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SORGHUM GRAIN MOLD IN SENEGAL

METHODS USED FOR IDENTIFYING RESISTANT VARIETIES

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The need, in intensive agriculture, for early maturing sorghum varieties (this fits in better with the duration of the rains, and allows end of season ploughing) has led to recently in Senegal to a problem which was previously unknown - grain moulds. Early varieties mature when atmospheric humidity is high, heavy dew falls and usually before the last rains fall. In these circumstances their grains are frequently mould covered, which causes several problems.

- grain appearance is spoilt: sometimes they turn pinkish, grey or black making them unacceptable
- intrinsic qualities are changed, mouldy grains become more floury and are less suitable for making bread
- germinability is reduced
- sometimes sorghum diseases can be transmitted on infected grains
- and finally, but this is not confirmed, certain *Fusarium* sp. of the roseum group may produce mycotoxins.

For these reasons it is necessary to identify sorghum varieties which are resistant to moulds.

1. Methods used for identifying mould resistant sorghums

11. Conditions for conducting field trials

111. Natural conditions. This technique is consciously or unconsciously used by all breeders. The breeder picks plants with the best looking panicles from plants cultivated in normal conditions, automatically eliminating the most moldy panicles. In fact it is often not known if the selected panciles are actually resistant to grain mold or if they have escaped since climatic conditions were unfavourable to the growth of fungi when the grains were at a susceptible stage.

112. Early sowing. High humidity at the time of grain maturation favors mold growth. Therefore as far as the material conditions permit, the plants to be tested for mold resistance should be sown before the start of

the rainy season on irrigated land so that the grains mature when the rainfall is still heavy. This method is particularly used at the CNRA Bambey.

113. Sowing in very wet areas. In order to encourage mold development, the tests can be set up in an area which is wetter than the one for which the varieties are bred. Thus the sorghum breeder sets up tests in Sefa, Casamance (average rainfall 1,250 mm), whereas the varieties are bred for 750 - 900 mm rainfall zones.

114. Bagging the panicles. A moist chamber is created by placing selfing bags (around the panicle). This should logically encourage mold development. But in fact the results apparently vary according to the case: sometimes mold damage increases, but sometimes bagging apparently protects the grains.

115. Delayed harvesting. Delayed harvesting long after physiologic maturity allows the molds to develop and damage the grains if the fungi were present during grain development. Different varieties should not be harvested the same day but a fixed number of days after each has attained physiological maturity.

116. Artificial inoculations. Panicles can be artificially inoculated to ensure that they do not escape mold infection. It is a simple principle: the mold is cultivated in artificial conditions, the panicles are sprayed with a suspension containing the mold spores, the panicles are then kept in an environment which is favourable to mold growth. But in practice this is not easy and involves several operations. This method should in fact be reserved for testing lines which have already shown resistance in natural conditions. At present this method is being used by an ICRISAT pathologist at Hyderabad who inoculates sorghum lines with *Curvularia lunata* and *Fusarium* spp strains.

The technique was experimented in Bambey in 1972 with *Fusarium moniliforme* but the results were disappointing showing the same infection rate as in the inoculated panicles. These experiments have not been repeated since then in Senegal.

12. Methods for analysis and evaluation of molds

121. Overall observation of the panicles. This is also a notation which is currently employed by breeders, either in the field or for laboratory selections. Molds affect grain appearance strongly particularly the "tan" varieties, by using this method the breeder eliminates the most moldy varieties. It is quite obvious that this type of notation is inadequate.

ICRISAT has suggested a notation for panicles in the field, according to the proportion of moldy grains (the actual problem of molds) and the degree to which the rachis and its ramifications are attacked (problem of head blight or dry rot of the panicle). The following scale has been used:

1. no mold;
2. scanty superficial mold growth on the rachis ramifications and on the glumes, grains generally mold free;
3. considerable mold growth on the rachis and upto 25% of the grains obviously mold;
4. considerable mold growth on the rachis and the glumes and 26-50% of the grains obviously moldy;
5. panicle severely molded and more than 50% of the grains discolored and covered with mold.

122. Notation of varieties by comparing with a range of moldy grain. This technique was developed by Dr. N. Zummo. Grain samples are observed through a magnifying lens and are classified by comparing them with a range of grains consisting of 10 samples with an increasing degree of moldiness (from 1 = strictly mold free till 10 = completely moldy grains).

Colored and light colored grains can be noted separately since grain color is a visual impression and if colored and light colored grains are noted together, colored grains are marked unfavourably. Hundreds of samples can be observed by this simple and viable method. It is very frequently used at the CNRA Bambey in the primary stages of breeding operations for mold resistance.

1 = mold-free grain or with scanty mold growth;

2 = 1-9% of the visible surface of the grain covered with mold;

3 = 20-79% of the visible surface of the grain covered with mold;

4 = more than 80% of the visible surface of the grain covered with mold;

An index is calculated on the basis of these notations:

$$i = \frac{n1 \times 0 + n2 \times 10 + n3 \times 50 + n4 \times 100}{N}$$

where n1, n2, n3, and n4 are the numbers for the grains classified in the categories 1, 2, 3, and 4 respectively and N is the total number of grains observed in the sample. Generally 4 samples of 50 grains each are observed.

Petri dishes are placed in an incubator at 27°C for 24 hours for the fructification of the mold. They are then identified by means of binocular magnifying lens.

Since the grains are disinfected before incubation, the advantage of this method is that it is undertaken regardless of the fact that the mold has penetrated the grain teguments. Samples which appear to be mold free but are in fact infected can thus be eliminated. Finally the fungi which is involved can be magnified for observation. This method has two

disadvantages: it cannot be used for screening a large number of varieties as it is long and tedious, moreover the same person has to conduct the observations since visual estimation of the moldy surface varies greatly with each observor. It is therefore reserved for a detailed study of the samples i.e. those which have already passed the first stages of the breeding operations.

124. Germination and harvest tests. Seeds are germinated in incubators on moist filter paper or in the field and the percentage of seeds which have developed into seedlings is noted after a given interval of time. Generally these tests are easy and there is apparently a good correlation between mold damage and the harvest. This reveals the internal mold damage. These tests are most useful for sorghum grains which are to be used as seed.

None of these tests are adequate; they are complementary and as a whole they are an effective instrument in breeding operations for grain mold resistance.

2. Some Results

21. Sorghum grain fungi found in Senegal. They are as follows:

-*Alternaria tenuis*, *Aspergillus* sp., *Choanephora* sp., *Cladosporium* sp., *Colletotrichum graminicola*, *Colletotrichum* sp., *Curvularia* spp., *Fusarium moniliforme*, *Fusarium roseum*, *Gloeocercospora sorghi*, *Gonatobotrys* sp., *Helminthosporium* spp., *Penicillium* sp., *Phoma* sp., *Nigrospora* sp., *Ramularia* sp., and other unidentified genera.

In spite of the strange appearance of the panicle covered by *Choanephora* sp., it is apparently absolutely harmless. It appears on the drying floral parts and disappears when they fall.

All the other fungi mentioned above can be found on maturing grains. The most common ones are: *Fusarium*, *Curvularia*, the Sphaeropsidales (including *Phoma* sp.) and *Helminthosporium*. *Colletotrichum graminicola* is also a causative agent of anthracnose (leaf spot, stem rot and head blight). *Gloeocercospora sorghi* causes zonal spots. In the latter cases grain infection is a sure means for conserving and propogating these diseases.

Certain grains which are placed in moist chambers are attacked by bacteria. They are perhaps responsible for certain bacterial diseases currently found in Senegal (Bacterial streak = *Xanthomones holciocola* in particular).

22.22. Comparative study of grain mold in Bambey, Nioro and Sefa

221 Description of the study. This study was begun in 1975. In the beginning Prof. R.A. Frederiksen* had proposed conducting comparative study of the mycoflora of the sorghum grains in Texas, Nigeria and Senegal.

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Four American varieties of sorghum (1 = NKX 3183, 2== B 3197, 3 = TAM 680 and 4 = TAM 428) were planted in different countries and harvest samples were sent to Dr. S.B. Mathur* for analysis. In Senegal these varieties have been planted in Bambey, Nioro-du-Rip and Sefa, along with three samples from Senegal (5 = CE 90, 6 = 7420.062.2 and 7 = 7403.048-1) and one Indian sample which is highly susceptible to mold (8 = M.35-1). Laboratory analyses were conducted at Bambey and Cophenhagen. Unfortunately the Copenhagen results have not yet arrived and only the Senegal results will be reported.

The following are the notations for grain samples of each specimen in each place:

1/-Estimation of molded grain surface (cf. 123);

2/- Determination of the rate of non-germinated seeds in gelose water after a 4-day incubation period at 27°C;

3/- Determination of the rate of non-germinated seeds on filter paper after a 4-day incubation period at alternate temperatures: 12 hours at 20°C, 12 hours at 30°C. (analysis by the seed production service of the CNRA of Bambey);

4/- Determination of the rate of non-germinated seeds and of abnormal seedlings after a 10-day incubation period on filter paper at alternate temperatures: 12 hours at 20°C, 12 hours at 30°C. (analysis of the seed production service of the CNRA of Bambey);

5/- notation according to the Zummo scale (cf. 122);

6/- Determination of the proportion of grains carrying *Fusarium spp.* (cf. 123);

7/- Determination of the proportion of grains carrying *Curvularia spp.* (cf. 123);

8/- Determination of the proportion of grains carrying *Helmintosporium spp.* (cf. 123);

9/- Determination of the proportion of grains carrying pycnides fungi (cf. 123);

10/- Determination of the proportion of grains carrying *Colletotrichum spp.* (cf. 123).

4 samples were noted for each treatment, except for criteria 3, and 4, for which only one sample was examined, and for 5 for which 4 observations were made for varieties 5, 6 and 7 and only 1 for the others.

Correlation studies were undertaken for collecting all these data, but variance analyses were only conducted for criteria 1, 2, 6 and 9.

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222. Results - Interpretation. Observation averages are given in tables (iii and IV at the end of the text (pages 11-15).

* Correlations (table 1)

The correlation study on all the data shows the following:

-Notation criterium 1, i.e. the estimation of the molded grain surface is positively related to the 1% level of criteria 2, 3 (percentage of non-germinated seeds), 4, (percentage of non-germinated seeds and abnormal seedlings), 5 (Zummo scale) and 6 (percentage of grains carrying *Fusarium sp.*.), and negatively related to the 1% level of 9 (percentages of grains carrying pycnides fungi), but it is not related to 7, 8, and 10 (percentage of grains carrying *Curvularia spp.*, *Helminthosporium spp.* *Colletotrichum spp.* respectively); however correlation coefficients are clearly higher in the case of criteria 2, 3 and 4 than in the case of 5 and 6.

Therefore the larger the molded surface, the more difficult it is for the seed to germinate. Germination tests which are easy to conduct in standard conditions would be of great use in the study of molds. If the fungi are taken into consideration, the *Fusarium* would greatly influence the conditioning of the molded grain surface whereas *Curvularia* and *Helminthosporium* have a slight or no influence. Pycnide funig vary in inverse proportion to the molded grain surface.

The last statement can be explained by the fact that pycnide fungi develop in the form of small spots on the grains, therefore the molded surface appears to be small in comparison to that covered by other fungi; it is also possible that the pycnides are only visible on not too modly grains.

-criteria 2, 3 and 4 concerning seed germination are obviously strongly interrelated, and with criterium 1 (molded grain surface) and 6 (*Fuscrium*). As in the case of 1, they are negatively related with criteria 7 (*Curvularia*) and 8 (*Helminthosporium*).

Fusarium would apparently harm germination unlike *Curvularia* and *Helminthosporium*.

-criterium 5 (Zummo scale) is positively related to all the other criteria, except 7 and 8 to which it is negatively related. This shows that it is of general use.

-For the criteria involving the different fungi an inverse relation has been observed between 6 (*Fusarium*) and 7 and 8 on the other hand (*Curvularia* and *Helminthosposporium*) is this a case of competition or the law of the first occupant.

The same can be said of criteium 9 (pycnides) whereas between 6 and 9 there is no significant correlation. 10 (*Colletotrichum spp.*) is positively related to 4 and 5 and negatively to 8 and 9. Thus it can be assumed that besides giving a bad appearance to the grains, *Colletotrichum* probably causes grain deterioration which consequently leads to abnormal seedlings (criterium 4).

* Variance analysis of all the data

The results of the homogeneity tests of the variances have enabled the analysis of the combined data from the 3 places, related to criteria 1 (molded surface), 2 (non-germination), 6 (*Fusarium*) and 9 (pycnides) which are more important for the determination of the most general criterium 1.

These analyses indicate that places and varieties are distinctly different from each other, and that there exists an interaction between the varieties and places (See table 11: Analysis of global variance).

The results apparently suggest the need to conduct tests in several places in order to obtain elite varieties resistant to differenttypes of molds.

In the case of criterium 1, the varieties are distinctly different, with variety 3 as the best and variety 8 as the worst.

For criteria 2, 6 and 9 the varieties do not differ so greatly (see table III). These results confirm the sound choice of criterium 1 for comparing the varieties. On the other hand criterium 1 cannot be used for differenciating the 2 southern stations, Nioro and Sefa, whereas the other criteria 2, 6 and 9 show the difference (see table IV). Generally the disease is more severe in Nioro and in Sefa than in Bambey.

*Variance analysis of separate data from Bambey, Nioro, and Sefa

Results indicate that highly significant differences exist between the varieties everywhere except for criterium 6 (*Fusarium*) in the Bambey test (see table 5).

Table VI shows the variety averages per place for each of the criteria 1, 2, 6 and 9. It confirms that variety 3 is one of the best, varieties 4 and 8 remain the worst. Variety 1 was the least affected by *Fusarium* in the 3tests. At Nioro, besides varieties 4 and 8 which are the worst, all the other varieties showed the same performance regarding germination and susceptibility to *Fusarium*.

223. Conclusion of this study

This method has enabled quite an accurate study of the reaction of 8 sorghum varieties to molds as seen in 3 locations in Senegal where they were grown. Several conclusions can be drawn:

- importance of scale 1 (estimation of molded grain surface) for separating the varieties. The obvious disadvantage of this method is that it is slow and can only be used for specific studies;

- importance of germination studies which are easy to conduct in standard conditions, and in close correlation with 1. However they do not necessarily give a clear picture of the health of the grains since they can also be influenced by other factors: intrinsic properties of the varieties, state of grain maturity etc.

- considerable importance of *Fusarium*: the rate of grains carrying these fungi seems to coincide with the estimated molded surface and the rate of non-germinated seeds;

- results for the other fungi are less consistant and more detailed studies are required;

- differences between the places: mold incidence is more severe in Nioro and Sefa than in Bambey.

- finally among the tested varieties, 1 and 3 appear to be the best whereas 4 and 8 are the worst. Among the others 4 is definitely the least good variety.

23. Example of the use of the Zummo scale for the 1975 screenings

231. The test. Fifty-four F_5 lines from the same cross were planted iith the parents in a random bloc test with 4 replicates at 3 experimental stations in Senegal having different ecological conditions, viz. Bambey, Nioro and Darou. These lines had already undergone 2 breeding cycles for better looking grains. While harvesting, a sample was taken from each plot. Each of these samples was marked by three observors according to the Zummo scale. This was done twice with a time interval between the two markings. According to this scale 1 is for a mold-free sample and 10 is for a completely molded sample. A global analysis for the 3 places was made on the basis of the total number of marks given by the 3 observors.

232. Results

*Variance analysis.

The results of the combined variance analysis for the 3 places are given in table VII. All the sources of variation viz. varieties, places and interactions are highly significant. Once again it is seen that molds vary from place to place and varieties do not react in the same way everywhere. This implies that varieties must be tested in several places and that a variety may perform well in one place but not in another. But that does not mean that it is impossible to find a variety which performs well in several areas.

*General performance of the varieties

The general averages of the observations for the different varieties are given in Table VIII. In the scale used the smallest possible value is 3 and the biggest is 30 (the sum of 3 observations with a 1-10 scale) which led to a theoretical averages of 16.5, whereas the smallest value in the test is 15.29, the biggest is 19.17 and the average is 16.80. It can therefore be concluded that most of the varieties have an average performance vis-a-vis molds, apart from varieties 28, 34, 36, 37, 5, 9, 41 and 25 which are apparently the best and varieties 50, 51, 60, 61 and 29 which which are visibly the worst.

233. Conclusion. In this particular case, the Zummo scale has proved to be a quite useful for sorghum breeding for mold resistance, since in a group of varieties with limited variability in terms of performance vis-a-vis molds, the application of this method has however enabled the differenciation of the varieties. However a large number of observations were used and since the grains were of a light color, notation made easier.

3. General conclusion

Each of the methods described has its own use and none of them can be used exclusively. Besides, it is logical to use several methods together, at least criteria 1 (estimation of molded surface), 2 (germination test), 5 (Zummo scale) and 6 (*Fusarium*). In practice the Zummo scale is used in the primary stages of breeding, operation, reserving more detailed studies for the advanced stages or for more specific research.

4 TABLES OF THE RESULTS

TABLE 1
1975 COMPARATIVE STUDY OF SORGHUM GRAIND MOLD
CORRELATION COEFFICIENTS [a.b]

	2	3	4	5	6	7	8	9	10	
B	.765	.764	.623	.574	-1168	.304	.317	-.392	.206	
N	.587	.857	.767	.302	.518	.073	-.265	-.479	-.123	
S	.659	.735	.523	.140	.484	-.071	-.127	-.403	-.270	1
G	.267	.674	.500	.351	.359	-.029	-.088	-.304	-.097	
	B	.771	.657	.292	.091	.292	.201	-.562	.526	
	N	.736	.723	.522	.448	-.143	-.365	-.277	-.098	
	S	.851	.738	.375	.420	-.226	-.053	-.526	.079	2
	G	.882	.822	.645	.427	-.273	-.397	-.144	.147	
		B	.896	.315	.125	.030	.137	-.489	.438	
		N	.898	.461	.616	-.081	-.400	-.566	-.044	
		S	.817	.541	.372	-.381	-.025	-.618	.163	3
		G	.917	.724	.489	-.411	-.491	-.123	.198	
			B	.230	.260	.150	.172	-.618	.568	
			N	.268	.671	-.202	-.370	-.535	-.085	
			S	.193	.453	-.040	-.082	-.689	.306	4
			G	.625	.483	-.328	-.485	-.105	.243	
				B	-.278	-.026	.034	.098	-.026	
				N	.155	-.040	-.064	.050	-.238	
				S	-.102	-.578	.065	-.247	.415	5
				G	.298	-.498	-.509	.218	.271	
					B	-.101	-.070	-.217	.440	
					N	-.490	-.423	-.302	-.221	
					S	-.166	-.315	-.454	-.132	6
					G	-.480	-.432	-.049	.112	
						B	.452	-.652	.060	
						N	.197	-.212	.061	
						S	.232	.239	-.064	7
						G	.530	-.388	-.180	
							B	-.384	-.171	
							N	.345	-.099	
							S	.242	-.243	8
							G	-.353	-.217	
								B	-.527	
								N	-.112	
								S	-.588	9
								G	-.248	

B = Bambey
N = Nioro
S = Sefa
G = Global

1. Surface evaluation of moldy grains
2. Proportion of non-germinated seeds in gelose water
3. Proportion of non-germinated seeds on filter paper
4. Proportion of non-germinated seeds and abnormal seedlings
5. "Zummo" scale
6. Proportion of grains carrying Fusarium spp.
7. Proportion of grains carrying Curvularia spp.
8. Proportion of grains carrying Helminthosporium sp.
9. Proportion of grains carrying Sphoeropsidales (pycnides)
10. Proportion of grains carrying Colletotrichum spp.

a=Significance levels for Bambey, Niro & Sefa, at 5%; .350, at 1%: .450
b=Significance levels for the combined results (global) at 5%; .205, at 1%: .267

TABLE II

1975 COMPARATIVE STUDY OF SORGHUM GRAIN MOLDS

ANALYSIS OF GLOBAL VARIANCE

Source of variation	D.F.	1.Moldy surface Variance	2.Non-germinated Variance	6.Fusarium Variance	9.Pyonides Variance
Place	2	358.553**	11,323.167**	1,516.292**	1,771.885**
Variety	7	2,087.842**	2,672.613**	327.613**	1,673.499**
Place & variety	14	51.639**	351.167**	144.577**	165.552*
Error	72	0.280	100.181	40.403	76.497
Total	95	-	-	-	-
C.V. = %		2.5%	16.9%	12.1%	26.1%

N.B.: * = 5% significance level

** = 1% significance level.

TABLE III

1975 COMPARATIVE STUDY OF SORGHUM GRAIN MOLDS

AVERAGES OF THE OBSERVATIONS

Criteria notations / Varieties		1 Moldy surface	2 Non-germi-nated 1	3 Non-germi-nated 2	4 Non-germi-nated+ Abnor-mal	5 Zummo scale	6 Fusarium	7 Curvu-laria	8 Helm-inth-ospo-rium	9 Pyc-nides	10 Coll-ecto-trium
1	Bambey	10.90	22.00a,b	8.00	20.00	4.00	39.00	19.00	10.00	44.50	0.00
1=NKX-3183	Nioro	16.15	71.00	53.50	83.50	6.00	48.00	18.00	3.00	47.50	0.00
	Sefa	14.00	57.50	52.00	66.00	6.00	46.50	5.50	2.00	56.50	0.00
	Av.	13.60b	50.17a,b	37.83	56.50	5.33	44.50a	14.17	5.0	49.50c	0.00
2	Bambey	15.00	18.00	8.00	15.00	5.00	43.50	14.00	3.50	5.00	0.00
2=B-3197	Nioro	19.75	67.00	55.50	77.50	6.00	50.00	12.00	3.50	48.00	0.00
	Sefa	18.75	52.50	43.00	52.00	6.00	54.50	7.00	0.00	53.50	2.50
	Av.	17.83d	45.83a	35.50	48.17	5.67	49.33a,b	11.00	2.33	50.50c	0.83
3	Bambey	8.95	35.50	12.00	18.00	4.00	44.00	28.00	10.50	28.00	0.00
3=TAM-680	Nioro	12.00	57.00	45.00	79.50	4.00	51.00	16.50	2.00	32.25	2.50
	Sefa	11.90	51.50	35.00	77.00	4.00	61.00	24.00	0.00	46.00	3.50
	Av.	10.95a	48.00a,b	30.67	58.17	4.00	52.00b	22.83	4.17	35.42b	2.00
4	Bambey	11.20	44.00	45.00	72.00	4.00	55.50	16.00	4.50	18.00	5.00
4=TAX-428	Nioro	20.90	87.50	83.00	93.00	6.00	62.00	5.50	0.00	27.00	4.00
	Sefa	15.80	79.50	81.00	94.50	7.00	59.50	3.00	0.00	17.00a	25.50
	Av.	15.97c	70.33c	69.67	86.50	5.67	59.00c	8.17	1.50	20.67a	11.50
5	Bambey	13.00	30.00	9.00	47.00	4.63	47.00	32.50	11.50	19.50	3.00
5=CE90	Nioro	13.90	74.50	58.50	81.50	6.00	43.50	25.50	4.00	32.00	0.50
	Sefa	12.85	63.50	51.50	76.00	6.13	62.00	10.50	1.50	54.00b	3.50
	Av.	13.25b	56.00a,b	39.53	68.17	5.59	50.83a,b	22.83	5.67	35.17	2.33
6	Bambey	13.40	21.00	10.00	36.00	3.75	47.50	32.00	12.50	22.50	0.50
6=7420-062-2	Nioro	22.45	67.00	66.00	81.00	6.13	54.00	23.50	0.50	35.00	0.00
	Sefa	34.30	71.00	65.00	80.00	5.88	75.00	7.50	0.00	34.50b	0.00
	Av.	23.38f	53.00a,b	47.00	65.67	5.25	58.83c	21.00	4.33	30.67b	0.17
7	Bambey	17.00	52.00	12.00	28.00	4.00	51.50	32.50	8.00	14.00	4.50
7=7403-048-1	Nioro	22.40	72.00	66.50	80.00	5.75	44.50	25.00	2.00	30.00	9.00
	Sefa	22.95c	53.00	45.50	71.00	5.88	53.50	19.00	0.00	35.00	15.50
	Av.	20.78c	59.00b	41.33	59.67	5.21	49.83a,b	25.50	3.33	26.33ab	9.67
8	Bambey	47.40	81.00	63.50	79.50	5.00	42.50	32.00	15.00	10.50	3.00
8=M.35.1	Nioro	56.15	94.50	98.00	98.00	6.00	62.00	20.50	1.00	18.00	0.00
	Sefa	52.45	97.00	98.00	99.00	6.00	68.00	11.00	0.50	29.50	0.50
	Av.	52.00g	90.83d	86.50	91.83	5.67	57.50c	21.17	5.50	19.33a	1.17

NB: Values with different letters (a,b,c ...) are significantly different from the 5% level for the criterium under consideration (Keuls test)

TABLE IV

1975 COMPARATIVE STUDY OF SORGHUM GRAIN MOLDS

DIFFERENCE BETWEEN THE PLACES

	1. Moldy surface	2. Non-germinated	3. Fusa-rium	9. Pycnides
Bambey	17.11[a]	37.94[a]	46.31[a]	25.88[a]
Nioro	22.96[b]	73.81[c]	51.88[b]	33.72[b]
Sefa	22.84[b]	65.69[b]	60.00[c]	40.75[c]

TABLE V

COMPARATIVE STUDY OF SORGHUM GRAIN MOLDS

PLACE-WISE ANALYSIS OF VARIANCE

Source of variation		D.F.	Variance			
			Moldy surface	Non germinated	Fusarium	Pycnides
Varieties	Bambey	7	624.390**	1,769.268**	111.125	814.214**
	Nioro	7	780.159**	572.839**	201.929**	403.817**
	Sefa	7	784.003**	1,032.839**	313.714**	786.571**
Replicates	Bambey	3	0.065	335.375*	1.642	8.167
	Nioro	3	0.218	184.542	42.833	353.031**
	Sefa	3	0.353	59.458	117.667	141.000
Error	Bambey	21	0.265	93.506	34.554	90.452
	Nioro	21	0.249	90.923	25.976	45.746
	Sefa	21	0.302	108.220	47.000	54.333
Total	Bambey	31				
	Nioro	31	-	-	-	-
	Sefa	31				
Coefficient of variation	Bambey		3.0%	25.5%	12.7%	36.8%
	Nioro		2.2%	12.9%	9.8%	20.1%
	Sefa		2.4%	15.8%	11.4%	18.1%

TABLE VI. 1975 COMPARATIVE STUDY OF SORGHUM GRAIN MOLDS

VARIETY AVERAGES PER PLACE

Varieties	1. Moldy surface			2. Non-germinated			6. Fusarium			9. Pyonides		
	Bambey	Nioro	Sefa	Bambey	Nioro	Sefa	Bambey	Nioro	Sefa	Bambey	Nioro	Sefa
1	10.90b	16.15c	14.00c	22.00	71.00a	57.50a	39.00a	48.00a	46.50a	44.50	47.50c	56.50c
2	15.00d	19.75d	18.75e	18.00	67.00a	52.50a	43.50a	50.00a	54.50ab	50.00	48.00c	53.50c
3	8.95a	12.00a	11.90a	35.50	57.00a	51.50a	44.00a	51.00a	61.00ab	28.00	32.25ab	46.00c
4	11.20b	20.90e	15.00d	44.00	87.50b	79.50b	55.50a	62.00b	59.50ab	18.00	27.00ab	17.00a
5	13.00c	13.90b	12.85b	30.00	74.50a	63.00ab	51.00a	43.50a	62.00b	19.50	32.00ab	54.00c
6	13.40c	22.45f	34.30g	21.00	67.00a	71.00ab	47.50a	54.00a	75.00c	22.50	35.00b	34.50b
7	17.00e	22.40f	22.95f	52.00	74.00a	53.00a	51.50a	44.50a	53.50ab	14.00	30.00ab	35.00b
8	47.40f	56.15g	52.45h	81.00	94.50b	97.00c	42.50a	62.00b	68.00bc	10.50	18.00a	29.50b

Table VII

ANALYSIS OF VARIANCE OF THE TEST

USING THE "ZUMMO SCALE"

Sources of variance	D.F.	sum of the deviation squares	Variance
Varieties	55	841.285	15.296**
Places	2	2020.850	1,010.425**
Varieties x places	110	180.650	1,642**
Error	1176	1048.375	0.891
Total	1343	4091.160	0.891

ppds: 0.2725
C.V.: 5.6%

Test average: 16.80

N.B. Values with different letters are significantly different from the 5% level for the considered criterium (Keuls test)

TABLE VIII

THE "ZUMMO SCALE" TEST

OBSERVATION AVERAGES

No.	Identification	Av.	No.	Identification	Av.
1	7410 140-1-1	16.25	29	7410 157-3-0 NAF	16.96
2	7410 140-1-2	16.12	30	7410 168-3-1	18.54
3	7410 069-3-0	16.87	31	7410 168-3-2	17.42
4	7410 226-0-3	16.29	32	7410 209-1-1	16.75
5	7410 082-3-1	15.75	33	7410 122-5-0 NAF	16.33
6	7410 179-1-0	16.25	34	7410 125-4-0	15.45
7	7410 134-0-0 NAF	16.62	35	7410 186-1-0	17.21
8	7410 185-1-1	17.17	36	7410 122-3-0	15.45
9	7410 231-2-1	15.83	37	7410 210-3-0	15.45
10	7410 231-2-2	16.12	38	7410 169-0-0	17.17
11	7410 216-2-0 NAF	16.75	39	7410 226-0-1	16.84
12	7410 231-1-0	16.17	40	7410 006-0-0	17.29
13	7410 168-2-0	17.17	41	7410 082-3-2	15.87
14	7410 209-2-0	17.79	42	7410 230-2-1 NAF	16.83
15	7410 088-0-0 NAF	16.83	43	7410 226-0-2	16.45
16	7410 237-2-1	16.96	44	7410 028-2-1	16.29
17	7410 069-2-0 NAF	17.79	45	7410 028-2-2	17.62
18	7410 237-2-2	16.75	46	7410 122-4-1	16.21
19	7410 157-2-0 NAF	16.25	47	7410 187-0-0 NAF	16.29
20.	7410 080-0-0	16.25	48	7410 122-4-2	16.50
21	7410 032-2-0	18.87	49	7410 020-4-0	17.12
22	7410 185-1-1	17.29	50	MS 59 CE90	18.112
23	7410 179-2-0 NAF	17.33	51	7410 020-6-0	18.21
24	7410 186-3-0 NAF	19.17	52	7410 209-1-2	16.92
25	7410 231-2-3	15.95	53	7410 230-2-2 NAF	16.42
26	7410 036-0-1	16.87	54	7410 226-2-0	16.71
27	7410 036-0-2	16.92	55	MS 60 67-17	16.75
28	7410 236-0-0 NAF	15.29	56	7410 122-2-0	16.79

ppds = 0.2725

ERRATA

ICRISAT
1977 International Sorghum Workshop

SORGHUM GRAIN MOLD IN SENEGAL

METHODS USED FOR IDENTIFYING RESISTANT VARIETIES

Jacques C. Denis, Technical Advisor, IDRC, Sorghum Breeder, and Jean-Claude Girard, Research Engineer, IRAT, Plant Pathologist of ISRA, CNRA, Bambey, Senegal (with technical collaboration of Ms. Mbayang Samb).

Page 3: Right in the middle of the page, after line 20 insert:

"123. Qualitative and quantitative evaluation of grain infestation.

This method has been developed at CNRA of Bambey. It gives information on both the damage caused to the grain and the composition of the mycoflora associated with molds. Grain samples are first surface sterilised by dipping them for 5 minutes in an alcoholic solution of sodium hypochloride (7 volumes of 95° ethyl alcohol with 1 volume of sodium hypochloride), rinsed 3 times with sterile water and then plated out on water-agar. The seeds are incubated overnight (14 hours) at 27°C, following which each grain is observed under binocular lens and classified in one of the following categories:

Page 3: Final paragraph, lines 1, 2 and 3 instead of "the advantages of this method is that it is undertaken regardless of the fact that the mold has penetrated" read "the advantage of this method is that it takes account only of the fungi which have penetrated".

Page 4: Line 7; instead of "germination and harvest tests" read "germination and emergence tests".

Page 4: Line 11; instead of "harvest" read "emergence".

Page 9: 223 Conclusion; in the final line instead of "made" read "was".

Page 9: Line 19; instead of "Besides" read "Hence".

Page 12: Table III, Column 9, delete the exponent letters a,b,c, etc.