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IMPROVING THE YIELD AND BIOLOGICAL NITROGEN FIXATION OF BAMBARA GROUNDNUT

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SECOND ANNUAL PROGRESS REPORT

Mamadou GUEYE
Soil microbiologist
Principal investigator

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Centre National de Recherches
Agronomiques de BAMBEY.

CONTENTS

1 - GENERAL BACKGROUND

In the developing countries , specially in the semi arid tropics in Afriça, the food availability and quality is a social and political problem. It is very important for those countries to develop the research **on** the nutritional crops which are the resources for the future. On this point of view, Voandzeia subterranea, a lso know-n as Bambara groundnut in Mali, Gajanga (1) in Senegal is a material of choice.

In 1983, Senegal Institute of Agricultural Research (ISRA) had submitted a proposa.1 to National Academy of Sciences (NAS) for studying the Biological Nitrogen Fixation by bambara groundnut (Voandzeia subterranea) in the framework of the West Africa MIRCEN. In December 1983, Dr. Michael DOW had a long discussion with the principal investigator and his collaborators. The discussion was about the objectives and methodology of the grant.

In May, 1984, the NAS approved to ISRA a two year grant to carry out a research project entitled "Improving the Yield and Biological Nitrogen Fixation of Ba.mbara groundnut".

2 - OBJECTIVES

The main objective of the project is to improve the yield of bambara groundnut through the nitrogen fixation. Because it is an underexploited legume, it is necessary to constitute first an important germplasm of bambara groundnut and a collection of effective Rhizobium strains. This is why the objectives of the first phase of this project are :

1. Obtain promising bambara groundnut germplasm in local markets and from international collections.
2. Determine responsiveness and select pure strains based on phenotype and yield.
3. Screen rhizobial strains, including some isolated locally and some obtained from international collections.
4. Observe possible diseases on bambara groundnut.

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(1) Gajanga / gadjanga / : Name of bambara groundnut in principal national language in Senegal.

MATERIALS AND METHODS

3.1. - Soils

Our expermients were carried out at two experimental stations : Bambey and Nioro. Ecological conditions at these stations are different and the two types of soil are indicated in Table 1.

3.2. - Cultivars

Seventy eight bambara groundnut cultivars obtained from different countries in Africa are listed in Table 2. Of these, first 24 cultivars have been used in our experiment.

3.3. - Field screening of bambara groundnut cultivars

During 1985 rainy season field screening experiments were carried out at Bambey (rainfall : 376.9 mm) and Nioro (rainfall : 532.3 mm) experimental stations in Senegal. Twenty four bambara groundnut cultivars (entries from 1 to 24) were hand sown in a randomized block design. The cultivars were sown in two treatments : without (-N) and with (+N) nitrogen fertilization (i.e. 50 kg urea/ha). All plots received phosphorus and potassium fertilization (i.e. GO kg P_2O_5/ha and 120 kg KCl/ha respectively) . Six weeks after planting, the Relative Effectiveness (R.E.) of each host plant - indigenous Rhizobium strains combination was evaluated by the following formula

$$R.E. = \frac{X \text{ of ten samples in the -N block}}{X \text{ of ten samples in the +N block}} \times 100$$

where X denotes shoot , root and nodule dry weights or shoot nitrogen content.

3.4. - Isolation of native *Rhizobium* strains from bambara groundnut nodules

Bambara groundnut nodule samples were collected from both Bambey and Nioro experimental stati.ons. The samples were taken from plants having well developed but still immature pods. In all 45 well developed, internally red cclored firm nodules were sampled from the tap roots. Rhizobium strains were isolated according to standard procedures. Isolated Rhizobia were cultured on agar slants made from YEM medium. Nitrogen fixing ability of the isolates was compared in terms of shoot dry weight and nitrogen content of Macroptilium atropurpureum cultivated in GIBSON's tubes. Each test plant was inoculated with 1 ml of a 7 day old isolate culture. Plants were grown in a growth chamber for 35 days at temperatures maintained between 20 and 30°C. Plant tops were clipped off, dried and weighed for dry matter production and nitrogen content determination.

ble 1 Characterists of soils at Bambey and Nioro stations

il	ppm			Granulometry (%)			
	Total C	Total N	Available P (Olsen, 1954)	Clay	Loam	Sand	pH (H_2O)
mbey	2970	290	121.8	4 ∘	2 ∘	96.∘	7 8
oro	4160	310	137.∘	6.4	3 6	90 ∘	5 8

Table 2. Germplasm collection of Bambara groundnut maintained at Bambey experimental station.

Entries Number	Cultivars	Origin
1	78-l	Senegal
2	79-l	Senegal
3	83-126	Mali
4	83-127	Mali
5	83-129	Mali
6	83-130	Mali
7	83-131	Mali
8	Sud Cameroun	Cameroun
9	Sarakawa 1	Togo (UMES)*
10	Sarakawa 2	Togo (UMES)
11	Sarakawa 3	Togo (UMES)
12	Sarakawa 10	Togo (UMES)
13	Thitchao 3	Togo (UMES)
14	Awandjelo 1	Togo (UMES)
15	Ketao 2	Togo (UMES)
16	Ketao 3	Togo (UMES)
17	Ketao 9	Togo (UMES)
18	Alheride 1	Togo (UMES)
19	Lassa 1	Togo (UMES)
20	Lassa 3	Togo (UMES)
21	Lassa) 4	Togo (UMES)
22	v2	Togo (UMES)
23	85001	Senegal
24	85002	Senegal
25	85003	Senegal
26	85004	Senegal
27	85005	Senegal
28	85006	Senegal
29	85007	Senegal
30	V1	Togo (UMES)
31	Mena Rangotra	Madagascar
32	Maso Takatra	Madagascar
33	Manga Kely	Madagascar
34	Atodin Isorohitra	Madagascar
35	Masom Pitatra	Madagascar
36	Kely Mana	Madagascar
37	Tsy Mandefitra	Madagascar
38	Marevaka	Madagascar
39	Voandelaka	Madagascar

.../...

Table (continued)

Entries number	Cultivars	Origin
40	Manjelatra	Madagascar
41	Dona	Madagascar
42	Mamokatra	Madagascar
43	Bakoly	Madagascar
44	H.T.B.	Madagascar
45	SA.1	Madagascar
46	SA.2	Madagascar
47	SA.3	Madagascar
48	SA.4	Madagascar
49	SM.2C	Togo
50	SM.6	Togo
51	SM.10B	Togo
52	SM.I.2	Togo
53	SM.13	Togo
54	SM.18 A	Togo
55	SM.20 A	Togo
56	SM.34	Togo
57	SM.36	Togo
58	SM 37	Togo
59	SM.42	Togo
60	SM.52	Togo
61	SM.54	Tpgp
62	SM.58	Togo
63	SM.62	Togo
64	SM.64	Togo
65	SM.65	Tpgp
66	SM,67	Togo
67	SM.68	Togo
68	SM.69	Togo
69	SM.70	Togo
70	SM.71	Togo
71	SM.95	Togo
72	SM.102B	Togo
73	SM.108	Togo
74	SM.116 A	Togo
75	SM.117	Togo
76	SM.119	Togo
77	SM.122A	Togo
78	SM.127	Togo

*These cultivars were obtained with collaboration with the University of Maryland Eastern Shore (UMES).

3.5. - Field inoculation tria1 of bambara groundnut

The experiment was carried out in 1985 at Hambey experimental station (rainfall : 376.9 mm). The indigenous rhizobial population in the field selected for this work is 10 cowpea rhizobia/g of soil as determined by plant infection test using Macrotyloma africanum. The cultivar V2 obtained from *Togo* was used. Applied treatments were : uni noculated, n o N (urea) ;uninoculated + 50 kg N (urea)/ha ; inoculated with 10 g of six different peat-base Rhizobium inoculants. Four of the inocula were supplied by the University of Maryland Eastern Shore : Mungo, Bam 618, TAI, 1380 and AH 169 ; two of them were supplied by the West Africa MIRCEN : MAO 11 and MAO 26. Randomized block design with four replicates was used. The size of eacln plot was 3 and 2. 1 m and the plants were spaced by 15 and 30 cm. Application of fertilizer was 60 kg P_2O_5/ha and 120 kg KCl/ha. Sixty days after planting, plants were sampled for nodulation, dry weight and ni trogen content determination.

3.6. - Survey of diseases on bambara groundnut

The experimental plots of bambara groundnut at both locations were visited periodically to see wether there îs any disease. Farmers' fields were also visited once just before flowering. Diseased samples of unknown disease were collected from experimental plot at Bambey. The preliminary symptom of the disease is withering of leaves which is generally observed after about one month from sowing. The leaves subsequently dry, finally resulting in complete death of the plant.

In order to find out the causal organism of the disease , isolations were made from the infected plant parts on Potato Dextrose Agar (PDA) medium as per siandard procedure. The pathogenicity test of these isolates was carried out by inoculating 3 weeks old seedlings of 2 varieties viz, 83-129 and 83-130. Two pots of each variety were inoculated with the spore suspension of each isolate with the help of small atomized. Uninoculated pots of each variety served as control. The pots were kept in the moist chamber for 48 hours and then transferred to greenhouse.

3.7. - Effect of pH on the growth of bambara groundnut

Bambara groundnut CV 79-l was grown in pot, each containing 15 kg of unsterilized soil from irrigate zone (A) and non irrigate zone (B). The plants were watered with tap water (a) and distilled water (b). Thus there were four treatments viz, A t a (pH = 8.20), A + b (pH = 7.15), B t a (pH = 7.50) and B + b (pH = 6 .00) wi.th four replicates arranged in completely randomized

block design. The pH of different treatments was determined before commencing the experiment as well as after completion of the experiment. Daily observations on the behaviour of plants were made. The plants were harvested 35 days after planting. The shoots and roots were separately dried and weighed.

4. - RESULTS AND DISCUSSION

4.1. - Field screening of bambara groundnut (GUEYE, M.)

Eighteen entries at Bambey station and 12 at Nioro station had a R.E. based on shoot dry weight in the ranges of 40-70% and 40-90% respectively . Most cultivars had a R.E. based on root. dry weight in the range of 60-90% with a peak between 60 and 70% at Bambey station and between 70 and 80% at Nioro station. While at Bambey station, 11 cultivars had a R.E. based on nodule dry weight between 30 and 50% and 3 cultivars between 80 and 90% , at Nioro station 16 and 6 cultivars had a R.E. respectively in the ranges of 70-240 and 360-480%. Most cultivars had a R.E. based on shoot nitrogen content between 80 and 110% at Bambey station with a sharp peak between 80 and 90 % and at Nioro station, all cultivars had the same R.E. over 90% with a sharp peak between 100 and 110%. The distribution of relative effectiveness values (Fig. 1 and 2) shows that Bambey and Nioro rhizobial population established a moderately effective symbiosis with the cultivars of bambara groundnut used. Among these cultivars, 12 grew better in the two locations, without nitrogen fertilizer : 79-1, 83-126, 83-129, 83-131, Sarakawa 1, Awandjelo 1, Ketao 2, Ketao 3, Alheride 1, Lassa 3, V2 and 85001 (Tables 3, 4 and 5) indi cating their ability to effectively symbiosis in the two field conditions. Oniy one cultivar, Sarakawa 10 performed poorly at Nioro station with 13% R.E. based on shoot dry weight.

These observations indicated a screening of our bambara groundnut germplasm for 12 lines of groundnut capable of forming most effective symbiosis with suitable Rhizobium strains. They will be inoculated with strains isolated at Bambey and Nicro where they had an effective symbiosis as an attempt to improve their performance where they yield poorly.

4 . - Nodulation and ni trogen fixing ability of bambara groun (GUEYE ,M.)

Bambara groundnut cultivars sampled were moderately nodulated on both tap and lateral roots. Few nodules appeared to be effective as ind icated by interior color. 31 rhi zobial i so 1 ates were obtained.

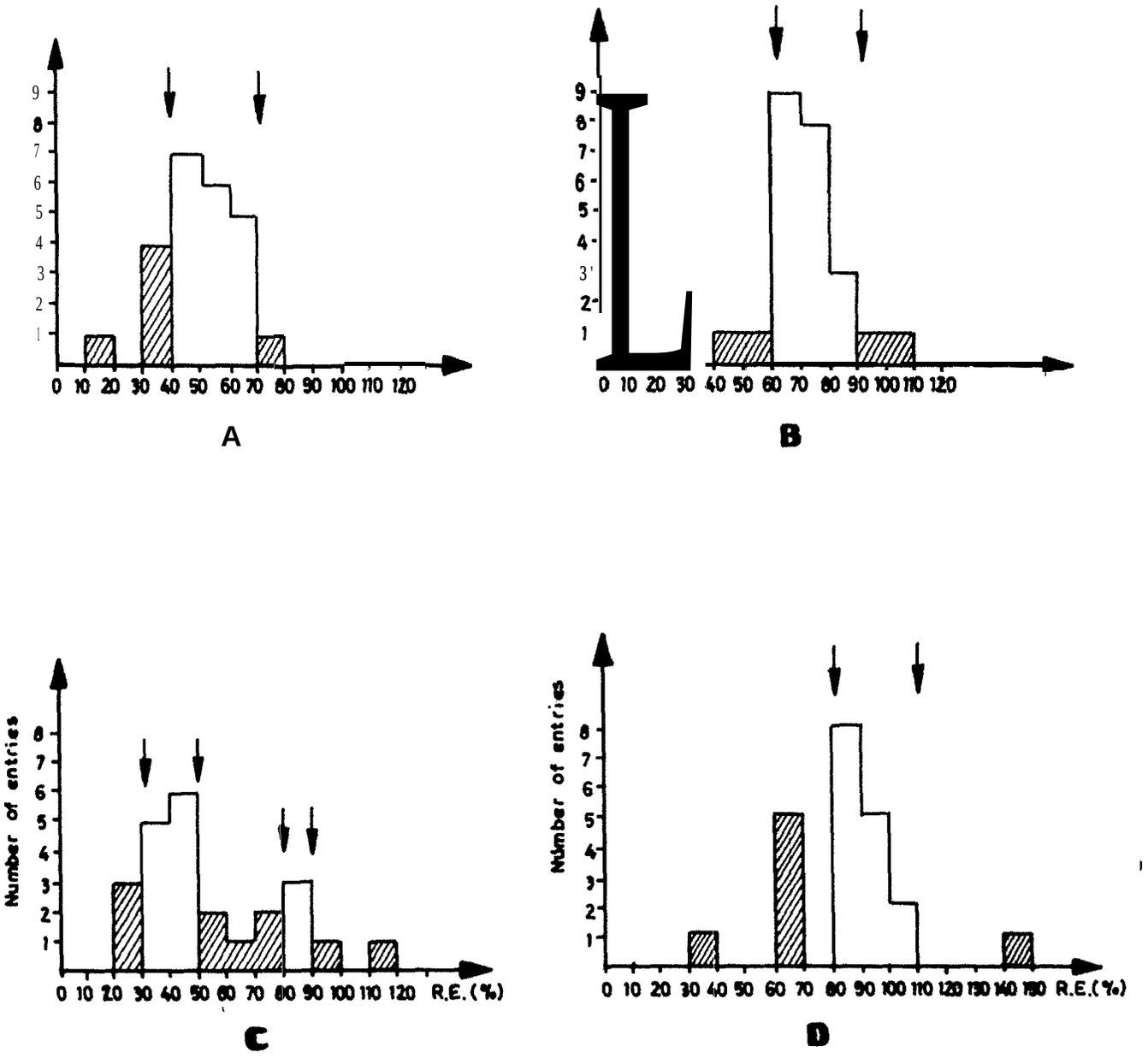


Fig. 1 : Distribution of the R.E. of 24 cultivars of the Voandzeia subterranea at Bambey experimental station

1 A : R.E. based on shoot dry weight

1 B : R. E. based on root dry weight

1 C : R.E. based on nodule dry weight

1 D : R.E. based on shoot nitrogen content

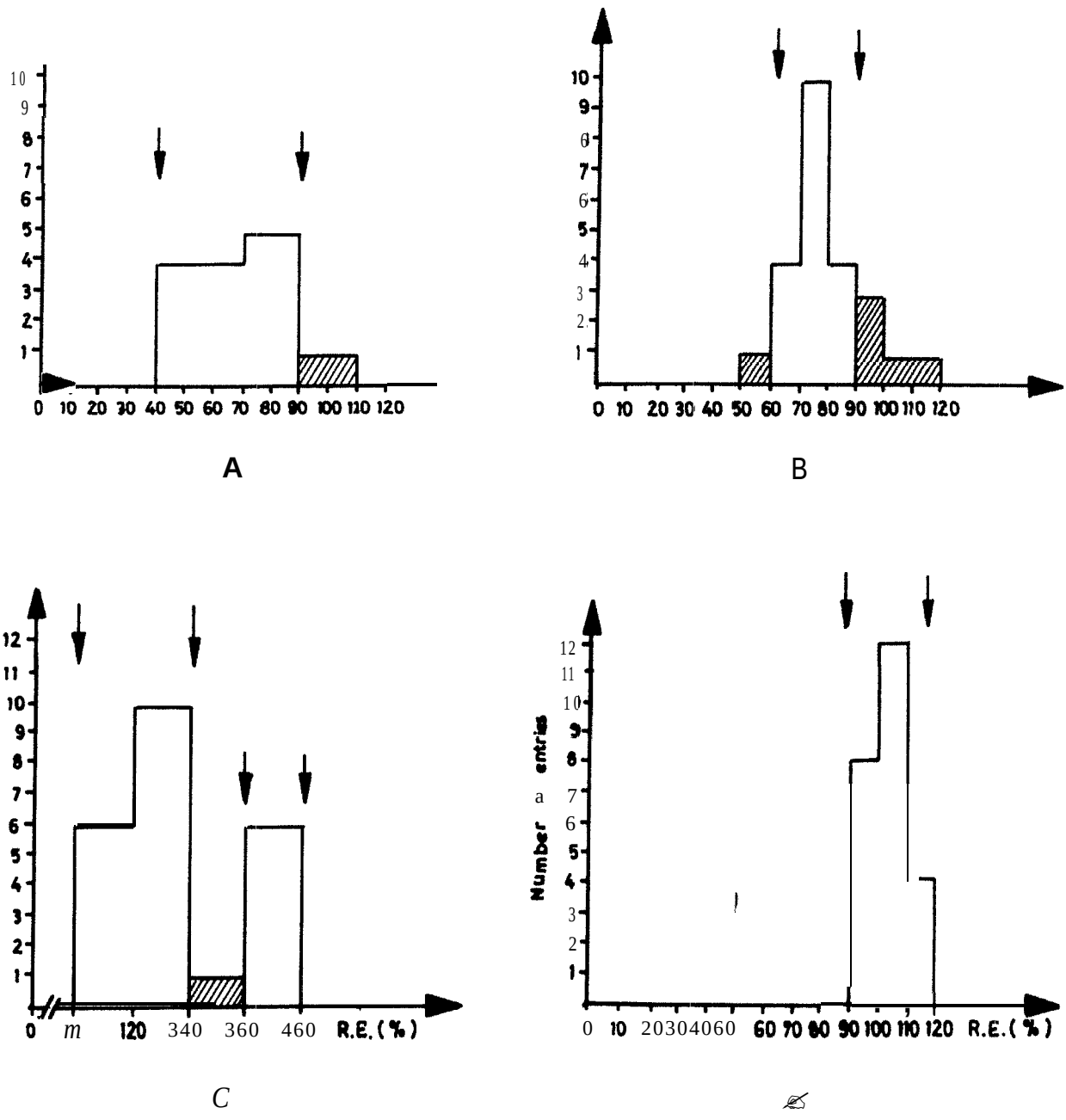


FIG. 2 : Distribution of the RE. of 24 cultivars of Voandzeia subterranea cultivated at Nioro experimental station

1 A : R.E. based on shoot dry wcight

1 B : R.E. based on root dry wcight

1 C : R.E. based on nodule dry weight

1D : R.E. based on shoot nitrogen content

able 3. Shoot, root and nodule dry weights and shoot nitrogen content of 24 cultivars of Voandzeia subterranea cultivated at Bambey in -N and +N blocks.

ultivars	-N block				i-N block			
	Shoot dry Weight (g)	Root dry weight (g)	Nodule dry weight(mg)	Shoot nitrogen content (N %)	Shoot dry weight (g)	Root dry weight (g)	Nodule dry weight (mg)	Shoot nitrogen content (N %)
3-1	49.00 ab	î.88 cd	40 b	î.58 hi	88.50 b	2.53 de	120 abc	2,02 de
3-î	55.50 ab	2.16 cd	50 b	1.55 hi	114.25 ab	2.77 de	100 abc	2?3- b
3-126	62.25 ab	1.67 d	50 b	1.62 gh	105.75 ab	2.53 de	80 abc	**1.92** fgh
3-127	43.25 abc	1.94 cd	70 b	1.86 de	135.00 ab	2.85 de	150 abc	2.07 **cd**
3-129	55.75 ab	2.19 cd	40 b	1.62 gh	108.25 ab	3.18 cd	160 ab	1.97 ef
3-130	62.50 ab	1.95 cd	60 b	1.70 e	104.00 ab	2.42 de	170 a	2.03 de
3-131	56.50 ab	2.62 bc	140 a	1.79 e	92.75 b	2.56 de	160 ab	1.88 ghi
id Cameroun	37.25 bc	1.39 d	40 b	1.84 de	103.79 ab	2.23 e	100 abc	1,95 fg
irakawa 1	52.75 ab	2.02 cd	20 b	1.59 hi	120.00 ab	3.00 de	40 c	1.86 hi
irakawa 2	49.00 ab	2.28 cd	40 b	1.90 d	84.25 b	3,02 de	110 abc	1,86 hi
irakawa 3	44.25 abc	1.97 cd	40 b	1.92 d	124.75 ab	3.25 cd	130 abc	2.31 a
irakawa 10	11.75 c	1.20 d	30 b	2.24 b	88.00 b	2.58 de	60 bc	2.06 cd
itchao 3	48.00 ab	2.01 cd	30 b	2.13 c	77.50 b	3.27 e	50 bc	2.22 b
andjelo 1	64.25 ab	2.64 bc	30 b	0.80 l	99.25 ab	2.96 de	60 bc	2,04 **de**
tao 2	63.75 ab	2.54 bc	70 b	1.21 k	150.50 a	3.67 bc	70 abc	1.92 fgh
tao 3	66.25 ab	3.28 ab	30 b	1.32 j	87.25 b	3.44 bc	50 bc	3,05 cd
tao 9	58.25 ab	2.30 cd	30 b	1.55 hi	119.25 ab	3.93 bc	60 bc	2.34 a
heride 1	68.25 ab	2.82 bc	40 b	1.531i	117.75 ab	4.20 abc	50 bc	î.93 fg
ssa 1	44.50 abc	2.68 bc	80 ab	1.69 fg	122.50 ab	3.65 bc	90 abc	1.83 i
ssa 3	78.50 a	3.70 a	30 b	2.31 b	134.25 ab	5.15 a	80 abc	2.31 a
ssa 4	43.50 abc	1.94 cd	80 ab	1.92 d	101.00 ab	3.18 cd	70 abc	2.12 c
	61.50 ab	3.27 ab	70 b	1.63 fgh	90.00 b	4.49 ab	90 abc	2.32 a
001	56.50 ab	2.24 cd	100 ab	1.86 de	88.00 b	2.72 de	140 abc	2.20 b
002	42.00 abc	1.90 cd	30-b.	2.82 a	84.50 b	2.39 de	120 abc	1.93 fg

alues followed by the same letter in each column do not differ significantly at the 0.05 level by DUNCAN's multiple range test.

ble 4. Shoot, root and nodule dry weights and shoot nitrogen content of 24 cultivars of Voandzeia subterranea cultivated at Nioro in -N and +N blocks.

	-N block				+ N block			
tivars	Shoot dry weight (g)	Root dry weight (g)	Nodule dry weight (mg)	Shoot nitrogen content (N %)	Shoot dry weight (g)	Root dry weight (g)	Nodule dry weight (mg)	Shoot nitrogen content (N %)
1	28.50 bc	5.50 a	70 b	2.69 ef	33.50 c	5.00 bcd	100 bcd	2.69 e
1	30.40 bc	4.80 abc	70 b	3.21 a	36.40 c	4.80 bcd	70 bcd	2.85 c
126	33.60 bc	3.80 abc	80 b	2.86 d	39.40 bc	5.80 abcd	90 bcd	2.99 b
127	LE.20 bc	4.30 abc	140 b	3.18 a	33.30 c	5.70 abcd	100 bcd	3.14 a
129	39.00 abc	5.50 a	350 b	2.61 gh	56.50 ab	6.80 ab	80 bcd	7.91 c
130	22.80 c	3.00 c	250 b	3.10 b	52.20 abc	5.30 abcd	250 a	3.02 b
131	30.20 bc	3.30 bc	320 b	3.01 c	44.80 bc	5.30 abcd	90 bcd	2.77 cd
Cameroun	26.60 bc	3.00 c	130 b	3.10 b	34.00 c	3.50 d	40 cd	2.71 de
akawa 1	31.10 bc	4.30 abc	70 b	2.62 gh	67.70 a	5.80 abcd	30 d	2.32 k
akawa 2	44.80 ab	5.30 bc	90 b	2.58 ghi	57.90 ab	6.50 abc	20 d	2.54 gh
akawa 3	29.90 bc	4.30 abc	60 b	2.60 gh	49.50 bc	5.80 abcd	30 d	2.46 hij
akawa 10	24.60 c	3.00 c	80 b	2.84 d	50.00 bc	4.80 bcd	80 bcd	2.84 c
tchao 3	41.00 ab	4.80 abc	50 b	2.57 hij	58.20 ab	6.00 abc	30 d	2.47 hij
ndjelo 1	40.50 abc	4.50 abc	90 b	2.52 ijk	61.80 a	6.00 abc	50 cd	2.47 hij
ao 2	31.70 bc	4.00 abc	70 b	2.36 b	64.20 a	5.80 abcd	30 d	2.47 hij
ao 3	32.9' bc	4.30 abc	80 b	2.58 ghi	57.30 ab	5.50 abcd	110 bcd	2.44 ij
a0 9	40.70 abc	5.50 a	120 b	2.54 hij	45.80 bc	5.50 abcd	30 d	2.79 c
erice 1	43.90 ab	5.80 a	220 b	2.72 e	59.70 a	7.50 a	140 bcd	2.52 ghi
sa 1	41.00 ab	5.50 a	190 b	2.56 hij	53.40 abc	6.00 abc	90 bcd	2.39 jk
sa 3	38.60 abc	5.30 ab	170 b	2.71 ef	67.86 a	7.50 a	150 abc	2.64 ef
sa 4	33.20 bc	5.00 abc	0ô b	2.51 jk	38.30 bc	4, 3 0 cc	40 cd	2.13 m
	41.30 ab	5.30 ab	90 b	2.47 k	72.80 a	6.50 abc	20 d	2.24 l
01	42.00 ab	4.50 abc	230 b	2.65 fg	42.60 bc	5.50 abcd	180 ab	2.58 fg
02	52.60 a	4.30 abc	370 a	2.57 hij	50.30 bc	6.00 abc	90 bcà	2.57 fg

ues followed by the same letter in each column do not differ significantly at the 0.05 level by DUNCAN's multiple range test.

Table 5. Relative Effectiveness (%) of 24 cultivars of Voandzeia subterranea cultivated at Bambey and Nioro experimental stations. RE is based on shoot, root and nodule dry weights and nitrogen content.

	Bambey				Nioro			
ultivars	Shoot dry weight	Root dry weight	Nodule dry weight	Nitrogen content	Shoot dry weight	Root dry weight	Nodule dry weight	Nitrogen content
8-1	55	80	33	78	85	110	70	100
9-1	49	78	50	69	84	100	100	113
3-126	59	66	62	84	86	65	88	94
3-127	32	68	46	90	79	75	140	101
3-129	49	69	25	82	69	8G	437	93
3-130	60	8C	35	84	44	57	100	103
3-131	61	102	87	95	62	62	422	109
ud Cameroun	36	62	40	94	78	85	325	114
arakawa 1	44	67	50	85	46	74	233	113
arakawa 2	58	75	36	SO2	77	81	450	101
arakawa 3	35	61	30	83	60	74	200	106
arakawa 10	13	46	50	108	49	62	100	100
hitchao 3	62	88	60	96	70	80	166	100
wandj elo 1	65	89	50	39	65	75	180	102
etao 2	42	69	100	63	49	69	233	95
etao 3	76	95	60	64	57	78	72	105
etao 9	49	58	50	66	88	100	400	91
lheride 1	58	67	90	79	73	77	157	108
assa 1	36	73	88	92	77	92	211	107
assa 3	58	72	37	100	57	71	113	103
assa 4	43	61	114	90	87	112	200	118
2	68	73	77	70	57	81	450	110
5001	64	82	71	84	98	82	127	103
5002	50	79	25	146	104	72	411	100

Fig. 3 and 4 show their effectivcness compared in terms of shoot dry weight; and nitrogen content of Macroptilium atropurpureum. Two strains (MAO 113 , MAO 118) had well stimulated dry matter production of test plants used while there was no difference between the strains in shoot nitrogen content,.

MAO 113, MAO 118 and three Niftal Rhizobium strains (TAI, 22, TAI. 169 and TAI, 569) were selected for a study of host bambara groundnut cultivars - Rhizobium strains interactions. Niftal strains served as standards for comparison against the native Rhizobium strains. This experiment is still in progress and the results are not yet available.

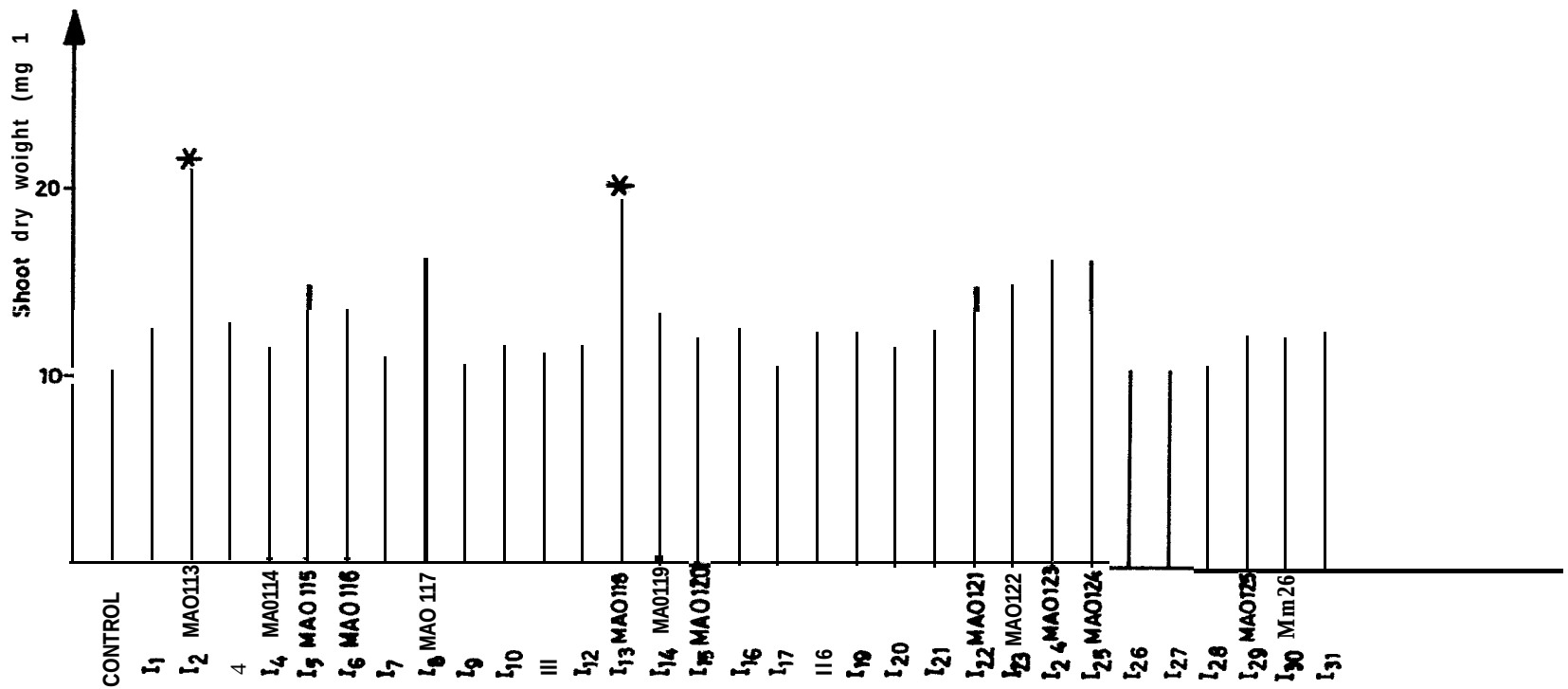
4.3.- Field inoculation trial (GUEYE , M.)

Response of bambara groundnut to inoculation with selected Rhizobium strains is shown in Table 6 . In most tropical soils, very effective and/or competitive strains may be the major constituents of the native rhizobial population. In Dior soil used for our trial, the native rhizobial population is lacking and the introduction of other strains had resulted in increase of nitrogen fixation. However, Rhizobium strains used as inocula varied markedly in ability to promote plant growth, in shoot nitrogen content and in nodule development.Appreciable responses to inoculation were obtained in shoot dry weight wfth strain Bam 618 (increase of 144 %), in nodule dry weight with strains Mungo, Bam 618 and MAO· 26 i increase of 95%, 100%, 73% respectively) and in nitrogen content with strains Bam 618, TAL 1380, MAO 11 and MAO 26 (increase of 27%, 39%, 24%, 17% respectively!. Increase in total shoot nitrogen was obtained with strains Bam 618 (+ 209%) and MAO 11 (+135%).

From these results, it is apparent that bambara groundnut , cv. V2 requires an inoculation with suitable Rhizobium strain for adequate nodulation and nitrogen fixation in Dior soil used. However, it is very important to know exactly the amount of nitrogen fixed by bambara groundnut. Pot experiment is being carried out for assessing the nitrogen fixed by bambara groundnut cv. 79-1 using 15, methods. Results of this experiment are not yet available.

4.4. - Survey of diseases on bambara groundnut (GAIKWAD, D.G.)

No serious disease was noticed on bambara groundnut except one at Bambey experimental station. The microscopic observations of the isolates obtained from the diseased plants revealed the presence of Alternaria sp. However, in the pathogenicity test, all the isolates failed to produce the disease symptoms. But during the course of time, the symptoms were developed on both the varieties including the uninoculated plants. This indicates that



Treatments with * differ significantly with the control at the 0.05 level by DUNCAN's multiple range test

Fig. 3 : Shoot dry weight of Macroptilium atropurpureum cultivated in GIBSON's tubes and inoculed with 31 native rhizobial isolates

6. Shoot and nodule dry weights, shoot nitrogen content and total shoot nitrogen of Voandzeia subterranea (cv. V2) cultivated at Bambey in field and inoculated with Rhizobium s-trains Mungo, Bam 618, TAL 1380, AH 169, MAO 11 and MAO 26.

eatment s	Shoot dry weight (g/10 plants)	Nodule dry weight (mg/10 plants)	Shoot nitrogen content (N %)	Total shoot nitrogen (g/10 plants)
ulated	10.75 d	55.00 bc	1.81 g	1.95 e
ulated + N (urea)/ha	13.25 cd	40.00 c	1.88 f	2.50 de
	15.50 bcd	107.50 a	1.92 e	2.98 cde
8	26.25 a	110.00 a	2.30 b	6.03 a
80	15.75 bcd	30.00 c	2.51 a	3.94 bc
	20.00 b	77.50 ab	1.87 f	3.74 bcd
	20.50 ab	30.00 c	2.24 c	4.58 b
	18.50 bc	95.00 a	2.12 d	3.90 bc

Values are averages of 10 plants.

Values followed by the same letter in each column do not differ significantly at the 0.05 level by DUNCAN's multiple range test,

the Alternaria fungus not the cause of the disease, but it was developed syprophytically on the deacl tissues.

It was suspected that the death of bambara groundnut plants at Bambey is associated with high pH of irrigation water which is later confirmed by another experiment. The results are presented under 4.5.

4.5. - Response of bambara groundnut to different pH levels (GUEYE,M.)

At pH 6.00 plant leaves were present and sone leaves were yellow. At pH 7.20 and 7.50 the plants grew better, all leaves were still green and did not wither. At pH 8.20 all leaves withered, the plants were very small and were dying. Fig. 5 shows shoot and root dry weights of cv. 79-1 at different pH levels. Better dry matter production is at pH 7.15. These results indicated that high pH levels stop the growth of bambara groundnut. Probably the absorption of unknown nutrients is not possible at these pH levels. POLLACK (1973) reported nutrients deficiency symptoms in bambara groundnut cultivated in water-culture or sand-culture lacking either nitrogen, phosphorus, potassium, sulfur or iron. However, the behaviour of plants varied with the cultivars (GUEYE, M.).

4.6. - Variety trials (CISSE, N.).

Agronomic characteristics of eight cultivars and their correlations with yield are shown in Tables 7 and 8. Variations were observed in responses of individual cultivars. Grain yields at Nioro were generally higher than at Bambey station. This is due to higher rainfall at Nioro (532.3 mm) than at Bambey (379.6 mm). However, grain yield was more than 1 t at both stations. At Bambey, the weight of 100 seeds only was significantly correlated with the yield while at Nioro number and weight of the pods and seeds were correlated with the yield. In conclusion, cv. **79-1** was the best one with 1419.40 kg/ha at Bambey and 1278.40 kg/ha at Nioro station. However, a second year test is needed at the same stations and/or other sites. After that , one or two cultivars will be proposed for vulgarisation. Therefore, it is necessary to initiate or to continue the study on population density or fertilization of bambara groundnut. Number and weight of the pods and seeds and the weight of 100 seeds seemed determinant for yield evaluation . This would be important for a variety improvement program.

able 7 : characteristics of eight cultivars of bambara groundnut cultivated at Bambey experimental station.

ultivars	Number per plant				Weight (g) per plant				Weight (g) of 100 seeds	Grain yield (kg/ha)
	Leaves	Stem	Pods	Seeds	Leaves	Stem	Pods	Seeds		
3-1	60.75 c	9.25 a	11.75 a	12.25 a	7.32 c	1.54 b	6.03 a	4.19 a	44.66 cd	843.00 b
9-1	57.25 c	9.25 a	15.00 a	15.25 a	10.67 bc	1.62 b	8.49 a	6.34 a	51.76 bc	1419.38 a
3-126	71.75 bc	9.25 a	13.25 a	14.50 a	9.66 bc	1.76 b	6.96 a	5.28 a	40.62 d	1094.02 ab
3-127	54.75 c	8.25 a	15.00 a	15.75 a	9.92 bc	1.72 b	9.60 a	7.25 a	47.87 bcd	831.22 b
3-129	92.00 a	13.50 a	10.75 a	12.00 a	14.51 a	3.43 a	7.82 a	5.83 a	70.98 a	1001.45 b
3-130	79.25 ab	9.75 a	14.25 a	15.00 a	11.26 ab	2.12 b	7.53 a	5.83 a	47.39 bcd	1123.00 ab
3-131	58.75 c	9.25 a	18.25 a	19.75 a	11.33 ab	1.91 b	11.16 a	8.51 a	53.00 b	1078.40 ab
ud-ameroun	62.00 bc	9.00 a	18.00 a	18.75 a	9.25 bc	2.08 b	8.39 a	6.68 a	45.32 bcd	1024.25 b
orrelation ith grain ield	0.07^{ns}	0.13^{ns}	0.03^{ns}	0.01^{ns}	0.22^{ns}	0.09^{ns}	0.11^{ns}	0.13^{ns}	0.44^{s}	

s : significant
s : non significant
alues followed by the same letter in each column do not differ significantly at the 0.05 level by DUNCAN's multiple range test.

Table 8 : Agronomic characteristics of eight cultivars of bambara groundnut at Nioro expérimental station.

Cultivars	Number per plant				Weight (g) per plant				Weight (g) of 100 seeds	Grain yield (kg/ha)
	Leaves	Stem	Pods	Seeds	Leaves	Stern	Pods	Seeds		
78-l	68.50 a	9.75 a	15.50 a	17.50 a	11.38 a	2.09 a	8.34 abc	6.19 abc	54.00 d	963.12 a
79-1	64.25 a	14.00 a	21.50 a	22.75 a	13.03 a	1.99 a	11.08 ab	8.76 ab	60.09 bc	1278.42 a
83-126	64.50 a	10.25 a	11.75 a	13.75 a	11.39 a	1.67 a	7.43 abc	5.74 bc	63.98 ab	1173.12 a
83-127	61.00 a	9.25 a	12.25 a	13.00 a	9.75 a	1.49 a	6.39 c	5.12 c	61.15 bc	1043.82 a
83-129	59.75 a	9.75 a	17.00 a	21.75 a	10.82 a	1.76 a	11.64 a	9.39 a	69.23 a	1381.92 a
83-130	72.25 a	9.75 a	18.00 a	19.75 a	13.30 a	1.92 a	9.53 abc	7.76 abc	58.65 bcd	1247.42 a
83-131	77.00 a	14.25 a	13.00 a	15.00 a	12.47 a	2.34 a	7.17 bc	5,35 c	54.00 b	1023.05 a
Sud-Cameroun	70.50 a	9.50 a	16.25 a	19.25 a	11.54 a	1.75 a	8.26 abc	6.73 abc	55.65 cd	1382.40 a
Correlation with grain yield	0.04^{ns}	0.03^{ns}	0.38'	0.41^{s}	0.07^{ns}	0.15^{ns}	0.50^{s}	0.52'	0.24^{ns}	

s : significant
ns : non significant
Values followed by the same letter in each column do not differ significantly at the 0.05 level by DUNCAN's multiple range test.

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APPENDIX 1 : Equipments received under the grant .

Equipment	1985	1986
Incubator	1	
Autostill	1	
pH meter	1	
Shaker (1)	1	
Centrifuge	1	
Freezer	1	
Refrigerator	1	
Kjeldhal digester (2)	-	1
Glassware	many	many

(1) : The first shaker NAS sent is with Bambey National Center of Agronomic Research (CNRA) for returning it to Thomas Scientific : att. M. Mitchel MONTCHINSKI.

(2) : All equipment for kjeldahl nitrogen analysis are not yet received. Kjeldahl distilling unit is still awaited.

APPENDIX 2 : Training and consultants'visits.

1 . Programme teaching is not included in the grant. But a consultant visit was held during the second year of the project. Consultant was BORDELEAU, L.M. from Canada Agriculture . He has made some suggestions as indicated by Dr. SOMASEGARAN from Niftal project in Hawaii.

2 . NAS audit mission supervised by Ms. Joyce FREELAND inspected our project during 1986. Ms FREELAND had to give her conclusions to NAS.

APPENDIX 3 : Grant staff

The following staff devoted the percentage of work time indicated below to research under the grant.

Ndiaga CISSE, plant breeder 30 percent each year

D.G. GAIKWAD,* phytopathologist 30 percent each year

Mamadou GUEYE, microbiologist 80 percent each year

Oumar TOURE, technician 100 percent each year.

* : D.G. GAIKWAD replaced Demba F. MBAYE because GAIKWAD , D.G. works for legume pathology and MBAYE, D.F. works for cereal pathology according to ISRA staff.