243	116	1.9	2.3	2.5	4	1	3.8	2.0	23.0	7.88
3	90176 X 90301	70	249	132	1.2	2.1	1.5	0	2	5.3	3.3	21.9	7.56
40	90204 X 90301	71	235	117	2.2	2.3	2.5	2	3	3.3	2.3	23.2	7.35
16	90188 X 90301	73	248	125	1.5	2.0	2.2	0	5	4.5	2.7	23.5	7.32
15	90188 X 89223	72	250	130	1.1	2.1	2.5	1	3	3.0	3.7	23.8	7.27
19	M131 X 90194	76	252	128	1.5	3.1	2.9	4	25	4.2	2.0	24.3	7.19
	Mean	73	257	128	1.8	2.1	2.2	5	9	3.5	2.6	24.5	8.53
	LSD.05	2	10	8	0.5	0.4	0.5	12	19	1.4	1.1	2.2	0.91
	No. Locs.	5	5	5	5	5	5	1	2	2	2	5	5

Table 19 Cameroon midaltitude hybrids Set 3, across locations in Nigeria (Plateau State).

No.	Entry Name	Days Silk	Plant Height cm	Ear Height cm	Husk Cover 1-5	Ear Aspect 1-5	Ear Rot 1-5	Root Lodge %	Stalk Lodge %	Leaf Blight 1-9	Physo derma 1-9	Grain Texture 1-9	Yield Mg/ha
41	90204 X 90314	76	230	109	1.8	2.2	2.7	3	1	2.7	3.2	4.8	8.82
1	M131 X 90176	78	269	137	1.3	2.2	1.7	9	7	3.8	3.3	2.8	8.70
11	90183 X 90313	77	246	123	2.3	1.8	3.0	2	3	2.3	1.8	6.2	8.62
*4	90176 X 90323	78	248	126	1.8	1.8	1.2	3	3	4.2	3.7	3.2	8.49
53	M131 X 90219	81	253	126	1.3	1.8	2.3	0	46	4.3	2.2	3.5	8.44
48	90210 X 89274	77	253	129	2.0	3.5	1.8	1	5	2.0	4.0	6.3	8.38
*13	90183 X 89365	79	254	128	2.3	1.8	2.2	8	2	1.8	1.8	4.3	8.37
6	C70 X 90183	78	261	134	2.0	2.3	2.7	4	7	3.8	2.2	5.3	8.36
25	90194 X 90323	79	226	113	2.7	1.7	2.5	1	4	4.2	2.3	4.8	8.35
46	90210 X 88099	78	251	126	3.3	3.3	2.2	7	14	3.8	3.2	7.3	8.35
27	90194 X 87036	77	243	119	2.2	2.5	2.0	14	0	2.5	2.5	5.7	8.35
5	90183 X 89293	79	256	133	3.3	1.8	2.8	0	9	3.2	1.8	6.0	8.34
45	90204 X 87036	78	238	115	1.8	2.5	2.0	14	5	2.3	2.7	7.0	8.26
23	90194 X 89274	74	249	127	2.2	3.8	2.2	0	2	3.0	2.7	7.2	8.26
*12	90183 X 90332	80	240	118	1.0	1.8	2.0	3	6	1.7	2.3	5.0	8.23
8	90183 X 89242	77	244	126	1.0	1.8	2.5	4	4	2.2	1.8	5.3	8.20
7	90183 X 88099	76	258	131	2.7	2.3	2.2	8	26	2.7	1.8	6.5	8.09
50	ZS206	77	254	121	1.5	1.7	2.3	2	14	3.2	2.7	8.0	8.06
2	90176 X 88094	75	256	129	1.7	1.7	1.3	3	5	3.3	3.7	4.5	8.06
10	ZS206	77	249	125	1.8	1.5	2.3	11	14	2.8	2.7	7.2	8.03
35	90204 X 89293	77	254	127	2.8	1.5	2.8	10	9	4.5	2.7	4.7	8.00
55	90219 X 88094	78	264	133	1.5	1.7	3.0	1	11	3.7	2.0	5.3	7.94
43	90204 X 90332	81	235	120	2.0	2.3	2.0	0	4	3.0	2.7	5.5	7.93
44	90204 X 89365	81	239	117	2.3	1.3	1.8	0	7	2.3	1.7	5.2	7.90
9	90183 X 89291	76	255	132	2.0	2.2	2.5	35	21	2.5	1.8	6.7	7.90
52	90210 X 89343	81	248	121	1.3	2.7	2.3	11	6	4.2	3.3	5.2	7.85
21	90194 X 88099	75	242	121	3.2	4.0	2.3	3	18	4.2	2.2	6.3	7.83
*17	90188 X 90323	79	237	117	1.3	1.8	2.3	0	2	3.3	3.2	4.2	7.73
42	90204 X 90323	81	214	108	2.0	2.5	3.0	3	8	4.0	2.2	5.7	7.69
24	90194 X 90313	78	223	111	2.0	2.2	2.3	0	2	3.7	2.2	7.5	7.62
30	SYN4	77	243	121	2.0	2.7	2.8	2	8	3.0	2.8	4.7	7.61
29	90201 X 88094	76	244	130	2.2	2.0	2.7	12	11	4.0	1.8	7.2	7.53
56	90219 X 88099	78	246	128	1.8	1.7	2.0	6	31	3.8	3.0	6.3	7.45
28	M131 X 90201	79	248	120	1.8	2.2	2.5	9	34	4.3	2.2	4.0	7.43
32	90201 X 89274	74	237	122	1.7	2.8	2.8	11	10	2.3	3.0	7.3	7.39
54	C70 X 90219	79	247	126	1.0	2.2	3.2	1	16	5.8	3.2	6.2	7.36
36	C70 X 90204	78	246	122	1.7	2.3	2.2	18	5	4.5	3.3	6.3	7.36
49	90210 X 90313	81	228	113	2.5	2.3	2.7	3	1	3.3	3.3	6.3	7.25
51	90210 X 90323	83	225	111	2.3	2.3	2.3	7	5	3.0	2.5	4.3	7.23
22	90194 X 89223	76	233	117	1.3	2.0	2.0	1	1	2.7	2.7	5.8	7.23
33	90201 X 90313	77	220	108	1.5	2.7	3.3	4	1	4.2	2.7	8.3	7.21
39	90204 X 89242	78	233	119	1.8	2.3	2.8	3	9	4.0	2.3	6.3	7.19
31	90201 X 89223	76	230	108	1.3	2.5	2.7	3	6	2.8	2.2	7.2	7.17
47	90210 X 89223	78	249	123	1.5	2.2	2.0	2	5	2.8	3.3	7.0	7.15
20	C70 X 90194	77	233	110	1.5	2.7	3.0	4	1	3.8	2.0	5.8	7.07
14	M131 X 90188	80	246	125	1.5	2.2	2.2	1	15	4.2	2.2	4.2	7.00
37	90204 X 88094	76	247	118	2.3	2.2	2.3	2	5	4.5	2.3	6.0	6.98
40	90204 X 90301	76	223	109	2.7	2.2	2.5	2	3	3.3	2.3	5.2	6.95
26	90194 X 89343	79	233	113	1.0	2.3	1.8	1	2	4.2	2.2	6.0	6.94
16	90188 X 90301	76	233	112	1.3	2.0	2.7	0	5	4.5	2.7	4.7	6.92
3	90176 X 90301	75	236	121	1.3	2.2	1.7	0	2	5.3	3.3	4.3	6.91
18	90188 X 89343	79	243	114	1.0	2.2	2.2	1	3	3.5	2.8	5.3	6.91
38	90204 X 88099	77	251	126	2.5	2.3	2.8	6	25	4.8	3.0	6.7	6.76
34	90201 X 89343	80	228	111	1.2	2.5	2.8	2	6	5.0	2.5	6.2	6.53
19	M131 X 90194	80	236	117	1.3	3.5	2.7	4	25	4.2	2.0	5.3	6.36
15	90188 X 89223	77	228	112	1.0	2.3	2.8	1	3	3.0	3.7	6.5	6.21
	Mean	78	242	121	1.9	2.3	2.4	5	9	3.5	2.6	5.7	7.67
	LSD.05	2	13	11	0.7	0.7	0.9	12	19	1.4	1.1	1.3	1.41
	No. Locs.	2	2	2	2	2	2	1	2	2	2	2	2

Table 20 Cameroon midaltitude hybrids Set 4, across locations in Cameroon and Nigeria (Plateau State).

No.	Entry Name	Days Silk	Plant Height cm	Ear Height cm	Husk Cover 1-5	Ear Aspect 1-5	Ear Rot 1-5	Root Lodge %	Stalk Lodge %	Leaf Blight 1-9	Physo derma 1-9	Moist. %	Yield Mg/ha
23	90251 X 89223	73	252	121	1.1	2.0	2.1	15	9	1.8	3.2	25.0	8.94
9	90220 X 89274	72	258	135	2.0	2.0	2.6	1	16	2.8	4.2	26.1	8.83
50	89320 X 89274	75	267	135	1.4	2.7	2.2	3	19	2.7	5.2	24.5	8.82
47	89320 X C70	76	272	133	1.7	1.6	2.1	15	31	5.3	4.5	25.2	8.78
6	90220 X 88094	73	270	133	1.5	1.6	2.3	6	27	2.7	2.8	26.5	8.78
41	90268 X 88094	75	276	137	2.4	1.8	2.1	4	17	3.8	3.3	24.4	8.77
*39	90267 X 89223	75	263	125	1.3	1.7	2.1	6	3	2.2	2.0	23.5	8.73
34	90267 X M131	75	261	124	2.1	2.1	2.4	9	20	2.3	2.5	23.8	8.71
22	90251 X 88099	72	247	127	1.4	2.5	1.7	4	32	3.7	3.2	23.8	8.69
35	90267 X 89293	74	262	123	1.4	1.9	2.6	11	9	2.7	2.5	24.3	8.68
*12	90220 X 89365	74	240	125	1.5	1.7	2.2	2	10	1.5	2.7	25.6	8.64
29	90252 X 89291	71	252	121	1.7	2.0	2.0	7	14	3.0	3.0	22.5	8.64
*2	90219 X 90314	75	249	124	1.1	1.8	1.9	1	4	2.3	3.5	26.6	8.62
40	90268 X C70	77	274	131	1.3	2.1	2.5	7	4	4.0	4.3	24.5	8.60
21	90251 X 88098	70	251	123	1.1	2.9	2.0	14	21	4.0	3.2	23.3	8.60
52	89320 X 90323	77	258	126	1.3	2.0	1.9	7	25	4.3	3.2	27.7	8.53
4	90219 X 89343	75	255	131	1.1	1.5	2.3	17	21	3.3	2.8	26.3	8.53
53	89320 X 89365	77	266	129	1.8	1.9	2.1	2	31	2.0	3.5	25.2	8.49
5	90219 X 87036	75	268	132	1.2	1.8	1.9	1	28	1.8	3.0	27.4	8.48
20	90251 X 88094	72	258	124	1.5	1.9	2.1	9	21	3.5	3.0	24.8	8.47
45	90268 X 89343	75	265	128	1.1	2.1	2.3	9	9	3.5	3.7	22.9	8.46
30	90263 X 89293	73	251	122	1.6	1.7	2.7	1	27	5.3	4.3	22.2	8.44
14	90250 X 88098	71	259	122	1.1	2.7	2.3	2	7	3.5	3.0	22.0	8.39
25	90251 X 89365	75	255	118	1.2	2.1	1.9	11	10	1.5	2.7	24.7	8.39
36	90267 X C70	78	266	130	1.2	2.2	2.5	4	4	2.7	3.2	25.3	8.38
28	90252 X 88099	71	257	126	1.5	3.0	1.9	15	25	3.2	3.7	23.7	8.35
27	90252 X 88094	71	250	117	2.1	2.1	2.1	29	6	3.3	3.8	24.1	8.33
38	90267 X 88099	73	252	122	1.7	2.7	1.9	8	7	2.2	2.2	22.9	8.33
7	90220 X 88098	72	250	130	1.2	1.9	2.1	1	33	3.0	3.2	25.5	8.30
16	ZS206	73	267	126	1.9	1.7	2.5	6	27	2.2	3.3	24.6	8.28
15	90250 X 89242	72	252	120	1.0	2.0	2.9	7	8	2.3	2.3	23.2	8.26
24	90251 X 89274	70	251	122	1.3	2.8	2.3	16	16	2.8	4.0	24.0	8.25
8	90220 X 89223	73	256	125	1.4	1.6	2.3	0	12	2.3	3.3	24.4	8.24
33	90263 X 89343	73	261	127	1.1	1.7	2.5	19	14	4.8	3.3	21.6	8.20
44	90268 X 89291	76	271	130	1.9	2.0	2.1	7	6	2.8	3.5	24.1	8.14
49	89320 X 89223	75	266	130	1.1	1.7	1.8	0	11	2.7	4.3	24.3	8.14
55	89246 X C70	77	276	134	1.5	1.7	2.3	4	13	2.8	3.8	23.6	8.13
42	90268 X 88098	74	265	129	1.7	2.7	2.2	11	7	3.2	3.7	23.8	8.13
17	90250 X 89343	73	255	126	1.0	2.4	2.2	12	8	3.7	3.3	22.4	8.10
48	89320 X 88099	74	261	127	1.5	2.3	1.8	3	57	4.5	3.5	24.0	8.08
13	90250 X M131	75	251	122	1.3	2.3	2.3	0	11	4.3	2.2	23.4	8.06
26	90252 X C70	73	261	120	1.0	2.4	2.1	13	5	3.5	4.8	24.2	8.02
51	89320 X 90301	76	262	130	1.3	2.0	1.9	5	21	3.7	3.3	25.1	8.02
32	90263 X 88099	72	260	126	2.1	1.7	1.9	8	36	5.3	3.5	22.5	8.01
*3	90219 X 90332	77	257	119	1.3	1.6	1.5	2	19	2.3	3.0	27.0	7.97
11	90220 X 90323	76	240	123	1.2	1.9	1.9	11	6	3.2	3.3	27.3	7.91
10	90220 X 90313	75	240	122	1.6	2.2	2.8	5	5	3.2	3.3	26.9	7.82
37	SYN4	74	261	129	1.4	2.6	2.7	8	15	2.3	3.5	24.8	7.81
43	90268 X 89242	75	259	121	1.1	2.3	2.8	12	4	2.5	3.5	24.8	7.75
54	89320 X 87036	77	271	139	1.7	2.3	1.9	18	22	2.2	2.8	27.0	7.72
19	90251 X C70	74	256	123	1.1	2.5	2.2	18	9	4.5	3.3	25.6	7.72
31	90263 X C70	75	261	123	1.3	2.0	2.7	4	19	5.2	4.0	22.0	7.66
56	89248 X C70	77	276	127	1.3	2.1	2.5	4	27	3.7	4.0	21.2	7.60
18	90251 X M131	76	258	124	1.3	2.7	2.4	20	33	3.8	2.7	25.8	7.53
1	90219 X 90301	74	256	126	1.5	1.6	2.2	11	29	5.0	2.5	24.8	7.52
46	89320 X M131	78	247	122	1.3	2.9	2.7	11	32	5.0	3.0	24.9	6.71
	Mean	74	259	126	1.4	2.1	2.2	8	17	3.2	3.3	24.5	8.26
	LSD.05	2	11	10	0.4	0.5	0.5	17	22	1.4	1.4	1.8	0.87
	No. Locs.	5	5	5	5	5	5	1	2	2	2	5	5

Table 21 Cameroon midaltitude hybrids Set 4, across locations in Nigeria (Plateau State).

No.	Entry Name	Days Silk	Plant Height cm	Ear Height cm	Husk Cover 1-5	Ear Aspect 1-5	Ear Rot 1-5	Root Lodge %	Stalk Lodge %	Leaf Blight 1-9	Physo derma 1-9	Grain Texture 1-9	Yield Mg/ha
*2	90219 X 90314	79	231	115	1.0	1.7	2.0	1	4	2.3	3.5	4.3	8.46
9	90220 X 89274	76	249	130	2.0	2.0	2.7	1	16	2.8	4.2	5.8	8.17
40	90268 X C70	81	270	137	1.2	2.5	2.8	7	4	4.0	4.3	5.7	7.74
38	90267 X 88099	78	243	119	2.2	3.5	1.7	8	7	2.2	2.2	5.8	7.69
50	89320 X 89274	77	258	132	1.3	3.2	2.0	3	19	2.7	5.2	5.2	7.68
16	ZS206	77	251	125	1.8	1.7	2.2	6	27	2.2	3.3	8.0	7.57
53	89320 X 89365	80	251	123	2.2	1.8	2.2	2	31	2.0	3.5	4.5	7.53
8	90220 X 89223	78	248	123	1.2	1.7	2.5	0	12	2.3	3.3	5.8	7.50
15	90250 X 89242	76	234	111	1.0	2.0	3.3	7	8	2.3	2.3	4.8	7.49
20	90251 X 88094	75	248	117	1.7	2.2	2.3	9	21	3.5	3.0	5.0	7.43
10	90220 X 90313	79	226	112	1.5	2.0	2.5	5	5	3.2	3.3	7.7	7.43
5	90219 X 87036	79	248	123	1.2	2.0	1.8	1	28	1.8	3.0	5.3	7.43
34	90267 X M131	80	252	123	3.2	2.0	2.0	9	20	2.3	2.5	3.2	7.39
22	90251 X 88099	76	235	118	1.3	3.2	2.2	4	32	3.7	3.2	6.2	7.38
23	90251 X 89223	78	241	123	1.0	2.0	2.0	15	9	1.8	3.2	6.5	7.37
25	90251 X 89365	80	235	109	1.3	1.8	1.8	11	10	1.5	2.7	4.3	7.37
*12	90220 X 89365	79	213	113	1.3	1.7	2.3	2	10	1.5	2.7	4.7	7.36
6	90220 X 88094	77	256	129	1.7	2.0	2.8	6	27	2.7	2.8	5.5	7.32
41	90268 X 88094	78	267	140	2.3	2.5	2.0	4	17	3.8	3.3	6.0	7.32
52	89320 X 90323	81	240	117	1.3	2.0	2.0	7	25	4.3	3.2	4.2	7.31
47	89320 X C70	82	258	128	1.8	2.0	2.5	15	31	5.3	4.5	4.8	7.30
13	90250 X M131	79	235	118	1.3	2.3	2.0	0	11	4.3	2.2	3.3	7.28
36	90267 X C70	82	251	122	1.0	2.8	2.5	4	4	2.7	3.2	4.5	7.27
4	90219 X 89343	79	238	118	1.2	1.7	2.7	17	21	3.3	2.8	5.0	7.22
7	90220 X 88098	76	237	122	1.0	2.0	2.5	1	33	3.0	3.2	5.8	7.15
44	90268 X 89291	79	248	126	2.3	2.3	2.2	7	6	2.8	3.5	6.7	7.13
14	90250 X 88098	74	241	111	1.0	3.2	2.2	2	7	3.5	3.0	6.3	7.12
*39	90267 X 89223	79	253	130	1.3	1.8	2.2	6	3	2.2	2.0	5.2	7.10
11	90220 X 90323	80	218	108	1.0	2.0	2.3	11	6	3.2	3.3	4.0	7.05
30	90263 X 89293	77	236	120	2.0	1.7	2.8	1	27	5.3	4.3	3.7	7.00
24	90251 X 89274	75	237	117	1.5	3.2	2.2	16	16	2.8	4.0	5.5	6.99
45	90268 X 89343	81	250	127	1.0	2.3	2.3	9	9	3.5	3.7	5.7	6.97
*3	90219 X 90332	80	241	117	1.2	1.8	2.0	2	19	2.3	3.0	3.8	6.96
43	90268 X 89242	78	249	126	1.0	2.7	2.8	12	4	2.5	3.5	5.0	6.94
26	90252 X C70	77	244	120	1.0	2.7	2.2	13	5	3.5	4.8	5.2	6.90
27	90252 X 88094	75	238	107	2.5	2.2	2.3	29	6	3.3	3.8	5.3	6.90
54	89320 X 87036	81	260	134	1.8	2.5	2.2	18	22	2.2	2.8	5.3	6.89
51	89320 X 90301	79	245	122	1.3	2.3	2.0	5	21	3.7	3.3	5.2	6.88
18	90251 X M131	80	239	119	1.5	3.0	2.5	20	33	3.8	2.7	3.3	6.87
49	89320 X 89223	79	245	123	1.2	2.0	1.7	0	11	2.7	4.3	5.8	6.84
21	90251 X 88098	75	240	120	1.2	3.7	2.3	14	21	4.0	3.2	6.0	6.82
28	90252 X 88099	75	235	114	1.3	3.8	2.2	15	25	3.2	3.7	6.5	6.82
55	89246 X C70	81	259	126	1.2	2.0	3.2	4	13	2.8	3.8	5.2	6.77
37	SYN4	78	247	126	1.5	2.2	2.3	8	15	2.3	3.5	4.7	6.74
19	90251 X C70	79	242	118	1.0	2.8	2.5	18	9	4.5	3.3	5.7	6.72
1	90219 X 90301	78	234	116	1.7	1.5	2.2	11	29	5.0	2.5	5.0	6.71
17	90250 X 89343	78	238	118	1.0	2.7	2.2	12	8	3.7	3.3	6.2	6.63
48	89320 X 88099	77	238	116	1.5	2.7	2.0	3	57	4.5	3.5	5.2	6.63
35	90267 X 89293	79	249	123	1.3	2.0	2.3	11	9	2.7	2.5	4.0	6.60
42	90268 X 88098	77	248	125	1.5	3.5	2.2	11	7	3.2	3.7	6.3	6.59
33	90263 X 89343	77	243	121	1.0	1.8	2.7	19	14	4.8	3.3	4.3	6.56
32	90263 X 88099	76	246	124	2.5	2.0	2.0	8	36	5.3	3.5	4.7	6.44
29	90252 X 89291	76	232	114	1.7	2.3	2.5	7	14	3.0	3.0	6.5	6.32
31	90263 X C70	80	243	123	1.2	2.5	2.8	4	19	5.2	4.0	5.7	5.94
56	89248 X C70	83	264	129	1.3	2.5	2.7	4	27	3.7	4.0	6.2	5.60
46	89320 X M131	83	229	118	1.5	3.3	3.0	11	32	5.0	3.0	4.0	5.45
	Mean	78	244	121	1.5	2.3	2.3	8	17	3.2	3.3	5.3	7.05
	LSD.05	2	17	11	0.7	0.7	0.7	17	22	1.4	1.4	1.2	n.s.
	No. Locs.	2	2	2	2	2	2	1	2	2	2	2	2

The rapid summary of field selections (starred entries) identified 28 hybrids for advanced testing in Nigeria in 1992. These, and 68 new hybrids were formed in the 1991 dry season. Note the lines with good general combining ability, repeated in several selected hybrids. These are being intercrossed to form new source (SynA6 and SynB6) and variety (Syn5) synthetics which should show improved adaptation to the Jos environment (Appendix 1)

Inbreds

Sublines of the inbred parents of the hybrids in the advanced and preliminary trials were scored, selected, and selfed in the UTC nursery (Jos) in 1991. Scores averaged across the selected sublines of the most recent inbreds (1990 series primarily) are presented in Table 22 along with the pedigree of the line. Note these are all recycled lines, i.e. the parents were all inbreds and synthetics.

Exserohilum turcicum, (probable) Cercospora zeae-maydis, and Physoderma maydis pressures were high: Cercospora had not been observed in Cameroon, and some lines appearing resistant to turcicum in Cameroon were partially susceptible at UTC. The possibility of a race difference in the pathogen exists. Even the border rows (commercial hybrid 8535-23) in the hybrid trials were rating 5-6 out of 9 for turcicum, an indication of the intensity of the epidemic.

The advanced inbreds (1989 series and before), in addition to subline selection and selfing, were entered into an evaluation trial, four replications, single row plots, at UTC and WAMCO. Results are shown in Table 23: the principal value of the trial was the disease scoring and days to silk data. Note that as in other trials, the leaf blight score contains not only turcicum, but also Diplodia at WAMCO. Stands were irregular, so covariance analysis was used to adjust yields, which appear to be somewhat overestimated. Ear rots on the inbreds **per se** appear to be a serious constraint to single cross seed production on the Jos Plateau: a more favorable environment for quality seed production would be off the Plateau in a lower rainfall zone. Parents of the advanced inbreds are shown in Table 24.

Extraction of new inbred lines was initiated by selfing under streak virus screening in the Ibadan 91A and 91B seasons. Single crosses constituting the first diallel recombination of SynA4 and SynB4 were selfed to S2, from which 276 lines were kept. The midaltitude reselected Population 32, previously crossed onto SynA4, was also selfed to S2, and 225 lines were kept. Midaltitude reselected Population 43SR F2 families (S1 bulks) were selfed under heavy E. turcicum pressure at Jos, obtaining 263 S2 lines. All three groups of S2's were then distributed to Cameroon-NCRE and CIMMYT, and prepared for 1992 planting in Jos. In addition, 727 S2 lines, resulting from crosses between SynA3 or SynB3 and introductions from East Africa, Hawaii, and the U.S., were planted under streak pressure at Ibadan in the 91A season, and resistant lines were selfed. The selected lines were again advanced, without streak pressure, in the 91B season, and are candidates for

Table 22 New Cameroon inbreds selected in 1991 preliminary hybrid trials.

Inbred	Pedigree	S4 Sublines Jos91A-408	Exserohilum turcicum 1-9	Cercospora zeae-maydis 1-9	Physoderma maydis 1-9	Maize Streak 1-9	Grain Texture 1-9
90113	SynA1x87004	4-6	1	3	1	1	2
90143		26-30	1	7	3	1	3
90147		33	4	2	2	1	3
90156		39-43	2	2	2	1	2
90176		44-50	3	4	6	1	2
90183	SynA1x87014	52-57	2	3	2	1	4
90188		62-65	2	2	2	1	4
90204		82-87	3	2	3	1	5
90219		96-101	3	2	4	1	3
90220		102-104	2	3	3	1	3
90263	SynA1x87036	134-138	2	4	4	2	2
90267		141-149	2	4	3	1	2
89320	M131xS62	176-183	2	3	3	1	3
90301	SynB1x87036	157-160	3	1	3	1	7
90313		165-172	2	2	2	2	4
90323		191-204	3	3	3	1	3
90332		208-212	3	2	2	1	3
89343	S85xC70	213-219	4	2	2	2	3
89365		221-228	2	2	2	1	3

Note: Disease scores are averages of selected sublines in the Jos 91A nursery, except for maize streak, which was rated on line bulks at Ibadan 91A.

Table 23 Cameroon midaltitude inbred trial, means across UTC and WAMCO locations, Plateau State, Nigeria.

Entry No.	Inbred Name	Days to Silk	Plant Height cm	Ear Height cm	Husk Cover 1-5	Ear Aspect 1-9	Ear Rot 1-9	Moisture %	Leaf Blight 1-9	Cerco-spora 1-9	Physo-derma 1-9	Root Lodging %	Stalk Lodging %	Yield Mg/ha
1	89223	80	156	73	1.0	4.4	3.5	28.7	1.9	2.5	4.8	12	5	3.05
2	89274	75	191	101	1.5	3.6	3.4	27.1	2.8	4.1	7.0	8	10	4.16
3	89277	80	175	90	1.4	3.4	3.5	32.0	2.5	4.6	3.6	2	4	3.64
4	88091	80	176	89	1.3	4.8	3.3	27.6	2.5	5.1	2.8	22	14	2.93
5	88098	78	174	84	1.0	3.8	4.4	25.1	3.8	6.3	4.4	10	6	3.19
6	89182	75	161	77	1.0	6.9	4.4	24.9	2.4	6.6	3.1	29	9	2.44
7	89183	73	186	91	2.3	4.8	3.1	27.1	2.4	2.6	2.9	9	5	3.67
8	89199	83	191	90	1.0	6.8	5.1	32.9	2.4	1.5	2.3	12	6	2.43
9	89207	83	173	81	1.4	4.4	3.9	30.1	4.6	5.1	3.9	10	6	2.49
10	89243	83	164	75	1.0	7.8	5.1	29.6	2.9	2.1	2.1	14	10	2.36
11	89246	83	198	89	1.0	3.9	4.1	27.6	2.5	2.4	2.6	11	2	2.69
12	89248	82	199	97	2.0	4.3	3.9	26.5	2.8	2.3	3.0	7	9	3.43
13	89258	80	149	74	1.4	4.1	4.6	25.5	2.1	2.8	5.4	5	2	2.94
14	89260	79	159	78	1.8	4.6	4.0	25.3	2.0	2.9	4.1	13	9	2.99
15	89291	77	186	85	1.6	4.1	4.3	25.6	2.5	1.9	2.4	20	10	2.99
16	89292	77	191	101	2.1	5.9	4.0	31.9	2.4	1.0	2.4	4	10	3.43
17	89293	83	178	83	1.3	6.0	5.0	29.2	3.1	1.8	2.5	10	6	2.13
18	89302	78	127	56	1.4	5.0	5.6	27.2	1.6	1.1	5.9	1	2	2.88
19	89303	75	127	53	1.4	4.6	7.0	27.5	2.0	2.0	6.3	4	2	2.79
20	89310	80	163	83	1.3	4.6	3.5	32.8	2.0	2.0	3.4	6	2	3.81
21	88099	80	195	94	1.4	5.3	2.9	26.5	3.8	4.3	2.6	24	21	2.90
22	89242	83	168	74	1.0	6.8	5.3	32.8	3.6	2.3	3.0	13	11	2.60
23	89299	84	192	104	1.0	5.1	3.0	35.1	2.0	1.9	2.9	27	3	3.34
24	89311	83	144	60	2.1	5.9	5.8	23.2	2.8	7.8	3.3	8	40	2.32
25	88094	83	191	89	1.6	3.6	4.3	28.7	4.1	5.4	3.3	22	5	3.16
26	88069	83	164	74	3.4	4.3	3.9	31.8	1.9	1.5	2.4	3	2	4.12
27	88030	83	186	86	1.0	5.1	4.3	25.9	3.5	1.9	1.3	14	9	2.89
28	87014	79	164	82	1.6	3.8	5.4	27.0	3.0	4.5	2.9	4	16	2.89
29	87366	79	174	81	1.3	4.4	4.3	25.5	6.4	3.1	2.9	10	13	2.98
30	87036	80	204	103	1.4	3.4	1.8	30.9	2.0	2.1	2.1	12	6	4.89
31	C70	83	172	79	1.0	5.5	5.0	31.2	4.8	1.4	2.6	16	11	2.76
32	Z28	83	183	94	1.0	3.6	4.6	31.8	3.1	4.0	2.3	4	4	3.80
33	M131	82	179	89	1.9	3.8	3.9	27.7	5.3	2.6	2.3	8	33	4.18
	Mean	80	174	84	1.4	4.8	4.2	28.6	2.9	3.1	3.3	11	9	3.13
	LSD.05	3	14	10	0.5	1.7	2.2	4.7	1.3	1.4	1.4	n.s.	n.s.	1.14

Table 24 Advanced Cameroon inbreds.

Inbred Name	Pedigree	Selected in Hybrids 1991	Grain Color	Grain Texture 1-9	Maize Streak 1-9*	Stored at USDA Ft.Collins	Sublines 1991 Plots Jos-410	Sublines 1991 Plots Jos-411
89223	MSR	CN	W	5	1	X	3-9	1-10
89274	(Kit2xMSR)Kit2	C	W	6	2	X	11-31	14-37
89277	(Kit2xMSR)Kit2		W	4	3		38,46	43-55
88091	MSR	C	W	1	2	X	53-58	56
88098	MSRxEast Africa Hyb.		W	8	8	X	69-79	63-93
89182	MSR	C	W	2	2		87-92	96-105
89183	MSR	C	W	2	3		96	108-110
89199	MSR		W	2	2	X	105	112
89207	MSR		W	2	2	X	120	119-123
89243	MSR		W	7	3			130,131
89246	MSR		W	5	2	X	126-137	135-148
89248	MSR		W	4	3	X	140-143	149-152
89258	H625xZ10	CN	W	2	8	X	150-168	159-191
89260	H625xZ10	CN	W	2	8	X	173,176	194-196
89291	(ZS206xMSR)ZS206	CN	W	8	1	X	181,182	198-205
89292	(ZS206xMSR)ZS206		Y	9			190	
89293	(ZS206xMSR)ZS206	CN	W	2	2	X	193,197	
89302	(H625xZ10)H625	CN	W	2	8	X	201-218	208-228
89303	(H625xZ10)H625		W	2				236-252
89310	(ZS206xZ10)ZS206		W	4	9	X	227,229	254-256
88099	MSRxEast Africa Hyb.	CN	W	6	8	X	231-234	261,262
89242	MSR	C	W	7	3	X	237,243	270
89299	(H625xZ10)H625		W	3	8	X	discarded	275,276
89311	M122xN103		W	1	1	X	260	280-282
88094	MSRxEast Africa Hyb.	C	W	5	9	X	275-312	283-316
88069	ZS206xMSR	CN	Y	4	3	X	315-320	318-332
88030	MSR	C	W	5	1	X	321-324	333-337
87014	MSR	C	W	4	1	X	326,337	341-361
87366	Population 32		W	1	8	X	327-332	362-365
87036	MSR	CN	W	7	1	X	338	367-370
C70	CommercialxSR	C	W	5	2	X	339	372-387
Z28	ZambiaxSR	CN	W	2	1	X	334-336	389-401
M131	MSR	C	W	2	2	X	340,341	404-409

Note: C and N indicate selected in hybrids in Cameroon and Nigeria respectively.

Note: Maize streak virus ratings from Ibadan 91A nursery.

screening at Jos in 1992. The streak scores were provided back to the NCRE-Cameroon team. A second recombination of SynA4 and SynB4 was also made in the Jos 1991 nursery, for further inbred extraction.

Testcrosses

Six sets of testcrosses, four from the A group and 2 from the B group were planted at two locations in Cameroon and two in Nigeria: the BARC farm trial was discarded due to herbicide kill, so only the WAMCO site was available in Nigeria. Each set contained 72 entries and was planted in two replications, one row plots in Cameroon and two row plots at WAMCO. The single cross tester from the A group crossed onto the B group S3 lines was Z27xZ99. The tester from the B group for testing the A group lines was C70xM87. Selections were based on rapid summaries of field selections at harvest. In Cameroon, 35 inbreds were selected and promoted to formation of new hybrids for 1992. Since the S3 lines **per se** were not evaluated at Jos (the limited seed was planted and selfed under streak pressure at Ibadan instead), a larger number were selected based on testcross performance across all three sites: it is expected that some will be unadapted, and thus eliminated in the Jos 1992 nursery. Eighty five lines (S4's/S3's) were advanced for additional testcrossing and **per se** evaluation in Jos (Appendix 1): these constitute the latest group of recycled lines from the "comprehensive breeding system" in Cameroon. The ten highest rated lines were advanced for formation of new hybrids in Ibadan, in combination with the advanced lines selected in hybrids. Selected S4/S3 lines were also included in the formation of the source synthetics SynA6 and SynB6, and were recombined to form another varietal synthetic (Syn6) in the Ibadan nursery (Appendix 2). Similar synthetics based on Cameroon selections were made in the Foumbot nursery.

Evaluation of Progress from Selection in Populations

Six main varietal populations and a series of varietal synthetics were developed or introduced, and improved or maintained during the project. Selection methods and intensities varied among populations and cycles: the objective of the selection was improved varieties, not a breeding methods study. Selection criteria emphasized good agronomic and ear traits: reduced plant and ear height, better husk cover, ear rot resistance, and yield. In an effort to evaluate progress, seed samples of cycles of selection of five midaltitude populations and four varietal synthetics were increased in 1990 in Cameroon. The six trials were sent to CIMMYT and Pioneer in Zimbabwe for the 1990-91 growing season, and were planted in Cameroon and Nigeria in 1991. Entries were planted in two row plots, four replications per location.

Data on all traits were analyzed, however, only those traits showing significant trends or differences are presented. Trends were determined by simple linear regression of trait value on cycle of selection, using all data across all sites relevant to the trait. The slope is presented if the t-test probability was <.05 (except in one noted case).

Synthetics. The most intense selection occurs in the selection of inbred parents of hybrids and synthetics: the inbreds forming the varietal synthetics have been selected **per se** at the S3 or higher stage of inbreeding, and have been selected for combining ability in testcrosses and sometimes in single cross hybrids. In the Cameroon program, a modified form of the Eberhart comprehensive breeding program was implemented, combining reciprocal recurrent selection and pedigree breeding for inbred extraction, with the formation of a varietal synthetic from each new group of inbreds (Figure 1). Synthetics 1 through 4 were formed from successive groups of "first cycle" lines, ie. all inbreeding was from populations, population crosses, or population by hybrid crosses, involving parentage which had not been previously inbred. The initial "second cycle" lines (1990 and 1991 series) are included in the new Syn5 and Syn6 (Appendix 2).

Results of the evaluation of successive synthetics across nine locations in three countries are shown in Table 25. Significant trends were observed in ear height (-3.13 cm/syn, 2.1%), ear rot score (-0.13/syn, 5.9%) leaf blight score (-0.34/syn, 10.0%), and yield (0.265Mg/ha/syn, 3.9%). These reflect an improvement in parental inbred quality through successive groups of inbred extraction and testcrossing. It also reconfirms the superiority of Syn4 in several traits as observed in the NVT-L.

ATP. The Acid Tolerant Population was developed in response to the observation that significant production areas in the Cameroon midaltitudes are on acid, phosphorus fixing soils. Several lowland populations known to be tolerant to acid soils were tested in a 1984 multilocational split block (lime, no lime) experiment. Selected entries were combined with midaltitude adapted populations to form ATP. Four cycles of half sib family selection at two locations (Nfonta and Bansoa), one acid and one not, concentrated on reduction of plant and ear height, ear quality, yellow flint grain, and yield. Selection trials consisted of one row plots, two replications per location.

Results are shown in Table 26. The trials sent to Zimbabwe were formed prior to availability of ATP-cycle 4, so it was necessary to omit those locations in the across site analyses. Significant reductions over cycles in ear height (-2.77cm/cycle, 1.9%), ear rot score (-0.13/cycle, 6.5%), and leaf blight score (-0.28/cycle, 7.2%) were attained. The response of yield to selection is clearly non-linear, with no progress after cycle 2 noted. Average increase over cycles was 0.152Mg/ha/cycle, 1.9%.

Table 25 Improvement in successive varietal synthetics.

Entry	Ear Height cm	Ear Rot 1-5	Leaf Blight 1-9	Yield Mg/ha
Syn1	148	2.2	3.4	6.87
Syn2	141	2.2	3.1	7.25
Syn3	140	1.9	2.8	7.27
Syn4	137	1.8	2.4	7.75
LSD.05	7	n.s.	n.s.	0.44
Slope	-3.13	-0.13	-0.34	0.265
%/syn	2.1	5.9	10.0	3.9
s.e. slope	1.54	0.06	0.1	0.098
No. Locs.	9	6	2	9

Table 26 Progress over cycles of ATP

Entry	Ear Height cm	Ear Rot 1-5	Leaf Blight 1-9	Yield Mg/ha
ATP-C0	145	2.0	3.9	6.84
ATP-C1	139	2.1	3.4	6.91
ATP-C2	139	2.0	3.0	7.50
ATP-C3	137	1.7	2.9	7.28
ATP-C4	133	1.5	2.8	7.42
LSD.05	5	n.s.	n.s.	0.35
Slope	-2.77	-0.13	-0.28	0.152
%/cycle	1.9	6.5	7.2	1.9
s.e. slope	1.08	0.04	0.09	0.062
No. Locs.	5	6	2	6

Although greater uniformity has been achieved, the population is still quite variable for all traits: a yield plateau could not have been reached. It is more likely that one row plots in two replications at two sites is not providing sufficient precision to identify superior half sib families for traits of lower heritability like yield. It would be advantageous to change the recurrent selection program to S2 testcross improvement, which would allow greater selection pressure for disease resistance and grain color during inbreeding, and greater variability among testcross families for yield improvement. Greater resistance to *P. sorghi* would be rapidly obtained with this system.

MSR. The IITA Midaltitude Streak Resistant population entered full sib family recurrent selection in 1983. Each cycle requires two years, including family formation, international family trials, and recombination of selections. With each cycle, ten families out of (usually) 250 are selected at each test site and recombined from remnant seed for testing as an experimental variety. In addition, one variety is formed based on selection across all sites, and 40-60 families are selected across sites to recombine the population itself to begin the next cycle. One location of the international family trial was evaluated in Cameroon for each of the four cycles, and a variety was formed based on results at that site.

Results of an evaluation of the MSR Cameroon variety cycles are presented in Table 27. The ANOVA indicates significant differences among cycles for husk cover, ear rot, leaf blight, and yield. It appears that excellent husk cover was achieved by the second cycle, and there was no improvement after that. Similarly, the leaf blight scores of the last three cycles were better than those of the first cycle, with no significant differences among the last three. Ear rot scores improved linearly, at a rate of -0.295 units (10%) per cycle. Yield showed a significant linear response, 0.263 Mg/ha (4%) per cycle, with no significant difference between the second and third cycles.

Selection progress in this system is dependent on selection across single sites in several countries (3-4 in the case of MSR), two replications per site. Improvement for common agronomic traits with little genotype x environment interaction would be expected, however improvement for traits expressed at only one or two sites, or with different importance in the various regions, would be expected to see little if any improvement unless the trait were specifically targeted. With MSR, weak points for special attention would be *P. sorghi* resistance for the Cameroon Western Highlands, and lower plant height and ear position for eastern and southern Africa. Disease resistance is much easier to screen at the S2 stage in an area of natural epidemics (UTC farm for *E. turcicum* and Bansoa in Cameroon for *P. sorghi* resistance). Plant and ear height can be addressed across all sites. Note the much greater average ear height across cycles of MSR at the Zimbabwe locations compared to those in West Africa:

Table 27 Progress over cycles of MSR varieties.

Entry	Husk Cover 1-5	Ear Rot 1-5	Leaf Blight 1-9	Yield Mg/ha
Bab(1)MSR83	1.7	2.9	3.8	6.13
Fbt(3)MSR85	1.1	2.6	3.0	6.73
Fbt(5)MSR87	1.2	2.2	3.4	6.50
Bab(3)MSR89	1.2	2.0	3.0	7.09
LSD.05	0.3	0.3	0.6	0.38
Slope		-0.295		0.263
%/cycle		10.2		4.3
s.e.slope		0.066		0.111
No. Locs.	3	5	2	8

Table 28 Progress over cycles of Population 34/ Early White

Entry	Days to Silk	Plant Height cm	Ear Height cm	Leaf Blight 1-9	Yield Mg/ha
34C1	71	228	107	4.9	5.30
34C2	71	222	105	4.6	5.26
34C3	72	231	108	3.8	5.64
Early White	70	243	120	3.5	7.24
LSD.05	1	8	7	0.7	0.36
Slope				-0.5	
%/cycle				10	
s.e.slope				0.13	
No.Locs.	6	7	7	3	7

Location	Ear Height (cm)
Foumbot, Cameroon	159
Nfonta, Cameroon	105
Mbang Mbirni, Cameroon	125
UTC farm, Nigeria	127
WAMCO farm, Nigeria	122
Pioneer farm, Zimbabwe	173
Glendale farm, Zimbabwe	169
Rattray Arnold farm, Zimbabwe	169
LSD.05	8

Varieties with appropriate plant height in West Africa are often too tall in Zimbabwe. Factors involved may include soil fertility, but might also include other climatic and latitude related factors: higher solar radiation (less overcast, less rain), different temperature regime, and different photoperiod in Zimbabwe.

Population 34/Early White. CIMMYT subtropical Population 34 was tested in 1984 with other subtropical materials. It was early maturing in the Cameroon midaltitudes, with white flint grain. However, it did not yield well, showed considerable leaf disease and ear rot susceptibility, and had poor husk cover. An international full sib family (IPPT) trial from CIMMYT was evaluated in 1984, and 27 full sib families were selected. Remnant seed was obtained and families were recombined to form 34C1. Two subsequent cycles of half sib family selection across two locations were performed to form 34C2 and 34C3. It was obvious that progress in plant health was being made by the third cycle, however, a major improvement in overall performance was needed if the population was to be useful as a variety. Early S3 lines selfed out of MSR were identified and testcrossed to Population 34. Following evaluation, selected testcrosses **per se** were recombined to form Early White, which entered multiple recombinations in ear to row isolation/seed increase plots. Early White is thus 50% Population 34C3 and 50% early lines from MSR.

Results are shown in Table 28. Significant differences among entries were found for days to silk, plant and ear height, leaf blight score, and yield. Differences in days to silk were non-directional, with Early White flowering one day earlier than the other entries. Plant and ear height are greater in Early White, however it is still compact, with good stalk strength (note results in the NVT-E trial). Leaf blight resistance improved linearly over cycles of Population 34 and Early White, at 0.5 units (10%) average per cycle. Yield did not change much over cycles of selection within Population 34, however a major increase was obtained when lines from MSR were added to form Early White. The increment in robustness and yield without loss of earliness are due primarily to the better midaltitude adaptation of MSR derivatives compared to the subtropical Population 34.

Shaba. The CIMMYT-USAID bilateral institution building project in Zaire, 1971-1980, developed two principal varieties: Shaba and Kasai. Shaba was formed on the midaltitude plateau of Shaba province. Parents were Kenya hybrid H632, Zimbabwe hybrid SR52, Tuxpeno 1 (Mix1 x Col.Gpo.1), and Eto; i.e. it is a mix of high, mid and low altitude varieties. Shaba had been in multilocation trials since 1982, and was found to be suited to the Adamaoua Plateau, where it was eventually released as the first improved open pollinated variety in that province. It has been maintained as an ear to row isolation at the IRA Mbang Mbirni site since 1985. Selection intensity among 300 half sib families was 40-60%, and mass selection was applied within selected rows, at approximately 10% intensity to obtain the next cycle of 300 ears. Principal selection criteria were stalk strength, ear position, husk cover, ear rot resistance, and ear shape and size. No data were taken, all selection being made at harvest. The objective is varietal maintenance with mild improvement for the above listed criteria: single row, single plot, single site selection is not expected to shift gene frequencies rapidly for most traits, even at much higher selection intensities.

Results of the evaluation of cycles of selection in Shaba are shown in Table 29. Significant differences among entries were detected in the ANOVA for days to silk and yield, however, no overall trend was seen in either trait. Days to silk was not expected to change with selection. Yield was high in the cycle 0, then dropped to a low in the C1, and gradually increased to C5. Whether these differences are random, or due to a correlated negative response to husk cover in the first cycle is open to speculation: differences among extreme values were barely significant. Significant slopes were obtained for husk cover, plant aspect, ear aspect, and ear rot scores over cycles. The first three traits were scored only at the four Cameroon sites, while ear rot was also scored at the two Nigerian sites. Given that these traits were principal selection criteria, a response would be expected. Leaf disease resistance would not have been shifted: disease pressure at Mbang Mbirni is light and selection was not made before leaf senescence. P. sorghi was shown to be a problem on Shaba in the more humid Western Highlands, especially at the Bansoa site.

It was expected that Shaba would be quickly replaced by new varieties from MSR or the synthetics, however, the particular adaptation of Shaba to the Adamaoua Plateau (similar to Shaba Province) has made it difficult to surpass at that site. Should it continue to be recommended, selfing to S2 and selection for disease resistance would be advisable, as would introduction of streak resistance.

Kasai. Kasai is the second of the two varieties introduced from the Zaire bilateral program. It is Tuxpeno 1 x Eto, i.e. constitutes half the parentage of Shaba, and was developed for Kasai province, 600-800m altitude. It has a compact plant type with excellent stalk strength and white flint/dent grain. It has

Table 29 Progress over cycles of Shaba

Entry	Days to Silk	Husk Cover 1-5	Plant Aspect 1-5	Ear Aspect 1-5	Ear Rot 1-5	Yield Kg/ha
ShabaC0	75	1.5	2.1	2.2	2.6	6.61
ShabaC1	75	1.3	1.9	2.3	2.8	6.11
ShabaC2	76	1.5	2.1	1.9	2.5	6.23
ShabaC3	74	1.3	1.7	2.1	2.4	6.23
ShabaC4	76	1.2	1.8	1.8	2.6	6.43
ShabaC5	76	1.2	1.5	1.6	2.3	6.65
LSD.05	1	n.s.	n.s.	n.s.	n.s.	0.39
Slope		-0.055	-0.096	-0.123	-0.060	
%/cycle		3.3	4.6	5.5	2.3	
s.e.slope		0.028	0.044	0.041	0.031	
No.Locs.	8	4	4	4	6	9

Note: Slope for Ear Rot, P<.06 that slope=0; P<.05 for other trait slopes.
Note: Yield adjusted for plant stand by covariance analysis.

Table 30 Progress over cycles of Kasai

Entry	Days to Silk	Plant Height cm	Ear Height cm	Ear Aspect 1-5	Ear Rot 1-5	Moisture %	Yield Mg/ha
KasaiC0	76	261	137	2.3	2.6	26.1	6.47
KasaiC1	76	253	132	2.2	2.8	25.5	6.52
KasaiC2	75	253	127	1.9	2.7	25.6	6.19
KasaiC4	75	247	126	1.7	2.5	25.6	6.45
KasaiC5	74	260	132	2.0	2.5	24.9	6.51
KasaiC6	74	262	130	1.3	2.4	24.8	6.77
LSD.05	1	8	7	0.5	n.s.	0.8	0.28
Slope	-0.336			-0.119	-0.048		
%/cycle	0.4			5.2	1.8		
s.e.slope	0.150			0.033	0.021		
No.Locs.	6	7	7	3	5	7	7

been maintained in the Cameroon Western Highlands, at Foumbot and Babungo (1000-1200m), and was released through the on farm testing and liason unit. It is primarily targeted at the fertile Ndop and Noun plains at 1000-1200m altitude, where other varieties are too tall and lodge. Primary selection criteria were again husk cover, ear position, stalk strength, ear rot resistance, and ear size and shape. Ear to row isolation/selection, as described for Shaba above, was used.

Results are shown in table 30. Two sites were omitted from most trait analyses because of severe stand loss. Days to silk and moisture at harvest decreased slightly over cycles, although these were not selection criteria, and were not correlated with yield, which showed no trend. No significant trend was found for plant or ear height. Ear aspect and ear rot showed small but significant regressions over cycles, indicating some progress in selection for these traits (-0.119 and -0.048 units per cycle respectively). Ear aspect was scored only in Cameroon, and ear rot was scored in Cameroon and Nigeria. Leaf blight resistance showed no significant differences or trends, and P. sorghi pressure was insufficient to determine changes.

Kasai, with its excellent plant type and lower altitude adaptation, has found a niche in the Western Highlands on fertile (alluvial, colluvial, and volcanic ash) plains of 1000-1300m altitude. It was therefore converted to streak resistance (now in recombination in Cameroon) and has been used extensively at Jos for inbred extraction from various Kasai x MSR backcross generations. It still carries some sensitivity to E. turcicum and P. sorghi from its lowland parentage, which is only expressed under heavy inoculum loads. It would therefore be prudent to self the SR version to at least S2 stage for improvement of resistance to these leaf diseases.

SEED STORAGE AND DISTRIBUTION

Given the erratic funding and staffing of many national programs in Africa, including Cameroon, there is an ever present risk of losing improved germplasm due to poor storage conditions. It is essential that salient germplasm be placed in international long term storage in order to prevent loss of years of work. In this regard, all advanced inbred lines (Tables 22 and 24), as well as all major populations developed or used in the Cameroon midaltitude program (Appendix 3) have been placed in long term storage at IITA (GRU) and CIMMYT. The first group of advanced lines (Table 22) was also sent to USDA long term storage in Ft. Collins in 1990 for registration through Crop Science (manuscript in preparation), and the second group of inbreds, together with some populations, will follow. It is expected that the registration of the materials will lead to wider distribution: there have been virtually no publically available midaltitude lines in Africa, and only a limited selection of populations.

All germplasm from the program has been provided to CIMMYT-Harare and CIMMYT-Mexico. Advanced inbred lines have been provided to Pioneer-Zimbabwe and Pioneer-Nigeria, bases for the Pioneer midaltitude and lowland maize breeders. A wide range of advanced and segregating lines from the program was in testing by AGSEED Nigeria when that company was purchased by Pioneer. The challenge to IITA will now be in maintaining good quality seed stocks to fulfill expected requests.

Appendix 1 Midaltitude S3 lines selected in testcrosses in Cameroon and Nigeria.

Inbred	Pedigree		S3 Source Cameroon F90A	S3 Row Cameroon F91A	S3 Row Ibadan IB91A-403	Streak Score 1-9 IB91A403
91006	Z27x87A68	-4-1	518-1	006	9	5
91010		-8-1	522-1	010	16	1
91013		-8-5	-5	013	20	1
91016	Z27x88094-104	-2-3	531-3	016	27	3
91027	Z99x88067,69	-2-2	551-2	027	45	1
91028		-3-1	552-1	028	46	1
91033	Z99x88094-104	-1-1	558-1	033	52	2
91034		-1-3	-3	034	54	4
91035		-1-4	-4	035	55	1
91038	M131x87014	-2-2	561-2	038	59	3
91039		-2-3	-3	039	60	1
91045	M131x87046,47	-5-1	567-1	045	72	2
91046		-5-2	-2	046	73	1
91050		-5-6	-6	050	77	1
91061	87014x87A68	-5-2	596-2	061	96	1
91063		-5-6	-6	063	99	1
91074	87014x88067,69	-2-3	604-3	074	115	2
91078		-3-2	605-2	078	120	1
91083		-3-7	-7	083	125	4
91097	87014x88209	-1-1	623-1	097	141	1
91102	87046,47x88010-3	-1-3	624-3	102	147	1
91103		-2-4	625-4	103	149	3
91105		-3-3	626-3	105	154	3
91106		-4-1	627-1	106	157	1
91112		-6-3	629-3	112	165	2
91114	87046,47x88067,6	-2-1	632-1	114	167	5
91115		-2-3	-3	115	168	5
91116		-2-4	-4	116	169	4
91119		-5-2	635-2	119	173	3
91125	87046,47x88094-1	-1-2	639-2	125	180	3
91128		-5-1	643-1	128	183	3
91129	87046,47x88209	-1-1	647-1	129	185	2
91139	88010-36x88067,6	-3-1	673-1	139	200	1
91141	88010-36x87366,6	-3-2	681-2	141	206	2
91142		-3-4	-4	142	207	1
91146		-6-5	684-5	146	211	3
91147		-6-6	-6	147	212	1
91149	88010-36x88209	-1-1	686-1	149	216	1
91155	88083,84xM131	-6-1	710-1	155	230	2
91156		-10-4	714-4	156	232	3
91158	88094-104x87A68	-4-1	723-1	158	235	1
91162	ZS107xAW	-1-5-2	3002-2	162	241	1
91183	Z27xC24	-3-2-2	3151-2	183	275	1
91194	ZS206xAW	-1-1-1	3202-1	194	288	1
91198		-6-7-2	3222-2	198	293	2

Continued next page.

Appendix 1 Continuation

Inbred	Pedigree		S3 Source Cameroon F90A	S3 Row Cameroon F91A	S3 Row Ibadan IB91A-403	Streak Score 1-9 IB91A403
91206	ZS227xAW	-10-4-1	3307-1	206	307	1
91207		-11-1-1	3308-1	207	308	1
91216	H625xAW	-4-2-3	3341-3	216	325	2
91223	H8102xAW	-11-1-4	3375-4	223	335	3
91224	EV8443SRxAW	-3-3-2	3571-2	224	337	1
91226		-12-1-2	3597-2	226	339	1
91228	EV8422SRxAW	-15-1-1	3636-1	228	343	1
91229		-15-3-1	3638-1	229	345	2
91231		-15-5-4	3640-4	231	350	2
91245	EV8443SRxAW	-38-1-2	3806-2	245	373	1
91259	U01x87036	-2-3	741-3	259	386	2
91260		-2-4	-4	260	387	1
91265	U01x88060	-1-2	747-2	265	396	3
91269	U01x87923	-2-3	755-3	269	404	1
91271		-4-5	757-5	271	410	1
91273		-5-4	758-4	273	416	1
91276	M87x88084	-2-1	765-1	276	419	1
91277	M87x87923	-6-1	772-1	277	423	1
91279		-6-3	-3	279	425	1
91282	C70x88030-44	-1-1	781-1	282	432	1
91288	C70x87923	-3-3	786-3	288	441	1
91293		-3-8	-8	293	446	1
91298	87036x88030-44	-3-1	791-1	298	456	1
91300	87036x88060	-1-3	794-3	300	459	1
91303		-2-2	795-2	303	462	2
91305	87036x87923	-1-3	800-3	305	469	1
91309		-2-2	801-2	309	473	1
91313		-4-4	803-4	313	481	1
91314		-4-5	-5	314	482	1
91315		-5-1	804-1	315	483	1
91329	88030-44x87923	-3-3	817-3	329	505	1
91330		-3-4	-4	330	506	1
91340		-6-3	820-3	340	517	2
91359	H625xBW	-8-1-3	3115-3	359	555	3
91364	H8102xBW	-14-2-1	3538-1	364	581	3
91369	H625xBW	-13-3-3	3929-3	369	600	3
91373	ZS206xBW	-19-2-6	4014-6	373	613	2
91375		-28-3-2	4038-2	375	619	1
91501	C70x87070	-3-1	777-1	501	428	1
91502	F88A,S3	-30-1-3	393	n/a	640	2

Note: Lines 91006 to 91245 are "A" group, others are "B" group.

Appendix 2 New varietal and inbred source synthetics: inbred components.

Varietal Synthetics	
Jos Syn5	Jos Syn6
M131	91045
90113	91106
90183	91128
90188	91142
90219	91206
Z28	91224
89302	91226
89291	91259
90313	91277
90323	91501
90332	91300
89343	91313
89365	91330
89223	91502
87036	

Source Synthetics	
Jos SynA6	Jos SynB6
M131	90313
90113	90323
90183	90332
90219	89343
Z28	89365
89302	89223
89291	87036
91045	91277
91106	91330
91128	91502
91142	
91206	

Appendix 3

POPULATIONS AND SYNTHETICS FOR LONG TERM STORAGE

1. High Altitude Population.
Objective: Provide varieties for high altitudes (1600-2000m)

Composition:

Material	Source
Highland Hybrids	Kenya
Pool9a	CIMMYT
V301,V304	Guatemala
MSR	IITA
Dekalb 690	Dekalb
SR52, ZS206	Zimbabwe
Ndu Local	Cameroon

Status: Three cycles recombination followed by two cycles half-sib family selection (3 locations, 2 replications, approximately 350 families) were completed. HAP has been tested as a variety since 1989. Resistance to Phaeosphaeria maydis, a leaf spot prevalent in the area but only recently identified, is required.

2. Acid Tolerant Population.
Source: IB91B-C8-904
Objective: Provide yellow flint grained varieties tolerant to acid soils of midaltitude zone.
Composition:

Material	Source
ESAL QYF3, Q5VF1	Brazil
CMS 36 SAFRI	CIMMYT/Brazil
HE1066, 1049	Limagrain
Suwan 1	Thailand
Across 7728	CIMMYT
COCA	Cameroon
Shaba	Zaire
MSR	IITA

Status: Three recombinations followed by four cycles of half sib family selection have been completed: two locations with two reps/location of approximately 300 families are tested each cycle. ATP needs improvement for rust resistance, as parents are primarily lowland materials. Selection for streak resistance was made at Ibadan in 1991 by selfing and recombining under streak pressure.

3. Early White Population.
Source: IB91B-C8-901
Objective: Provide early maturing, white grained varieties for the midaltitudes.
Composition: CIMMYT subtropical Population 34
Early maturing lines extracted from MSR in Cameroon.
Status: Three cycles of full sib and half sib family testing were completed in Population 34 in Cameroon, followed by testcrossing early MSR inbreds onto Population 34. Selected testcrosses **per se** were recombined to form the population, which is being tested as a variety. Disease resistance, ear tip cover, earliness, and flinty grain are principal selection criteria. Early White was reselected for streak resistance at Ibadan in 1991 by selfing and recombining under streak pressure.

4. **EMSR-Cameroon reselection.**
Source: Jos 91A-415-3
Objective: Provide early maturing, white grained varieties for the midaltitudes.

Composition: See IITA reports.
Status: EMSR was formed by Dr. Kim at Jos. It was forwarded to Cameroon, where it was selected under <u>Exserohilum turcicum</u> and <u>Puccinia sorghi</u> pressure and selfed to S3's/S2 families. Selected families were recombined twice. Improvements in leaf disease and ear rot scores were noted in the 1991 Jos trials, comparing it to EMSR of Jos origin.

5. **Synthetic 4 White.**
Source: IB91B-EN7-909
Objective: Late white grained high yield midaltitude variety.

Composition: M87, M131, 87036, 88069, 89199, 89243, 89258, 89292-89293, 89302, 89310.
Status: Recombination of the best combining inbreds began in 1989B at Foumbot. Syn4 is the highest yielding o.p.v. tested in 1991. It was reselected for streak resistance by selfing and recombining under streak pressure at Ibadan. White kernels were sorted.

6. **Synthetic 4 Yellow.**
Same as Syn4 White, except yellow kernels were selected from last recombination. It is heterozygous for color.

7. **Synthetic 3.**
Source: IB91B-EN7-910
Objective: Late white grained high yield midaltitude variety.

Composition: M87, C70, U01, M131, 87036, 87047, 87369, 87A68, 87B68, 87958, 87923, 88010, 88014, 88015, 88018, 88028, 88029, 88030, 88033, 88036, 88044, 88060, 88067, 88069, 88084, 88097, 88099, 88103, 88104, 88209, 88210.
Status: Recombined three times and placed in trials. Reselected for streak resistance in Ibadan by selfing and recombining under streak pressure.

8. **Population 32, midaltitude.**
Source: Jos 91A-415-2
Objective: Midaltitude adapted Eto population suitable for crossing/inbred extraction.

Composition: CIMMYT Population 32, reselected.
Status: Selfed to S3 lines at Foumbot, Cameroon, under <u>E. turcicum</u> and <u>P. sorghi</u> disease pressure, recombined twice, selfed to S3 as before, recombined twice. Rust and blight resistance moderate to good, but not streak resistant. Used in crosses with SynA4 for inbred extraction. Compact plant type with white flint grain.

9. **Population 43SR, midaltitude, bulk S2 seed.**
Source: Jos 91A-413
Objective: Midaltitude adapted Tuxpeno population suitable for crossing/inbred extraction.

Composition: CIMMYT Population 43SR, reselected.
Status: Selfed to S2 at Foumbot, Cameroon, under E. turcicum and P. sorghi pressure, recombined twice, selfed to S1 at Foumbot, and to S2 at Jos under heavy E. turcicum pressure. Seed provided is bulk across S2 lines.

10. **Synthetic A4.**
Source: Jos 91A-412:1-14
Objective: Source synthetic for A group inbred extraction.

Composition: Z28, 87014, 87366, 88069, 89258, 89302
Status: Recombined twice.

11. **Synthetic B4.**
Source: Jos 91A-412:15-28
Objective: Source synthetic for B group inbred extraction.

Composition: C70, 88099, 89223, 89242, 89274, 89292
Status: Recombined twice.

12. **MSR-su Sweetcorn.**
Source: IB91B-C8-903
Objective: Midaltitude sweetcorn variety with su gene.

Composition: MSR and Syn3 recurrent parent, BC2, with various su-2 sources.
Status: BC2 recombined twice, selfed and recombined under streak pressure, mixed color.

13. **MSR-sh Sweetcorn.**
Source: IB91B-C8-902
Objective: Midaltitude sweetcorn variety with sh gene.

Composition: MSR recurrent parent, BC3, recombined three times, selfed and recombined under streak pressure, mixed color. Poor germination.

14. **Shaba.**
Source: Jos91A-415-15

Composition: H632xSR52xEtoxTuxpeno (Mix1 x Col. Gpo.1) recombined.
Status: Variety was formed by CIMMYT team in mid 1970's in Zaire. It was released on the Adamaoua Plateau of Cameroon and maintained as ear to row selection/recombination at Mbang Mboum IRA station in Cameroon. Late white midaltitude variety performing well on the Adamaoua Plateau but too sensitive to P. sorghi for the Western Highlands.

15. **Kasai.**
Source: Foumbot 90A Isolation.

Composition: EtoxTuxpeno (Mix1 x Col. Gpo.1) recombined.
Status: Variety was formed by CIMMYT team in mid 1970's in Zaire. It was released in the Western Highlands of Cameroon, targeted to good soils at 1000-1300m altitude. Short plant type white low to midaltitude variety with excellent stalk quality. Maintained as ear to row selection/recombination at Foumbot and Babungo IRA stations in Western Highlands. Streak resistant backcross-3 version under recombination in Cameroon.

16. **MIR Syn1B.**
Source: Jos 91A-415-1

Composition: Primarily E. turcicum resistant temperate inbreds.
Status: Formed by Dr. J. Brewbaker, Univ. Hawaii. Primarily yellow flint/dent, short plant type. Maintained by bulk pollination in Cameroon and used in crosses for inbred extraction.

17. **Ecuador 573.**
Source: Jos 91A-415-14

Composition: Population from highlands of Ecuador.
Status: One of the two heterotic source populations in the Kenya 600 series hybrid program at Kitale. Obtained from the Kenya recurrent selection program in 1985 and maintained by hand pollination in Cameroon. Excellent source of E. turcicum and P. sorghi resistance. Unadapted in low midaltitudes; used in crosses with lowland material as source of midaltitude inbreds.

18. **Kitale 2.**
Source: Jos 91A-415-13

Composition: Kenya flat white developed at Kitale, Kenya. Second of two heterotic source populations in the Kenya 600 series hybrid program at Kitale. Obtained from the Kenya recurrent selection program in 1985 and maintained by hand pollination in Cameroon. Good source of E. turcicum and P. sorghi resistance. Very tall in midaltitude zone: used in crosses with short lowland material as source of midaltitude inbreds.

19. **EV8190.**
Source: Jos 91A-415-10

Composition: East Africa mid-high altitude varieties. Related to CIMMYT Pool9a.
Status: Population 90 was developed in Tanzania as a high midaltitude late white variety.

20. **EV8192.**
Source: Jos 91A-415-12

Composition: (Check Tanzania reports, some Tuxpeno background)
Status: Population 92 was developed in Tanzania as a late white midaltitude variety. Maintained by hand pollination in Cameroon. CIMMYT-Harare team is obtaining excellent inbreds with Population 92 crossed onto Population 44SR.

21. **Kilima 7992.**
Source: Jos 91A-415-11

Composition: Another variety selected from Tanzanian Population 92.
Status: See EV8192 description.

22. **Population 62.**
Source: Jos 91A-415-9

Composition: Tanzanian late white midaltitude population.