Report of Agronomic Trials

1997A

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Contents

Summary and conclusions

This report is an internal document where all data recorded and they analysis are shown in detail. It will constitute a clear memory of the work done on maize agronomy in 1997A.

During the 1997A cropping season we moved one of the experimental fields from the Center of Carimagua to a farm named Matazul, where CIAT teams have been working for 10 years. This farm is located 40 km east of Puerto Lopez, Meta, adjacent to the main paved road. We prepared this change during the first months of 1997. Initial soil analysis and a laboratory test of the phosphorus fixation are reported.
During this cycle I have conducted 5 agronomy trials at La Libertad and 3 at Matazul. L.A. León conducted 3 trials at Matazul. They all are reported here.

Four trials (1 to 4) were planted at La Libertad and Matazul and two others (5, 6) were only planted at Matazul. These were:

1. Choice of one leguminous pasture to develop a system of permanent cover crop in which maize will be directly sown.
2. Comparative effect of tolerant versus non-tolerant varieties on soil fertility evolution. It was chosen to study a maize-soybean rotation, which is feasible in the area.
3. Interactions between maize tolerance and fertilization management for plant and root growth.
4. Need of micronutrients (Zn, B, Cu, Mn) application for maize growth.
5. Comparative effect of two nitrogen fertilizers: Nitromag vs. urea.
6. Interactions between phosphorus doses and types or doses of nitrogen fertilizers.

The trial on sulfates or sulfur effect, initiated in 1996, was again conducted at La Libertad, to confirm the results and measure the residual effect of the amendments.

At La Libertad trials were sown on April 29 and harvested on August 20, that is 15 days delayed from the recommended date of planting. Water was available in excess during all the cycle (page 5). Average trial yields varied from 2 to 3 t/ha, that is low when considering the inputs level. At Matazul, trial were only sown on May 21 and June 4, due to a rain coming delay and the need to wait one month after the dolomite application. Trials were harvested on September 22 and 26. They probably suffered some slight drought periods (page 5). Average yields varied from 1.5 to 2.5 t/ha, with more inputs than in La Libertad.

The main conclusions are:

- The growth of every six legumes tried was low, and grasses have to be carefully controlled during the first year (pages 11-18). *Calopogonium mucunoides* and *Arachis pentoi* showed the best growth. Both *Centrosema* species did not grow well. The leguminous cover did not compete with maize yield on this first year.
- At La Libertad, the residual effect of the combination of sulfur and sulfate with calcium and magnesium amendment insured 12 % more yield compared with dolomite lime (pages 19-22). In the conditions of this experimental field, there is no effect of the small quantities of amendments.
- At La Libertad, the 0-20 cm soil layer was poorer in exchangeable calcium, richer in aluminum and had a lower pH when plot was cultivated with Sikuani, compared with Tuxpeño (pages 23-26). The amounts of Ca involved are too high to be accumulated in the aerial tissues of the plants of the tolerant variety. It will have to be checked whether calcium was more lixiviated from the surface in plots cultivated with the tolerant variety, or it was incorporated in their roots.

- At Matazul, when TSP is hand-incorporated, the level of available phosphorus in the top 0-20 cm soil layer was 3 times higher than when it was mechanically incorporated (pages 27-30). A hypothesis is that phosphorus remained in the top few centimeters, then it only interacts with this layer and saturated the soil fixing capacity with less quantity than calculated for 20 cm. Consequently it would be available in large quantities but only in a reduced superficial layer.
- At Matazul, the Al saturation levels measured at harvest after liming with Sulcamag, were lower than expected in the 0-20 cm layer (pages 27-30). It is not known if it is an effect of the product or an effect of the hand-incorporation as for available phosphorus. On the contrary, at la Libertad, there was no reduction of the Al saturation in the 0-20 cm layer at harvest time, when 1230 kg/ha Sulcamag were applied (pages 23-26). It was like if the initial level of 62 % Al saturation was in an equilibrium stage the soil had reached after years of dolomite application.
- At La Libertad, the interaction between acid-soil tolerant varieties and amendments with sulfates was confirmed (pages 31-34). The results obtained with Dolomite + gypsum is not similar to those obtained in 1995 with Sulcamag. This year, gypsum increased Tuxpeño yield, and decreased the yields of Sikuani and the tolerant hybrid.
- The nitrogen efficiency was low to very low in these trials. (Pages 31-38). At La Libertad, maize responded to a higher nitrogen application, added to the 120 kg/ha already applied. It seems the application splitting from 2 to 5 times did not have a great effect. On the contrary, at Matazul, maize did not respond to the same additional nitrogen application. The nitrogen efficiency is very low at this location.
- The non-conventional white hybrid showed better growth and yield than Sikuani in both localities. Especially, it showed a better nitrogen efficiency at the lower fertilization level (pages 31-38).
- At the present level of yields, there was no effect of the application of 2.2 kg/ha zinc at La Libertad. (Pages 39-50).
- There was a tremendous effect of zinc application at Matazul (pages 41-43). Without any micronutrient there was no harvest of grain. The yield reached 2 t/ha with 8 kg/ha of Zn. The other agronomic and breeding trials reached the same yield level with only 2.2 kg/ha of Zn. At the present level of yield the small effect of the other micronutrients (B, Cu, and Mn) did not justify their application.
- The trial of ammonium nitrate and Nitromag (a mixture of calcium end magnesium nitrates) confirmed the lower efficiency of nitrate fertilizers compare to urea (pages 45-50).
- Yields got with 200kg/ha of TSP are the same than with 350 kg/ha of TSP (pages 47-50). Evermore the higher dose of TSP seemed to interact negatively with ammonium nitrate and ammonium sulfate fertilizers.

Climatic data during the growing period

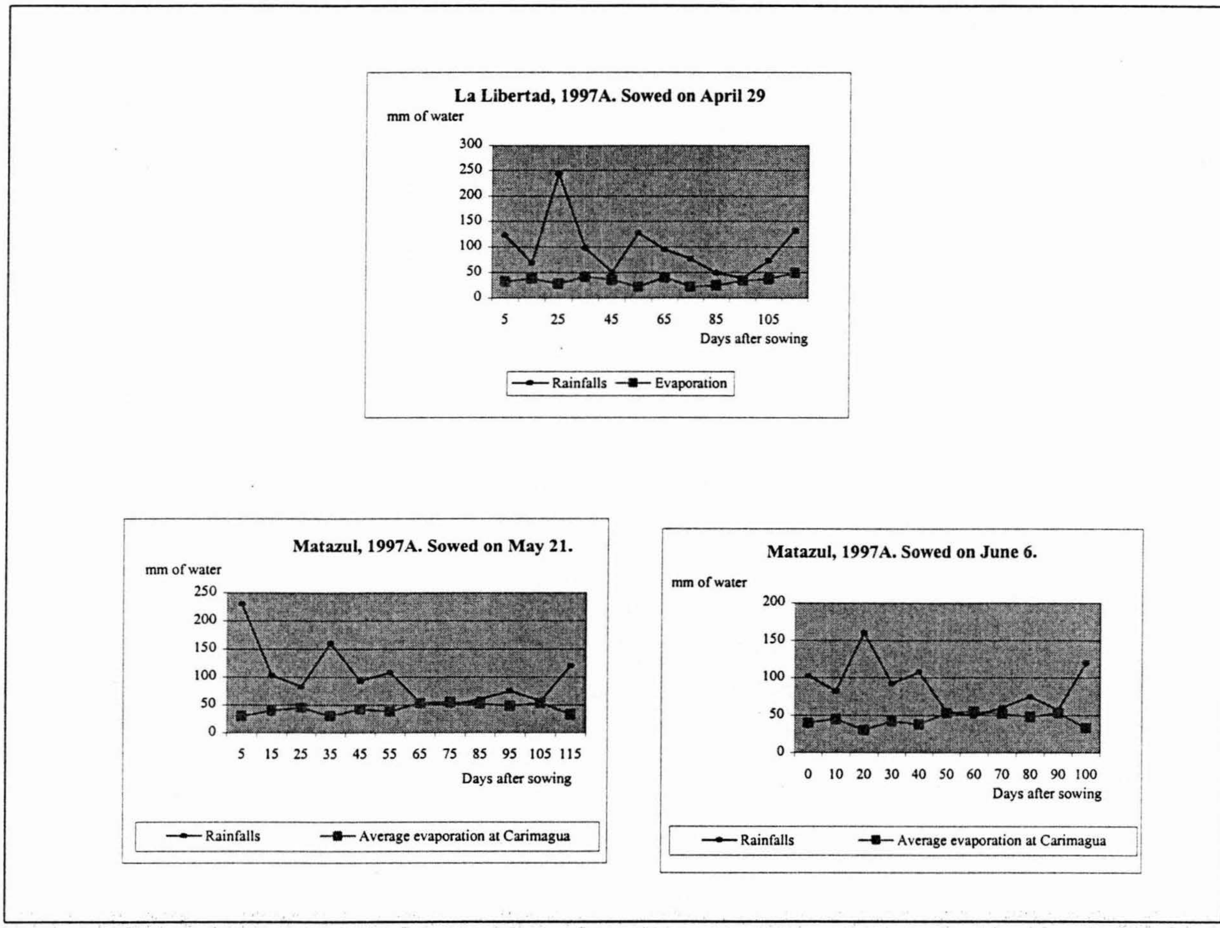

Fig . 1: Ten days record of rainfall and evaporation, during the growing period. For Matazul, rainfall data came from the Santa Cruz farm, 10 km away, and evaporation is estimated from mean data of Carimagua on 18 years.

At La Libertad water was in excess during all the growing period. At Matazul, on the contrary it appears that maize had probably suffer some small water deficit after it flowered (60 days) when it was sown on May 21. It perhaps met this water deficit at flowering time when it was sown on June 6. The water needs are higher than the tank evaporation at that time.

1. New facilities at Matazul, Meta. 1997A

During the first months of 1997, we prepared a new experimental field at Matazul. A 4.5 ha field (150 x 300 m) was selected and enclosed. Soil analysis were done, taking samples from 50 x 75 m rectangles (Table 1). Bands of approximately 40 m large were drawn in field, following contour lines, and were deep plowed (Fig.1).

Soil analysis showed that soil characteristics of the field were homogeneous. In fact, some heterogeneity was expecting, due to old anthills with poorer soil at the surface. P, Ca, Mg and K were deficient. Al saturation was 95 %. Concerning the micronutrients, S and Fe were sufficient, B, Zn and Cu were at critical concentrations and Mn was deficient.

Table 1: Soil analysis of Matazul field, at the initial stage (native savanna). March 1997

Rectangle	pH	ppm P Bray II	meq / 100 g					Al Sat. %	ppm					
			Al	Ca	Mg	K	Σ bases		S	B	Zn	Mn	Cu	Fe
1	4.0	1.8	2.10	0.08	0.04	0.04	2.25	93	16.3	0.26	0.30	0.88	0.30	15.1
2	3.9	1.9	2.25	0.06	0.03	0.04	2.38	95	17.5	0.20	0.26	0.75	0.35	14.8
3	3.9	1.7	2.32	0.06	0.03	0.04	2.45	95	15.7	0.22	0.26	0.83	0.31	14.4
4	3.8	1.7	2.56	0.09	0.04	0.04	2.72	94	15.6	0.19	0.28	0.74	0.34	13.4
5	3.8	1.6	2.36	0.11	0.05	0.04	2.56	92	15.3	0.19	0.29	0.75	0.29	14.1
6	3.9	1.8	2.27	0.09	0.04	0.04	2.43	93	17.7	0.32	0.34	0.97	0.32	14.2
7	3.9	1.6	2.22	0.08	0.04	0.04	2.38	93	18.6	0.26	0.30	0.77	0.34	15.5
8	3.8	1.5	2.41	0.09	0.04	0.04	2.57	94	16.8	0.26	0.32	0.77	0.33	13.6
9	3.8	1.5	2.48	0.07	0.04	0.04	2.63	95	16.7	0.23	0.27	0.83	0.31	13.7
10	3.8	1.9	2.45	0.06	0.03	0.04	2.58	95	15.8	0.22	0.35	0.67	0.29	13.1
11	3.8	1.3	2.44	0.08	0.03	0.04	2.59	95	16.9	0.16	0.27	0.84	0.26	13.4
12	3.9	1.9	2.49	0.07	0.03	0.04	2.63	95	14.4	0.23	0.32	0.97	0.32	15.4
Critical level		10		3	0.4/0.8	0.15		55	10-15	0.1-0.7	2	5-7	0.2-0.8	2

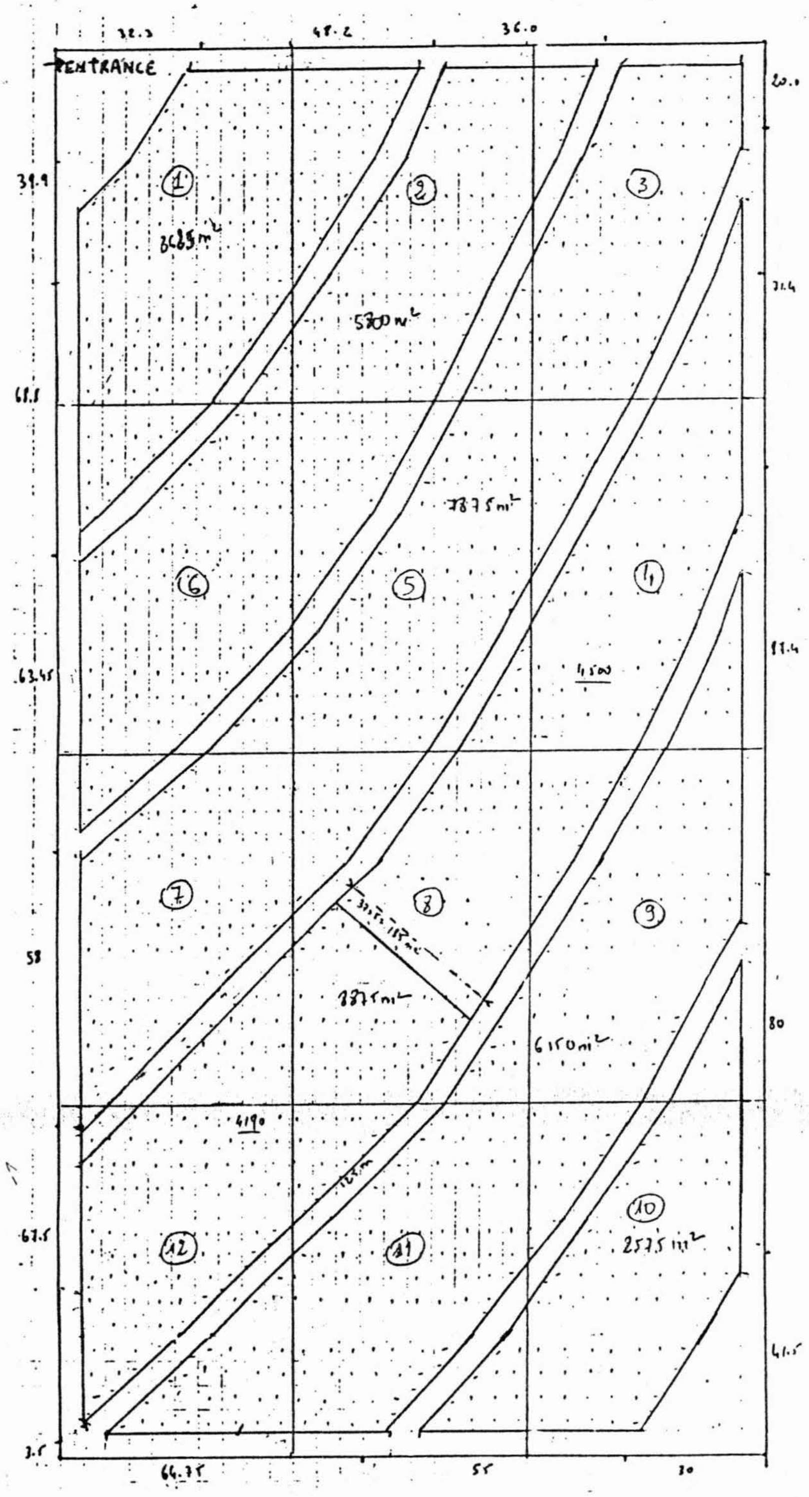

Fig. 1: Map of the Matazul field, with the 50 x 75 m rectangles used for the initial soil analysis sampling

2. Test of TSP fertilizer incubation in Matazul soil

Objective: Soils of the Colombian Llanos are well known to have a high phosphorus fixing capacity. In order to determine the triple superphosphate (TSP) quantity to apply to get 10 ppm Bray II soluble phosphorus, a test of TSP incubation was conducted.

Material and methods:
A soil mixture from 0-20 cm layer samples, made across all the 4.5 ha field were used. Ten glass Bescher recipients were filled with 100 g of soil. TSP quantities were added as described in Table 1, and mixed with soil. The doses were calculated assuming an apparent soil density of 1.3. Each TSP dose was replicated two times. Then, each recipient received 20 ml of desionized water to get approx. the field capacity, and covered with a plastic film. Incubation took 15 days, in dark, at environmental temperature. Later, soil was dried, ground and phosphorus Bray II content determined.

Results:

Table 1: Five TSP dose used in the incubation test and result of the test

Treatment number	Mg TSP / 100 g soil	Equivalent to kg TSP / ha	Ppm P Bray II
0	0	0	1.50
1	4	104	2.90
2	8	208	4.95
3	12	312	8.35
4	16	416	12.70

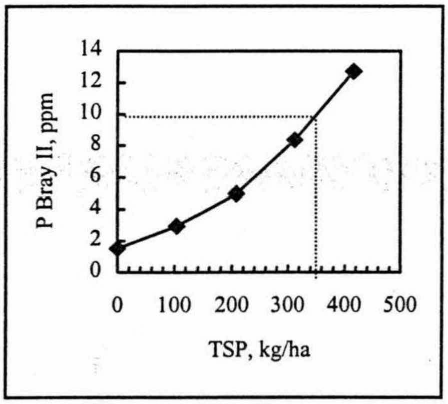

Fig. 1: graphical interpolation of the TSP quantity needed to reach 10 ppm P

Discussion: It is necessary to apply 350 kg/ha of TSP to reach 10 ppm P Bray II. The efficiency rate of the applied P quantity (26 ppm) is 38%.

VV97AA1

3a. Direct sowing of maize in a living mulch of leguminous pasture
C.E. La Libertad, Villavicencio, Meta. 1997A

Objectives: The rotation of monoculture of annual crops in washed acid soils is generally unsustainable because it degrades soil fertility within a few years: OM content and pH decrease, soil gets more compacted, and weed quantities increase. Different alternate solutions can be tried. We chose to try one that could participate to the forage production: the direct sowing of cereals in a living mulch of leguminous.
Six leguminous species well adapted to the area, and two cereal crops, rice and maize were included in this experiment.

Treatments:

Six leguminous species:	CIAT cultivar	batch	Sowing rate kg/ha	Rhizobium CIAT strain
Calopogonium mucunoides	20709	94-069	3	79
Pueraria phaseolides	9900	87-182	3	3918
Stylosanthes guianensis	11833	94-017	3	4969
Centrosema macrocarpum	5713	92-010	4	3101
Centrosema acutifolium	5277	89-021	4	3101
Arachis pentoi	17434	96-028	10	3101

Six crop rotations:

2 crops per year:	1- Maize - maize 2 - Maize - rice 3 - Rice - maize	1 crop per year:	1 - Maize - maize 2 - Maize - rice 3 - Rice - maize

Management:

Design: Criss-cross, with leguminous species in bands crossed with crop rotations
Replication: 1
Plot size: 48 m^2 (8 x 6 m)
Sowing distances: Leguminous broadcasted with fertilizers before cereal sowing. Maize sown on 6 m. long rows, at 0.75 x 0.50 m, 3 seed/ hill thinned to 2 plants/hill. Rice broadcasted at a rate of 100 kg/ha.
Varieties: Maize = Sikuani ; Rice = Sabana 6
Amendments: 1200 kg/ha dolomite + 400 kg/ha gypsum (20% H_2O)
Fertilizers: N,P,K + Zn: 40,66,75 + 2.2 kg/ha, as urea, TSP, KCl and Zn SO_4 at sowing date.
+ N: 80 kg/ha as urea, one month later.
Herbicides: 5 l/ha Lasso at preemergence, on maize
5 l /ha Prowl at preemergence, on rice
Insecticides: Lorsban + Hostathion
Sowing date: April 29, 1997
Harvest date: August 20, 1997

Results:

Table 1: Average data for each treatment

Leguminous	Rotation	Grain yield + (t/ha)	Days to tassel	Plant hgt (cm)	Ear hgt (cm)	Plants harvested	Ears/ plt
A. Results for maize							
Calopogonium mucunoides	Maize-maize, 2 crops/year	2.87	57	160	60	69	0.95
	Maize-rice, 2 crops/year	2.70	57	195	85	70	0.97
	Maize-maize, 1 crop/year	2.42	58	145	75	68	0.91
	Maize-rice, 1 crop/year	1.99	59	195	80	73	0.76
Pueraria phaseolides	Maize-maize, 2 crops/year	2.98	59	195	65	71	0.93
	Maize-rice, 2 crops/year	2.33	56	200	70	-	-
	Maize-maize, 1 crop/year	2.51	59	205	85	69	0.89
	Maize-rice, 1 crop/year	2.02	55	175	50	72	0.83
Stylosanthes guianensis	Maize-maize, 2 crops/year	2.42	58	195	70	72	0.81
	Maize-rice, 2 crops/year	2.06	54	180	70	72	0.82
	Maize-maize, 1 crop/year	2.54	54	180	75	66	0.94
	Maize-rice, 1 crop/year	2.13	55	190	80	70	0.85
Centrosema macrocarpum	Maize-maize, 2 crops/year	2.51	60	190	70	72	0.88
	Maize-rice, 2 crops/year	2.43	58	200	75	73	0.87
	Maize-maize, 1 crop/year	2.34	56	170	65	71	0.88
	Maize-rice, 1 crop/year	1.92	54	190	85	67	0.86
Centrosema acutifolium	Maize-maize, 2 crops/year	2.58	57	160	60	74	0.92
	Maize-rice, 2 crops/year	2.55	56	185	65	70	0.87
	Maize-maize, 1 crop/year	2.36	56	170	65	69	0.92
	Maize-rice, 1 crop/year	2.25	55	180	75	71	0.95
Arachis pentoi	Maize-maize, 2 crops/year	2.47	58	210	75	68	0.94
	Maize-rice, 2 crops/year	2.64	57	185	90	75	0.85
	Maize-maize, 1 crop/year	2.16	57	185	90	67	0.86
	Maize-rice, 1 crop/year	2.40	59	190	80	77	0.84
B. Results for rice							
Calopogonium mucunoides	Rice–maize, 2 crops/year	3.02					
	Rice-maize, 1 crop/year	2.52					
Stylosanthes guianensis	Rice–maize, 2 crops/year	1.75					
	Rice-maize, 1 crop/year	2.98					
Pueraria phaseolides	Rice–maize, 2 crops/year	1.88					
	Rice-maize, 1 crop/year	2.54					
Centrosema macrocarpum	Rice–maize, 2 crops/year	1.79					
	Rice-maize, 1 crop/year	2.04					
Centrosema acutifolium	Rice–maize, 2 crops/year	2.00					
	Rice-maize, 1 crop/year	1.88					
Arachis pentoi	Rice–maize, 2 crops/year	1.67					
	Rice-maize, 1 crop/year	2.56					

+ : grain at 15 % moisture

Table 2 : Average data per factor

Factor	Maize						Rice
	Grain yield (t/ha)	Days to tassel	Plants hgt (cm)	Ear hgt (cm)	Plants harvested	Ears/plt	Grain yield (t/ha)
Leguminous							
Calopogonium mucunoides	2.34	57	174	75	70	0.89	2.77
Pueraria phaseolides	2.46	56	194	68	71	0.88	2.36
Stylosanthes guianensis	2.29	58	186	74	70	0.86	2.21
Centrosema macrocarpum	2.30	57	188	74	71	0.87	1.92
Centrosema acutifolium	2.43	56	174	66	71	0.92	1.94
Arachis pentoi	2.42	58	193	84	72	0.87	2.11
Rotation							
Maize-maize, 2 crop/year	2.54 a	58	185	67	71	0.91	
Maize-rice, 2 crop/year	2.45 a	57	191	76	72	0.87	
Maize-maize, 1 crop/year	2.39 a	56	176	76	68	0.90	
Maize-rice, 1 crop/year	2.12 b	56	187	75	72	0.85	
Rice-maize, 2 crops/year							2.02
Rice-maize, 1 crop/year							2.22

Within column, means followed by a different letter differ significantly at P<0.05 by Newman and Keuls' range test. Means not followed by a letter did not show difference.

Table 3: Mean squares

Source	Maize							Rice	
	df	Grain yield (t/ha)	Days to tassel	Plants hgt (cm)	Ear hgt (cm)	Plants harvested	Ear/plt	df	Grain yield (t/ha)
Total	22	0.06	2.69	236.78	101.45	7.44	0.00	11	0.23
Leguminous	5	0.02	2.47	314.17	156.67	1.85	0.00	5	0.20
Rotation	3	0.20 *	6.39 *	240.28	119.44	16.95	0.00	1	0.49
Pooled error	14	0.05	2.02	210.18	79.44	7.40	0.00	5	0.21
CV %		9.2	2.5	7.9	12.2	3.8	5.6		20.7

*, **, *** Significant at 0.05, 0.01 and 0.001 probability levels, respectively.

Discussion: Grain yields are low, with a trial average of 2.4 t/ha of maize grain and 2.2 t/ha of rice paddy (Table 1).

On this first year, the trial can be analyzed as a four replications trial for maize and two replications for rice. For both cereals there were not yield differences due to leguminous cover crops (Tables 2 and 3). There are no yield reductions observed, in comparison with the adjacent trials, but differences between blocks are observed due to field heterogeneity.

Concerning the leguminous growth, no quantitative data were recorded. It was noticed that *Calopogonium mucunoides* and *Arachis pentoi* showed a better development 40 days after sowing. *Calopogonium* and *Pueraria* suffered foliar beetle damage at this stage. At harvest, *Calopogonium, Stylosanthes, Pueraria* and *Arachis* showed good development. *Pueraria* grew up on maize plants and disturbed the harvest. In *Arachis* plots there was an abudant development of *Rottboellia*. Both *Centrosema* spp were poorly developed.

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3b. Direct sowing of maize in a living mulch of leguminous pasture
Matazul, Meta, 1997A

Objectives: The rotation of monoculture of annual crops in washed acid soils is generally unsustainable because it degrades soil fertility within a few years: OM content and pH decrease, soil gets more compacted, and weed quantities increase. Different alternate solutions can be tried. We chose to try one that could participate to the forage production: the direct sowing of cereals in a living mulch of leguminous.
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Arachis pentoi	17434	96-028	10	3101

Six crop rotations:

2 crops per year:	1- Maize - maize 2 - Maize - rice 3 - Rice - maize	1 crop per year:	1 - Maize - maize 2 - Maize - rice 3 - Rice - maize

Management:

Design: Criss-cross, with leguminous species in bands crossed with crop rotations
Replication: 1
Plot size: 49 m^2 (7 x 7 m)
Sowing distances: Leguminous broadcasted with fertilizers before cereal sowing. Maize sown on 7 m. long rows, at 0.75 x 0.50 m, 3 seed/ hill thinned to 2 plants/hill. Rice broadcasted at a rate of 100 kg/ha.
Varieties: Maize = Sikuani ; Rice = Sabana 6
Amendments: 1460 kg/ha dolomite + 500 kg/ha gypsum (20% H_2O)
Fertilizers: N,P,K: 40,68,120 kg/ha, as urea, TSP, KCl at sowing date.
+ N: 80 kg/ha as urea, one month later
Micronutrients: Zn, B, Cu, Mn: 2.2, 1.2, 9, 3 kg/ha as zinc sulfate, borosol, copper sulfate, and manganese sulfate at sowing date
No herbicide
Insecticides: Lorsban + Hostathion
Sowing date: June 4, 1997
Harvest date: September 26, 1997

Results:

Table 1: Data for each treatment

Leguminous	Rotation	Grain yield (t/ha)	Days to tassel	Plant hgt (cm)	Ear hgt (cm)	Plants harvested	Ears/plt
Calopogonium mucunoides	Maize-maize, 2 crops/year	1.27	64	145	60	278	0.48
	Maize-rice, 2 crops/year	1.01	65	145	60	270	0.49
	Maize-maize, 1 crop/year	1.24	66	145	60	278	0.52
	Maize-rice, 1 crop/year	1.08	66	145	60	270	0.41
Pueraria phaseolides	Maize-maize, 2 crops/year	1.41	66	145	60	265	0.44
	Maize-rice, 2 crops/year	1.43	66	145	60	268	0.54
	Maize-maize, 1 crop/year	1.73	65	145	60	280	0.60
	Maize-rice, 1 crop/year	1.70	64	145	60	257	0.84
Stylosanthes guianensis	Maize-maize, 2 crops/year	1.76	65	145	60	276	0.48
	Maize-rice, 2 crops/year	1.73	63	145	60	283	0.63
	Maize-maize, 1 crop/year	1.31	68	145	60	245	0.57
	Maize-rice, 1 crop/year	1.43	65	145	60	232	0.59
Centrosema macrocarpum	Maize-maize, 2 crops/year	1.53	63	145	60	276	0.37
	Maize-rice, 2 crops/year	1.47	64	145	60	280	0.58
	Maize-maize, 1 crop/year	1.28	68	145	60	242	0.45
	Maize-rice, 1 crop/year	1.75	64	145	60	274	0.51
Centrosema acutifolium	Maize-maize, 2 crops/year	1.62	66	145	60	280	0.61
	Maize-rice, 2 crops/year	1.71	65	145	60	260	0.68
	Maize-maize, 1 crop/year	1.52	64	145	60	274	0.58
	Maize-rice, 1 crop/year	1.41	66	145	60	246	0.54
Arachis pentoi	Maize-maize, 2 crops/year	1.19	65	145	60	278	0.43
	Maize-rice, 2 crops/year	1.35	65	145	60	250	0.48
	Maize-maize, 1 crop/year	1.63	64	145	60	275	0.77
	Maize-rice, 1 crop/year	1.54	64	145	60	262	0.66

Table 2: Average data for leguminous and rotation (used as replications)

Factor	Grain yield (t/ha)	Days to tassel	Plant hgt (cm)	Ear hgt (cm)	Plants harvested	Ears/plt
Leguminous						
Calopogonium mucunoides	1.15	65	145	60	274	0.48
Pueraria phaseolides	1.57	65	145	60	268	0.61
Stylosanthes guianensis	1.56	65	145	60	259	0.57
Centrosema macrocarpum	1.51	65	145	60	268	0.48
Centrosema acutifolium	1.57	65	145	60	265	0.60
Arachis pentoi	1.43	65	145	60	266	0.58
Rotation						
Maize-maize, 2 crops/year	1.46	65	145	60	276	0.47
Maize-rice, 2 crops/year	1.45	65	145	60	269	0.57
Maize-maize, 1 crop/year	1.45	66	145	60	266	0.58
Maize-rice, 1 crop/year	1.48	65	145	60	257	0.59

Within column, means followed by a different letter differ significantly at $P<0.05$ by Newman and Keuls 'range test. Means not followed by a letter did not show difference.

Table 3: Mean squares

Source	df	Grain yield (t/ha)	Days to tassel	Plants harvested	Ears/plt
Total	23	0.05	1.69	204.68	0.01
Leguminous	5	0.11 *	0.44	94.38	0.01
Rotation	3	0.00	1.71	358.15	0.02
Pooled error	15	0.04	2.11	210.75	0.01
C.V. %		13.2	2.20	5.4	18.6

*,**,*** Significant at 0.05, 0.01 and 0.001 probability levels, respectively.

Discussion: Grain yields were low, with an average of 1.46 t/ha of maize grain (Table 1). Rice plots were not harvested because their poor plant stand, due to a poor seed quality. Only the data of the maize trial are reported.

On this first year, the trial can be analyzed as a four replications trial for maize. The ANOVA shows a significant effect of leguminous on maize yield (Table 3). Maize sown with *Calopogonium mucunoides* yielded less than in other leguminous (Table 2). In fact, this difference is probably an effect of the field soil heterogeneity: the first block, sown with *C. mucunoides*, was situated on an old anthill. These areas are known to be less fertile, because ants moved up poor soil from deeper layers.

On the contrary, average for replications are remarkably similar, showing high soil homogeneity along contour lines.

Concerning the leguminous growth, no quantitative data were recorded. It was noticed that *Calopogonium mucunoides* and *Arachis pentoi* had the better development 76 days after sowing. Growth of all legumes was slow in this trial.

VV97AA2

4. Effect of amendments with sulfates or sulfur on maize production. La Libertad, Villavicencio, Meta, 1997A

Objectives: Preliminary results obtained in 1995 at Carimagua and La Libertad showed the advantage of using Sulcamag against dolomite as amendment in the acid soils of these two Centers. To understand the effect of sulfur, various sulfate and sulfur sources were tested in 1996B. The trial was also planned to study the effect of amendment levels and application methods. The trial was sown again in 1997A, in order to study the residual effect of the amendments applied in great quantities against the effect of smaller applications repeated at each crop establishment.

Treatments:

Amendments:	Check		
	Sulfur	100% S	152 kg/ha
	Dolomite	57% $CACO_3$, 35% $MgCO_3$	1.5 t/ha
	Dolomite + sulfur	''	1.5 t/ha + 152 kg/ha
	Sucromac®	21% CaO, 8% MgO, 11% SO_4, 15% MO	2.46 t/ha
	Sulcamag®	25% CaO, 13% MgO, 8% S	1.90 t/ha

Dolomite dose of 1.5 t/ha was decided before the soil analysis results were available. This dose was expected to decrease the aluminum saturation to 55 % . Sucromac and Sulcamag doses was calculated to bring a uniform Ca + Mg value per treatment. Sulfur dose was calculated to supply as much sulfur as in the Sulcamag treatment.
Sucromac contains gypsum, calcium and magnesium acids and concentrated sugarcane juice. Organic matter of the product is mainly composed of saccharose and caramel polymers.
Sulcamag is produced by an acidic treatment of dolomite with sulfuric acid.

Application methods:
a. broadcasted, at complete and half doses, done in 1996B. No amendment in 1997A.
b. application in bands, at one fourth and one-eighth doses. Repeated in 1997A.

Management:

Design: Split-plot with products as main and application methods in sub-blocks.
Replications: 3
Plot size: 5 rows of 5 meters, from which the 3 central rows were harvested (12.375 m^2)
Sowing distances: 0.75 x 0.50 m. 2 plants/ hill. Expected plant number: 66
Maize variety: Sikuani
Fertilizers: N, P, K + Zn: 120,66,75 + 2.2, as urea, TSP, KCl, and zinc sulfate
Herbicide: Lasso, 5 l/ha at pre-emergence
Insecticides: Lorsban + Hostathion
Sowing date: April 29, 1997
Harvest date: August 20, 1997

Results:

Table 1: Average data for each treatment

	Grain yield (t/ha)	Male flowering (DAS)	Plants hgt (cm)	Ear hgt (cm)	Plants harvested	Ears/plt
Broadcasted amendments						
Check	2.35	57	195	73	61	0.88
Sulfur, 1/2 dose	2.34	58	187	67	61	0.85
Sulfur , total dose	2.45	57	190	80	58	0.94
Dolomite, 1/2 dose	2.84	55	197	68	60	0.94
Dolomite, tot. dose	2.36	57	185	77	57	0.86
Dolomite + Sulfur, 1/2 dose	2.81	53	195	82	62	0.95
Dolomite + Sulfur, tot. dose	3.03	55	198	80	62	0.92
Sucromac, 1/2 dose	3.15	57	188	73	63	0.88
Sucromac, tot. dose	2.82	56	203	70	63	0.95
Sulcamag, 1/2 dose	2.88	56	196	82	61	0.97
Sulcamag, tot. dose	2.72	56	200	73	61	0.89
Band placed amendments						
Check	2.66	59	195	78	60	0.99
Sulfur, 1/8 dose	2.12	57	185	70	59	0.86
Sulfur , 1/4 dose	2.72	57	178	72	64	0.93
Dolomite, 1/8 dose	2.14	56	182	72	63	0.84
Dolomite, 1/4 dose	2.57	55	200	78	62	0.94
Dolomite + Sulfur, 1/8 dose	2.74	58	192	82	59	1.01
Dolomite + Sulfur, 1/4 dose	2.15	59	182	68	58	0.93
Sucromac, 1/8 dose	2.66	58	190	73	61	0.94
Sucromac, 1/4 dose	2.51	56	195	80	60	0.93
Sulcamag, 1/8 dose	2.41	56	188	87	63	0.82
Sulcamag, 1/4 dose	2.82	57	190	77	60	0.98

Within column, means followed by a different letter differ significantly at P<0.05 by Newman and Keuls' range test. Means not followed by a letter did not show difference.

Table 2: Mean squares for recorded data in broadcast and band placed treatments. Trial is analyzed as two trials of three replications randomized design.

Source	Df	Grain yield (t/ha)	Male flowering (days)	Plants hgt (cm)	Ear hgt (cm)	Plants harvested	Ear/plt
Broadcasted							
Total	32	0.17	3.96	135.50	85.94	11.20	0.01
Amendments	10	0.24	4.94	101.00	86.67	10.82	0.00
Reps	2	0.39*	4.45	373.91	118.18	29.21	0.01
Pooled error	20	0.11	3.42	128.91	82.35	9.58	0.01
CV %		12.2	3.3	5.9	12.1	5.1	8.7
Banded							
Total	32	0.13	4.40	187.55	102.75	11.90	0.01
Amendments	10	0.20	3.94	131.82	93.79	11.21	0.01
Reps	2	0.01	5.82	21.21	55.30	12.09	0.00
Pooled error	20	0.11	4.48	232.05	111.97	12.22	0.01
CV %		13.0	3.7	8.1	13.9	5.7	10.7

*, **, *** Significant at 0.05, 0.01 and 0.001 probability levels, respectively.

Discussion:

Grain yields were low, with a trial average of 2.6 t/ha. Check plots with no amendment yielded an average of 2.5 t/ha.
Very few differences were recorded between treatments. ANOVA shows a significant difference between replications that received broadcast treatments (Table 2). Effect of amendments is nearly significant ($P = 0.06$): with the exception of the treatment with dolomite at half-dose, plots which in 1996b received one amendment containing sulfate or sulfur associated with calcium and magnesium, yielded an average of 400 kg/ha more than the others (Table 1).

There was no effect of the amendments when applied in bands.
To conclude, it seems there is a strong limiting factor to maize yield in the acid soils of La Libertad. The yield limit of 3 t/ha with Sikuani had been previously met in previous agronomic trials (1994 and 1995).

VV97AA3

5a. Comparative effect on soil fertility of acid soil tolerant varieties used in the maize-soybean rotation against no-tolerant varieties La Libertad, Villavicencio, Meta, 1997A

Objectives: CIMMYT has bred maize varieties tolerant to acid soils and CORPOICA has released one soybean variety also tolerant to the same stress. It still exists a question on the long term effect of these bred varieties on the soil fertility: will not they uptake the remaining fertility of these acidic soils ?
A long-term experiment was planned in order to compare the effect the maize-soybean rotation, using tolerant and nontolerant varieties of these two crops. A small design was selected, in order to continue this experiment during some years. The two rotation systems were crossed with two levels of soil correction, 45 and 65 % of aluminum saturation. Yield differences are expected with nontolerant varieties on these two fertility levels. On the contrary, no differences are expected with tolerant varieties.

Treatments:

a. Varieties:

	Maize	Soybean
Tolerant	Sikuani	Altillanura 2
Non tolerant	Tuxpeño	Soyica P 34

b. Soil correction:

	Expected Aluminum Saturation	Amendment	
Level 1	45 %	Sulcamag®	1230 kg/ha
Level 2	65 %	Sulcamag®	300 kg/ha
		Applied 15 days before sowing	

Sulcamag is produced by the treatment of dolomite with sulfuric acid. It contains 25% CaO, 13% MgO, 8% S.

Management:
Design: Randomized blocks with 3 replications
Plot size: 6 m x 8 m, 48 m^2. Or 10 rows of 6 meters
Sowing distances: 0.75 x 0.50 m, 2 plants per hill.
Fertilizers: N, P, K + Zn: 40,66,75 + 2.2 kg/ha as urea, TSP,KCl, and $ZnSO_4$ at sowing date
N: 80 kg/ha as urea one month later
Herbicide: Lasso, 5l/ha at pre-emergence
Insecticides: Lorsban + Hostathion
Sowing date: April 30, 1997
Harvest date: August 20, 1997

Results:

Table 1: Average data for each treatment

Variety	Aluminum saturation %	Grain yield (t/ha)	Male flowering (DAS)	Plants hgt (cm)	Ear hgt (cm)	Plants harvested	Ears/plt
Sikuani	45	2.15	58	187	73	231	0.97
	65	2.07	57	180	72	222	0.99
Tuxpeño	45	1.87	59	150	45	221	0.93
	65	2.01	59	167	57	224	0.91

Table 2: Average data for each factor

Factor	Grain yield (t/ha)	Male flowering (DAS)	Plants hgt (cm)	Ear hgt (cm)	Plants harvested	Ears/plt
Variety						
Sikuani	2.11	58	183 a	73 a	226	0.98
Tuxpeño	1.94	59	158 b	51 b	223	0.92
Aluminum saturation						
45	2.01	59	168	59	226	0.95
65	2.04	58	173	64	223	0.95

Within column, means followed by a different letter differ significantly at P<0.05 by Newman and Keuls' range test. Means not followed by a letter did not show difference.

Table 3: Mean squares

Source	df	Grain yield (t/ha)	Male flowering (days)	Plants hgt (cm)	Ear hgt (cm)	Plants harvested	Ears/plt
Total	11	0.08	2.61	267.42	165.15	173.17	0.00
Aluminum saturation	1	0.00	1.33	75.00	75.00	24.08	0.00
Variety	1	0.09	8.33	1875.00 **	1408.33 ***	36.75	0.01
Aluminum x variety	1	0.04	0.33	408.33 *	133.33 *	102.08	0.00
Reps	2	0.15	1.58	77.08	27.08	6.08	0.00
Pooled error 1	6	0.08	2.58	71.53	24.31	288.31	0.01
CV %		13.8	2.8	5.0	8.0	7.6	8.1

*, **, *** Significant at 0.05, 0.01 and 0.001 probability levels, respectively.

Table 4: Soil analysis before amendment application.

Depth (cm)	% MO	P ppm	pH	Al	Ca	Mg	K	Al sat %
				meq / 100 g				
0-20	4.3	9.6	4.4	1.98	0.86	0.23	0.14	62
20-40	3.6	3.2	4.2	2.42	0.41	0.09	0.06	81
40-60				2.27	0.37	0.05	0.05	83

Table 5: Average data of soil analysis from the 0-20 cm layer at harvest.

Liming kg/ha of Sulcamag	Variety	P ppm	pH	Al	Ca	Mg	K	Al sat. %
				meq / 100 g				
1230	Sikuani	21.5	4.7	2.15	0.8	0.29	0.14	64
	Tuxpeño	22.7	4.8	1.82	0.99	0.36	0.12	55
300	Sikuani	19.7	4.7	2.22	0.74	0.22	0.14	67
	Tuxpeño	18.4	4.8	1.94	0.98	0.21	0.14	59

Table 6: Means for liming doses and varieties of soil analysis data from the 0-20 cm layer at harvest.

Factors	P ppm	pH	Al	Ca	Mg	K	Al sat. %
			meq / 100 g				
Liming							
1230 kg/ha	22.1	4.7	1.99	0.89	0.33 a	0.13	59
300 kg/ha	19.0	4.7	2.08	0.86	0.22 b	0.14	63
Variety							
Sikuani	20.6	4.7 b	2.18	0.77	0.26	0.14	65
Tuxpeño	20.6	4.8 a	1.88	0.98	0.29	0.13	57

Within column, means followed by a different letter differ significantly at P<0.05 by Newman and Keuls' range test. Means not followed by a letter did not show difference.

Table 7: Mean squares for data of soil analysis from the 0-20 cm layer at harvest.

Source	df	P	pH	Al	Ca	Mg	K	Al sat
Total	11	32.79	0.01	0.11	0.05	0.01	0.00	76.85
Liming	1	28.71	0	0.03	0.00	0.04 **	0.00	33.35
Variety	1	0.00	0.04 *	0.28 ①	0.14 ②	0.00	0.00	200.28 ①
Liming x Variety	1	5.07	0.00	0.00	0.00	0.01	0.00	0.15
Reps	2	32.58	0.01	0.24	0.08	0.00	0.00	146.98
Pooled error	6	43.71	0.01	0.07	0.04	0.00	0.00	52.94
C.V.%		32.1	1.8	13.4	23.5	19.9	17.1	11.9

*, **, *** Significant at 0.05, 0.01 and 0.001 probability levels, respectively.
① : P<0.10, ② : P<0.12

Table 8: Differences of cations quantities in the 0-20 cm layer between plots sowed with Sikuani or Tuxpeño

	Ca	Mg	K
Meq / 100 g	0.22	0.03	0.01
Kg/ha (estimation)	106	9	9

Table 9: Estimation of the average quantities of soluble cations and P balance in the 0-20 cm layer during the maize cultivation in this maize-soybean rotation trial.

Kg/ha in the 0-20 cm layer	300 kg/ha Sulcamag				1230 kg/ha Sulcamag			
	P	Ca	Mg	K	P	Ca	Mg	K
Initial	23	413	66	131	23	413	66	131
Additional	66	54	23	75	66	220	96	75
Final	46	413	63	131	53	427	95	122
Aerial part of maize plants [1)]	8	7	6	30	8	7	6	30
Exit from the soluble fraction	35	47	20	45	28	199	61	54
(% from additional)	(50)	(87)	(87)	(60)	(42)	(90)	(63)	(72)

[1)] Estimation on the basis of a crop which have produced 2 t/ha of grain.

Discussion:

1. Data on plants growth and harvest.
Yields were low, with a trial average of 2 t/ha. There are few differences between treatments, except the height differences between the two varieties and an interaction variety x aluminum saturation (Table 3). This interaction is due to the fact that the plant height of Tuxpeño is more affected than Sikuani's by the level of aluminum saturation in plots (Table 1). On the contrary, yield and measured yield components do not show differences between varieties and aluminum saturation levels (Tables 2 and 3).

2- Soil analysis data.
Results of soil analysis of the trial plots show more differences between factors than results on plant growth (Table 6), and the differences mostly come from the variety factor.
The first observation is that at the end of the crop cycle, the aluminum saturation in plots which received 1230 kg/ha of Sulcamag was not at the expected level. The mean level was 59 %, similar to the average aluminum saturation of plots treated with 300 kg/ha of Sulcamag at 63 %. There was a large difference between varieties: Sikuani at 64 % and Tuxpeño at 55 % (Tables 5 and 6).
Four months after the application of amendment, only the Mg content was different between both Sulcamag treatments in the 0-20 cm layer. After the application of 1230 kg/ha, the Mg content was higher than the initial level. With 300 kg/ha the Mg content remained at the initial level (Tables 4 and 6). On the other hand, the pH of the plots where Sikuani was planted, was 0.1 unit lower than in those where Tuxpeño was planted. With a risk $\alpha < 12$ %, it can be concluded that Al and Ca contents and the resulting aluminum saturation percentage of the plots depended on the variety used. It seems that the variety Sikuani caused the movement of a larger quantity of soluble calcium from the 0-20 cm layer than Tuxpeño (Table 8). The estimation of this difference between varieties is 106 kg/ha. This data is not of the same order than the calcium quantity incorporated in the maize plants above the soil whose estimation is 7 kg/ha for a grain production of 2 t/ha (Table 9).

The present results will have to be confirmed. Similarly, some hypothesis concerning the reason of this calcium movement have to be checked. Does Sikuani cause a larger calcium lixiviation, perhaps in relation with the release of organic acids by roots (Pellet, 1996)? Does Sikuani cause an unsolubilization of one fraction of the calcium contents, eventually still bound in the maize root apoplast (Horst, 1995)?

MA97AA3

5b. Comparative effect on soil fertility of acid soil tolerant varieties used in the maize-soybean rotation against no-tolerant varieties Matazul, Meta, 1997A

Objectives: CIMMYT has bred maize varieties tolerant to acid soils and CORPOICA has released one soybean variety also tolerant to the same stress. It still exists a question on the long term effect of these bred varieties on the soil fertility: will not they uptake the remaining fertility of these acidic soils ?
A long-term experiment was planned in order to compare the effect the maize-soybean rotation, using tolerant and nontolerant varieties of these two crops. A small design was selected, in order to continue this experiment during some years. The two rotation systems were crossed with two levels of soil correction, 45 and 65 % of aluminum saturation. Yield differences are expected with nontolerant varieties on these two fertility levels. On the contrary, no differences are expected with tolerant varieties.

Treatments:

a. Varieties:

	Maize	Soybean
Tolerant	Sikuani	Altillanura 2
Non tolerant	Tuxpeño	Soyica P 34

b. Soil correction:

	Expected Aluminum Saturation	Amendment	
Level 1	45 %	Sulcamag®	1230 kg/ha
Level 2	65 %	Sulcamag®	300 kg/ha
		Applied 15 days before sowing	

Sulcamag is produced by the treatment of dolomite with sulfuric acid. It contains 25% CaO, 13% MgO, 8% S.

Management:
Design: Randomized blocks with 3 replications
Plot size: 5 m x 10 m, 50 m^2. Or 6 rows of 10 meters
Sowing distances: 0.75 x 0.50 m, 3 seeds/hill thinned to 2 plants/hill.
Fertilizers: N, P, K: 40,68,120 applied as urea, TSP and KCl applied at sowing date
+ N: 80 kg/ha as urea, one month later
Micronutrients: Zn, B, Cu, Mn: 2.2, 1.2, 9, 3 kg/ha as zinc sulfate, borosol, copper sulfate and manganese sulfate
No herbicide
Insecticides: Lorsban + Hostathion
Sowing date: June 4, 1997
Harvest date: September 26, 1997

Results:

Table 1: Average data for each treatment

Variety	Expected Al saturation %	Grain yield (t/ha)	Days to tassel	Plantshgt (cm)	Ear hgt (cm)	Plants harvested	Ears/plt
Sikuani	45	2.54	62	155	75	62	80
	65	2.56	62	158	75	59	86

Table 2: Mean squares

Source	df	Grain yield (t/ha)	Male flowering (days)	Plant hgt (cm)	Ear hgt (cm)	Plants harvested	Ears/plt
Total	11	0.08	1.90	33.33	40.91	10.09	0.02
Aluminum saturation	1	0.00	0.75	33.33	0.00	21.33	0.01
Variety	1	0.08	0.08	75.00	75.00	8.33	0.02
Aluminum x variety	1	0.09	0.08	8.33	75.00	1.33	0.01
Reps	2	0.23 *	5.58	27.08	43.75	1.75	0.03
Pooled error 1	6	0.04	1.47	32.64	35.42	12.75	0.01
CV %			2.0	3.6	7.9	5.9	12.5

*, **, *** Significant at 0.05, 0.01 and 0.001 probability levels, respectively.

Table 3: Soil analysis of the 0-20 layer at harvest

Expected Al saturation %	Liming kg/ha of Sulcamag	ppm P Bray II	pH	milliequivalent / 100g					Al saturation at harvest %
				Al	Ca	Mg	K	Σ bases	
45	3050	29.8	4.9	1.08 b	1.27	0.60	0.13	3.08	35 b
65	1800	28.8	4.8	1.52 a	0.93	0.44	0.12	3.01	51 a
Initial analysis		1.9	3.9	2.49	0.07	0.03	0.04	2.63	95

Table 4: Mean squares for data of soil analysis from the 0-20 cm layer at harvest.

Source	df	P	pH	Al	Ca	Mg	K	Al sat
Total	11	213.27	0.02	0.12	0.09	0.02	0.00	143.12
Liming	1	3.00	0.04	0.57 *	0.35 ①	0.08 ①	0.00	717.90 *
Variety	1	147.00	0.00	0.01	0.03	0.01	0.00	49.13
Liming x Variety	1	374.08	0.02	0.02	0.05	0.01	0.00	3.42
Reps	2	368.31	0.03	0.06	0.02	0.00	0.00	35.79
Pooled error	6	180.87	0.02	0.010	0.09	0.02	0.00	122.04
C.V.%		45.9	2.9	23.9	27.9	25.0	16.3	25.7

①, *, **, *** Significant at 0.10, 0.05, 0.01 and 0.001 probability levels, respectively.

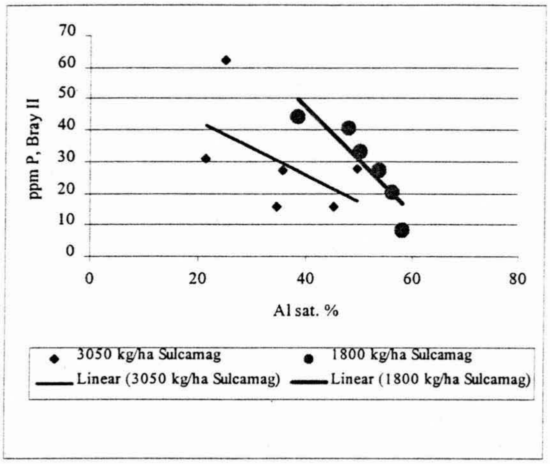

Fig. 1: Correlation between P and Al saturation on the results of the soil analysis of each plot

Discussion:

Due to a mistake when sowing, the trial was finally planted with only the tolerant variety, Sikuani. Then the results only concerned the results of Sikuani in two aluminum saturation levels.

1– Data on plants growth and harvest.
Yields were low, with a trial average of 2.55 t/ha. There were no differences between treatments.

2- Soil analysis data.
The aluminum saturation level was lower than expected and the soluble phosphorus level is three times higher than expected (Table 3). Moreover P and cations quantities are very different from one plot to another, as shown by the high C.V. of the ANOVA (Table 4 and Fig. 1). Soluble phosphorus and Al saturation appear to be correlated, and this correlation depends on the quantity of Sulcamag that was applied. With 1800 kg/ha the correlation is clear, but with 3050 kg/ha Al saturation and P concentration became very variable.
Results got in this trial are different from those registered with the dolomite application in the next plots of the breeding program. There, 1085 and 1530 kg/ha dolomite was applied to decrease Al saturation respectively to 70 and 60 %. At harvest, analysis showed the average Al saturations were 68 and 57 %, exactly as expected. The same phosphorus fertilizer quantity was applied, 350 kg/ha TSP. Results of P analysis are more variable, from 6.1 to 13.5 ppm, but the average is 9.8 ppm for the three first bands, where fertilizers were mechanically incorporated into soil. But available P is 33 ppm in the fourth band, where fertilizers were hands incorporated. This number is near from those got in this trial, where amendments and fertilizers were hand incorporated.
Consequently the type of incorporation seems to have played a role in the phosphorus became. Had it also an effect on Sulcamag became? Or Sulcamag differently acted than dolomite, in this soil?

VV97AA4

6a. Interaction between maize tolerance to acid soils and fertilization management La Libertad, Villavicencio, Meta, 1997A

Objectives: CIMMYT developed the OP variety of maize tolerant to acid soils, released by the Colombian government as Sikuani ICA V 110. The instituttion is also creating hybrids adapted to this stress. It is expected that these varieties will permit to save one part of the amendments that would have been needed to cultivate a nontolerant variety.

Roots of the tolerant varieties are able to grow in soils with a higher aluminum saturation rate. Consequently, it is expected that they would grow deeper and intercept a greater fraction of the soluble ions that are highly lixiviated under the Llanos heavy rainfalls.

Another way to get deeper rooting is trough the use of gypsum as amendment. This is able to reach deeper layers than dolomite, modifying their pH and aluminum saturation level. An experiment done in 1995 at the C. E. La Libertad, showed an interaction between the type of amendment used (dolomite or Sulcamag) and the genetic tolerance to acid soils (varieties Sikuani and Tuxpeño, as tolerant and susceptible to acid soils, respectively). Sikuani yielded more with Sulcamag while Tuxpeño yielded less.

During the preparation of a trial to confirm these three points, I discussed with I. Rao, CIAT 's specialist of root growth, to organize the measurement with him. It was decided to add a treatment with a higher level of nitrogen, applied earlier. This was done to test Dr. W. Horst's hypothesis, that maize could suffer nitrogen hunger at early stages.

Treatments:

3 varieties:
- . Sikuani ICA V 110, OPV tolerant to acid soils
- . Tuxpeño, OPV susceptible
- . Experimental white hybrid, tolerant SA8C3HC49-3-Auto x CIMCALI 93 SA6

3 fertilizations:
- . 1500 kg/ha dolomite, in 1997A
- . 1130 kg/ha dolomite + 500 kg/ha gypsum (20% H), in 1997A
- . 1500 kg/ha dolomite, in 1997A + 5 urea applications (40 kg N/ha), every two weeks from sowing to 60 DAS

Amendment doses were calculated to reduce aluminum saturation to 55% and to apply a constant (Ca+Mg) sum in every treatment. Five hundred kg/ha and 211 kg/ha of dolomite and the total dose of gypsum were applied one month before sowing. At sowing, dolomite quantities were increased, after a new soil analysis. 1000 kg/ha and 919 kg/ha of dolomite were then added to complete the total dose.

Management:

Design: Randomized blocks
Replications: 3
Plot size: 5 rows, 6 m. long each, from which the 3 central rows were harvested (14.6 m^2)
Sowing distances: 0.75 x 0.50 m with 3 seeds/hill thinned to 2 plants/hill
Fertilizers: N,P,K + Zn: 40, 66, 75 + 2.2 as urea, TSP, KCl and zinc sulfate at sowing time
N: 80 kg/ha as urea, one month after sowing (Except in the third fertilization treatment)

Herbicide: Lasso, 5 l/ha at pre-emergence
Insecticides: Lorsban + Hostathion
Sowing date: April 29, 1997
Harvest date: August 20, 1997

Results:

Table 1: Average data for each treatment

Variety	Treatments	Grain yield (t/ha)	Days to tassel	Plants hgt (cm)	Ear hgt (cm)	Plants harvested	Ears/plt
Sikuani	Dolomite	2.46 def	59	198	75 b	72	0.97
	Dolomite + Gypsum	2.07 ef	58	196	70 bc	70	0.91
	Dolomite + high nitrogen	4.25 ab	55	218	82 b	69	0.97
Tuxpeño	Dolomite	1.62 f	61	158	40 e	58	0.90
	Dolomite + Gypsum	2.49 def	59	163	60 cd	62	0.94
	Dolomite + high nitrogen	2.66 de	60	168	55 d	60	0.94
Exp. Hybrid	Dolomite	3.64 bc	60	198	77 b	70	1.09
	Dolomite + Gypsum	3.23 cd	59	197	73 b	69	0.99
	Dolomite + high nitrogen	4.67 a	57	223	97 a	75	0.99

Within column, means followed by a different letter differ significantly at P<0.05 by Newman and Keuls' range test. Means not followed by a letter did not show difference.

Table 2: Average data per factor

Factor	Grain yield (t/ha)	Days to tassel	Plants hgt (cm)	Ear hgt (cm)	Plants harvested	Ears/plt
Variety						
Sikuani	2.93 b	57 b	204 a	76 b	70 a	0.95
Tuxpeño	2.26 c	60 a	163 b	52 c	60 b	0.92
Exp. Hybrid	3.85 a	58 b	206 a	82 a	71 a	1.02
Treatments						
Dolomite	2.57 b	60 a	185 a	64 b	67	0.99
Dolomite + Gypsum	2.60 b	59 b	185 a	68 b	67	0.95
Dolomite + high nitrogen	3.86 a	57 b	203 a	78 a	68	0.97

Within column, means followed by a different letter differ significantly at P<0.05 by Newman and Keuls' range test. Means not followed by a letter did not show difference.

Table 3: Mean squares

Source	Df	Grain yield (t/ha)	Days tio tassel	Plants hgt (cm)	Ear hgt (cm)	Plants harvested	Ears/plt
Total	26	1.09	4.11	683.03	277.85	64.81	0.01
Fertilization	2	4.89 ***	14.78 **	990.33 *	462.04 ***	2.93	0.00
Variety	2	5.73 ***	14.78 **	5258.11 ***	2323.15 ***	357.48 **	0.02 *
Fertilization x variety	4	0.88 **	3.06	103.11	221.76 **	19.26	0.01
Reps	2	0.52 *	3.00	518.11	89.81	110.48	0.01
Pooled error 1	16	0.15	1.69	238.32	36.69	41.65	0.01
C.V. %		13.1	2.2	8.1	8.7	9.6	8.7

*, **, *** Significant at 0.05, 150.01 and 0.001 probability levels, respectively.

Table 4: Consumption rate of the nitrogen applied in plots amended with 1500 kg/ha dolomite. La Libertad 1997A.

	120 kg/ha N		200 kg/ha N		80 kg/ha additional N	
	Grain yield t/ha	Consumption rate kg N / t grain	Grain yield t/ha	Consumption rate kg N / t grain	Grain yield increase t/ha	Consumption rate kg N / t grain
Sikuani	2.46	49	4.25	47	1.79	44
Tuxpeño	1.62	74	2.66	75	1.04	77
Hybrid	3.64	33	4.67	43	1.03	78

Discussions:

It was finally impossible to organize the root growth measurement during this season. Consequently only data on plant growth were recorded. Trial yield average was 3.0 t/ha, higher than the average of the adjacent trials. This is due to the strong effect of the treatment with high level of nitrogen. It increased yield of each variety from 1 to 1.8 t/ha compared to dolomite treatment (Tables 1 and 2).
With the dolomite treatment 120 kg/ha of nitrogen was applied. The consumption rates of nitrogen (assuming that soil do not furnish nitrogen) are high for Sikuani and Tuxpeño (49 and 74 kg N/t grain) and better for the hybrid (33 N/t grain) (Table 4). In the nitrogen treatment, with 200 kg/ha N, the consumption rates did not change much, except for the hybrid for which it increased to 43. When the consumption rates are calculated for the additional 80 kg/ha N (by difference), it is showed that the hybrid badly used this additional dose.
It can be concluded that for the hybrid, the splitting of the nitrogen application did not ameliorate the consumption rate. The hybrid was able to well extract the nitrogen from soil when applied in two times. But it was not able to well use the additional N application because then another factor became limiting.
It is riskier to conclude for Sikuani and Tuxpeño. They were bad efficient to extract nitrogen from soil and they used the additional N application with the same bad efficiency. Consequently the split applications would not have any influence. But this point will have to be confirmed because of a possible interaction between split applications and dose effects.

A second important conclusion from this trial is the confirmation of a strong variety x fertilization interaction (Table 3). Yield of Sikuani increased more than other varieties with the nitrogen treatment, but above all variety responses to gypsum are opposite. With gypsum, Tuxpeño yielded more, whereas Sikuani and the hybrid yielded less. The difficulty comes from that this conclusion is opposite to the previous one, obtained in 1995 with Sulcamag as calcium and magnesium sulfates source. Consequently it will be necessary to check if Sulcamag and dolomite + gypsum truly produces these opposite interactions, and to understand the reason why.

MA97AA4

6b. Interaction between maize tolerance to acid soils and fertilization management Matazul, Meta, 1997A

Objectives: CIMMYT developed the OP variety of maize tolerant to acid soils, released by the Colombian government as Sikuani ICA V 110. The instituttion is also creating hybrids adapted to this stress. It is expected that these varieties will permit to save one part of the amendments that would have been needed to cultivate a nontolerant variety.
Roots of the tolerant varieties are able to grow in soils with a higher aluminum saturation rate. Consequently, it is expected that they would grow deeper and intercept a greater fraction of the soluble ions that are highly lixiviated under the Llanos heavy rainfalls.
Another way to get deeper rooting is trough the use of gypsum as amendment. This is able to reach deeper layers than dolomite, modifying their pH and aluminum saturation level. An experiment done in 1995 at the C. E. La Libertad, showed an interaction between the type of amendment used (dolomite or Sulcamag) and the genetic tolerance to acid soils (varieties Sikuani and Tuxpeño, as tolerant and susceptible to acid soils, respectively). Sikuani yielded more with Sulcamag while Tuxpeño yielded less.
During the preparation of a trial to confirm these three points, I discussed with I. Rao, CIAT 's specialist of root growth, to organize the measurement with him. It was decided to add a treatment with a higher level of nitrogen, applied earlier. This was done to test Dr. W. Horst's hypothesis, that maize could suffer nitrogen hunger at early stages.

Treatment:

3 varieties:
- . Sikuani ICA V 110, OPV tolerant to acid soils
- . Tuxpeño, OPV susceptible
- . Experimental white hybrid, tolerant SA8C1HC(27x26)x(CML247xCML254)

3 fertilizations:
- . 1650 kg/ha dolomite
- . 1270 kg/ha dolomite + 500 kg/ha gypsum (20% H_2O)
- . 1650 kg/ha dolomite + 5 urea applications (40 kg N/ha), every two weeks from sowing to 60 DAS

Amendment doses were calculated to reduce aluminum saturation to 55% and to apply a constant (Ca+Mg) sum in every treatment. They were applied one month before sowing.

Management:

Design: Randomized blocks
Replications: 3
Plot size: 5 rows, 5 m. long each, from which the 3 central rows were harvested (12.4 m^2)
Sowing distances: 0.75 x 0.50 m with 3 seeds/hill thinned to 2 plants/hill
Fertilizers: N,P,K + Zn: 40, 68,120 + 2.2 as urea, TSP, KCl and zinc sulfate at sowing time
N: 80 kg/ha as urea, one month after sowing (Except in the third fertilization treatment)
Micronutrients: Zn, B, Cu, Mn: 2.2, 1.2, 9, 3 kg/ha as zinc sulfate, borosol, copper sulfate and manganese sulfate

No herbicide
Insecticides: Lorsban + Hostathion
Sowing date: June 4, 1997
Harvest date: September 26, 1997

Results:

Table 1: Means of the 9 treatments.

Varity	Fertilization	Grain yield (t/ha)	Days to tassel	Plant hgt (cm)	Ear hgt (cm)	Plants Stand (3 rows)	Ears/plt
Sikuani	Dolomite	1.59	66	137	63	60	63
	Dolomite+ Gypsum	2.32	61	153	75	63	80
	Dolomite + High nitrogen	2.10	63	137	65	57	91
Tuxpeño	Dolomite	1.43	65	110	42	54	56
	Dolomite+ Gypsum	1.54	65	117	53	57	69
	Dolomite + High nitrogen	1.49	69	107	50	55	59
Hybrid	Dolomite	2.35	66	143	72	62	83
	Dolomite+ Gypsum	2.67	67	163	82	64	72
	Dolomite + High nitrogen	2.05	68	142	65	61	67

Table 2: Means for fertilization treatments and varieties.

Factors	Grain yield (t/ha)	Days to tassel	Plant hgt (cm)	Ear hgt (cm)	Plant Stand (3 rows)	Ears/plt
Variety						
Sikuani	2.01 b	63 b	142 a	68 a	60 a	0.78 a
Tuxpeño	1.49 c	67 a	111 b	48 b	55 b	0.75 a
Hybrid	2.36 a	67 a	150 a	73 a	62 a	0.62 b
Fertilization						
Dolomite	1.79 b	66 ab	130 b	59 b	58	0.67
Dolomite + Gypsum	2.18 a	64 b	144 a	70 a	61	0.74
Dolomite + High nitrogen	1.88 b	67 a	128 b	60 b	57	0.73

Within column, means followed by a different letter differ significantly at $P<0.05$ by Newman and Keuls' range test. Means not followed by a letter did not show difference.

Table 3: Mean squares of the recorded data.

Source	df	Grain yield (t/ha)	Days to tassel	Plants hgt (cm)	Ear hgt (cm)	Plant Stand (3 rows)	Ears/plt
Total	26	0.25	9.7	414	189	25	0.03
Fertilizations	2	0.37 **	16.26 *	706 *	337 **	39	0.01
Varieties	2	1.72 ***	36.04 ***	3734 ***	1501 ***	114 **	0.07 **
Fertilizations x varieties	4	0.17	10.26 *	43	51	3	0.04 *
Reps	2	0.28 *	31.81 **	95	104	0.11	0.04
Pooled error	16	0.07	3.19	96	52	20	0.01
C.V. %		13.4	2.7	7.3	11.4	7.6	15.5

*,**,*** Significant at 0.05, 0.01 and 0.001 probability levels, respectively.

Table 4: Consumption rates of the nitrogen applied in plots amended with 1500 kg/ha dolomite.

	120 kg/ha N		200 kg/ha N		80 kg/ha additional N	
	Grain yield t/ha	Consumption rate kg N / t grain	Grain yield t/ha	Consumption rate kg N / t grain	Grain yield increase t/ha	Consumption rate Kg N / t grain
Sikuani	1.59	75	2.10	95	0.51	157
Tuxpeño	1.43	84	1.49	134	0.06	1333
Hybrid	2.35	51	2.05	98	-0.30	?

Discussions:

It was finally impossible to organize the root growth measurement during this season. Consequently only data on plant growth were recorded. Yield average was 1.95 t/ha (Table 1 and 2). In spite of these low yields, significant differences were observed between fertilizations and varieties (Table 3). The hybrid produced more than Sikuani and Tuxpeño whatever the fertilization is. Gypsum significantly increased yields of every variety in this soil, but very few for Tuxpeño, and there was no fertilization x variety interaction.

On the contrary, there was no significant effect of the additional nitrogen application in this trial. Sikuani produced a little more and the hybrid a little less. The consumption rates of nitrogen were very high for all varieties (51 to 84 kg N/t grains) when 120 kg/ha N was applied. They still increased much when 200 kg/ha N was applied, showing that there was no effect of the application splitting. Here, the limiting factor to maize growth was not nitrogen, when 120 kg/ha was already applied.

Plant stand is inferior for Tuxpeño, compare to both other varieties.

VV97AA5

7a. Response to micronutrients
Zinc application in maize crop
C.E. La Libertad, Villavicencio, Meta, 1997A

Objectives: The washed acid soils of the Llanos show deficiency in macro and oligo-nutrients N, P, K, Ca, Mg, and S, and in some micronutrients. Zinc application is recommended for rice cultivation. Boron was previously tried for maize production in La Libertad (L.A. León, 1995A), without any response. Some plots were used to check an eventual response to zinc application.

Treatments:

2 treatments:	Zinc (kg/ha)	Zinc sulfate (22% Zn) (kg/ha)
	0	0
	2.2	10

Management:

Design: Randomized blocks
Replications: 3
Sowing distances: 0.75 x 0.50 m with 3 seeds/hill thinned to 2 plants/hill
Variety: Sikuani ICA V 110
Amendments: 211 kg/ha dolomite + 500 kg/ha gypsum (20% H) one month before sowing
917 kg/ha dolomite at sowing date, to complete 1130 kg/ha
Fertilizers: N,P,K: 40,66,75 as urea, TSP and KCL at sowing date
N: 80 as urea one month later
Herbicide: 5 l/ha Lasso, at pre-emergence
Insecticides: Lorsban and Hostathion
Sowing date: April 29, 1997
Harvest date: August 30, 1997

Results:

Table 1: Average data for each treatment

Zinc doses Kg/ha	Grain yield (t/ha)	Days to tassel	Plants hgt (cm)	Ear hgt (cm)	Plants harvested	Ears/plt
0	2.27	58	178	65	71	0.94
2.2	2.2	58	177	62	75	0.93

Table 2: Mean squares

Source	df	Grain yield (t/ha)	Days to tassel	Plant hgt (cm)	Ear hgt (cm)	Plants harvested	Ears/plt
Total	5	0.03	5.37	57.5	16.67	44.67	0.01
Zinc	1	0.01	0.17	4.17	16.67	54.00	0.00
Reps	2	0.06	7.17	87.5	29.17	78.17	0.02
Pooled error	2	0.01	6.17	54.17	4.17	6.50	0.00

Discussions: Grain yields were low with a trial average of 2.2 t/ha. Results show that at this yield level there is no Zinc deficiency at La Libertad, and no need to apply this micronutrient, at least when yields remain low due to other limiting factors (Tables 1 and 2). La Libertad is situated in a transition zone named "Piedmont" where soils are more fertile than in the true Llanos area. Their content in phosphorus and nutrients is slightly higher. Consequently this result is valuable only for the area of La Libertad.

L.A. León 1

7b. Response to micronutrients
Matazul, Meta, 1997 A

Objectives: Soils of the Colombian eastern plains are highly weathered and contain very low levels of available elements to plants, except aluminum. This trial was designed in order to check what micronutrients were necessary to grow maize in the Matazul region in the Llanos orientales.

Treatments: Four micronutrients were tried, B, Zn, Mn and Cu, using two types of formulation: sulfates or chelates. For each formulation, 9 treatments were tried: the complete treatment with the 4 micronutrients, 4 subtractive treatments (complete less on of the micronutrients) and 4 additive treatments (check plus one micronutrient). In addition there were check treatments without any micronutrient.

Doses in the 9 treatments and the check. Each treatment is replicated under the two formulations, sulfate and chelate:

		B	Zn	Mn	Cu
		kg/ha of the element			
1	Complete (C)	1.2	8.8	5.2	7.2
2	C – B	-	8.8	5.2	7.2
3	C – Zn	1.2	-	5.2	7.2
4	C – Mn	1.2	8.8	-	7.2
5	C – Cu	1.2	8.8	5.2	-
6	B	1.2	-	-	-
7	Zn		8.8	-	-
8	Mn	-	-	5.2	-
9	Cu	-	-	-	7.2
10	Check	-	-	-	-

These treatments were applied at sowing time.

Management:

Design: Split-plot with 9 treatments as main and formulations sub-blocks. Three check plots were set as additional plots.
Replications: 2
Plot size: 4 rows, 5 m. long, from which the 2 two central rows were harvested (8.25 m^2)
Sowing distances: 0.75 x 0.50 m. 2 plants/hill.
Maize variety: Sikuani ICA V110
Amendment: 1085 kg/ha dolomite, one month before sowing
Fertilizers: P, K: 68, 120 kg/ha as TSP and KCl applied at sowing date
N: 40 kg/ha and 80 kg/ha as urea applied 15 and 35 days after sowing
Insecticides: Lorsban + Hostathion
Sowing date: May 21, 1997
Harvest date: September 22, 1997

Results:

Table 1: Average field data for each treatment with microelements and each formulation

	Sulfates						Chelates				
	Yield (t/ha)	Days to silk	Plant hgt (cm)	Ear hgt (cm)	Ears/ plt		Yield (t/ha)	Days to silk	Plant hgt (cm)	Ear hgt (cm)	Ears/plant
C	2.56	57	152.5	56	0.83	C	1.70	58.5	141	57.5	0.80
C - B	2.07	57.5	155	55	0.84	C - B	1.57	59.5	139	55	0.75
C - Zn	0.31	57	164	67	1.00	C - Zn	0.28	-	-	-	1.00
C - Mn	1.86	54.5	162.5	70	0.80	C - Mn	1.70	57.5	160	65	0.85
C – Cu	1.99	56	165	75	0.80	C – Cu	2.05	58	146.5	67.5	0.82
B	0.14	-	-	-	1.00	B	0.28	-	-	-	1.00
Zn	1.86	62	115	50	0.85	Zn	1.70	60	145	50	0.76
Mn	0.20	-	-	-	0.74	Mn	0.14	-	-	-	0.94
Cu	0.52	-	-	-	0.75	Cu	0.12	-	-	-	1.00
Check	0.01					Check					

Table 2: Average field data per factor

	Yield (t/ha)	Days to ears	Plant hgt (cm)	Ear hgt (cm)	Ears/plant
Micronutrients					
C	2.13 a	57.8	146.8	56.8	0.81 ab
C – B	1.82 a	58.5	147	55	0.80 b
C – Zn	0.29 b	-	-	-	1.00 a
C – Mn	1.78 a	56	161.3	67.5	0.83 ab
C – Cu	2.02 a	57	155.8	71.3	0.81 ab
B	0.21 b	-	-	-	1.00 a
Zn	1.78 a	61	130	50	0.81 ab
Mn	0.17 b	-	-	-	0.84 ab
Cu	0.32 b	-	-	-	0.88 ab
Formulations					
Sulfates	1.28	57.4	150	61.2	0.85
Chelates	1.06	58.7	146.3	59	0.88

Within column, means followed by a different letter differ significantly at $P<0.05$ by LSD range test. Means not followed by a letter did not show difference.

Table 3: Mean squares of the field data ANOVA

Source	Df	Yield (t/ha)	Days to ears	Plant hgt (cm)	Ear hgt (cm)	Ears/plant
Formualtions	1	0.43	10.19	198.55	57.61	0.01
Reps	1	0.39	1.14	296.50	393.14	0.02
Pooled error 1	1	0.46	9.70	2.93	90.95	0.02
Micronutrients	8	3.11 ***	12.79 ***	798.85 ***	184.29 *	0.03
Micronutrients x Formulations	8	0.10	2.08	37.25	119.33	0.01
Pooled error 2	16	0.07	1.30	34.79	31.71	0.02

*,**,*** Significant at 0.05, 0.01 and 0.001 probability levels, respectively.

Table 4: Soil analysis of the 0-20cm layer, in plots that received micronutrients under sulfate forms. Each sample was a mixture of soil coming from the 2 replicated plots.

	ppm P Bray II	pH	Mg meq/100g	Ppm				
				S	B	Zn	Mn	Cu
C	48.0	4.6	0.24	26.0	0.64	5.30	4.80	9.79
C - B	16.4	4.6	0.22	30.0	0.45	1.26	3.43	6.56
C - Zn	9.0	4.6	0.28	30.0	0.50	1.60	2.03	0.70
C - Mn	29.7	4.7	0.28	30.0	0.73	4.69	1.64	1.81
C – Cu	23.4	4.7	0.29	33.6	0.79	6.19	7.69	0.49
B	62.0	4.6	0.23	27.7	0.83		2.03	4.07
Zn	11.5	4.8	0.49	32.2	0.53	4.31	4.49	2.02
Mn	32.9	4.6	0.26	31.8	0.43	3.90	5.74	2.18
Cu	19.4	4.5	0.25	30.0	0.62	4.40	4.34	4.97
Check	23.1	4.7	0.33	30.0	0.26	2.21	1.75	0.36
Initial	1.5	3.8	0.04	16.8	0.26	0.32	0.77	0.33

Discussion: Grain yields were low with a trial average of 1.2 t/ha. Many treatments yielded very low, but also the better treatment only reached 2.6 t/ha.
Tables 1 and 2 show a highly significant effect of micronutrients on maize yield at Matazul. Zinc had the main effect, higher than the other elements. Statistically, there were only two significant groups of treatments: those with zinc and those without zinc. It could be concluded that Zn is indispensable to grow maize in this area. The other elements do not appear indispensable at this level of yield (2-2.5 t/ha).

Soil analysis (Table 4) show that the application of 1085 kg/ha of dolomite raised the pH of nearly one unit and increased the Zn and Mn availability, when the check is compared to the initial analysis. The phosphorus availability is variable and sometimes P content is high in these plots. This fact seems due to the superficial application of the TSP, without mechanical incorporation.

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8. Types of nitrogen fertilizers: Nitromag vs. Urea.
Matazul, Meta, 1997 A

Objectives: Nitromag is a fertilizer composed of a mixture of calcium and magnesium nitrates (22 % N, 7 % MgO, 11 % CaO). It was compared to urea (46 % N).

Treatments:

		N	Fertilizer	CaO	MgO	Estimation of the Al saturation level (%)
		Kg/ha				
1	Nitromag	50	227	25	16	68.3
2	Nitromag	100	455	50	32	66.6
3	Nitromag	150	682	75	48	64.9
4	urea	100	217	-	-	70

These treatments were applied at sowing time.

Management:
Design: Complete randomized blocks
Replications: 3
Plot size: 4 rows of 5 m. from which the 2 central rows were harvested (8.25 m^2)
Sowing distances: 0.75 x 0.50 m. 2 plants/hill.
Amendment: 1085 kg/ha dolomite (347 kg/ha CaO, 184 kg/ha MgO), one month before sowing
Fertilizers: P, K: 68, 120 as TSP and KCl at sowing date
Micronutrients: B, Zn, Cu, Mn: 0.7, 2.2, 9, 2.4 kg/ha as Borax, zinc sulfate, copper sulfate and Microman
Insecticides: Lorsban, Hostathion
Sowing date: May 21, 1997
Harvest date: September 22, 1997

Results:

Table 1: Average field data for each treatment

	N (kg/ha)	Grain yield (t/ha)	Days to silk	Plant hgt (cm)	Ear hgt (cm)	Ears/plant
Nitromag	50	1.55	56.7	145	58	0.71
Nitromag	100	2.09	57	145	57	0.81
Nitromag	150	2.15	54.7	159	70	0.65
urea	100	2.36	54.3	159	70	0.99

Table 2: Mean squares of the field data ANOVA

	df	Grain yield (t/ha)	Days to silk	Plant hgt (cm)	Ear hgt (cm)	Ears/plant
Total	11	0.27	3.52	114.9	73.3	0.04
Reps	2	0.42	3.58	77.6	43.8	0.04
Fertilizers	3	0.35	5.55	196.0	157.6	0.07
Pooled error	6	0.17	2.47	86.9	41.0	0.02

*,**,*** Significant at 0.05, 0.01 and 0.001 probability levels, respectively.

Discussion: Grain yields are low with a trial average of 2 t/ha. There were no statistical differences between the treatments. Since Nitromag also modified the Al saturation level, this would have caused grain yield increases. Data shows that nitrates probably produced lower yields than urea. Nitromag did not appear as a good alternative to urea.

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9. Interactions between phosphorus doses and types or doses of nitrogen fertilizers Matazul, Meta, 1997 A

Objectives: To check the adecuate level of phosphorus and various types of nitrogen fertilizers at different doses and their interactions.

Treatments:

- Four phosphorus doses: 0, 50, 100, 150 kg/ha P_2O_5
- Three types of nitrogen fertilizers x 3 doses: 50, 100, 150 kg/ha N
  . Urea (46 % N)
  . Ammonium nitrate (33 % N)
  . Ammonium sulfate (21% N, 24% S)

All the treatments were applied at sowing time.

Management:
Design: Split-split-plot, with phosphorus as sub-blocks, types of nitrogen fertilizers as sub-sub-blocks, replications at the third level of division and nitrogen doses as main plots.
Replications: 3
Plot size: 4 rows of 2.5 m., from which the 2 central rows were harvested (4.25 m^2)
Sowing distances: 0.75 x 0.50 m. 2 plants/hill.
Maize variety: Sikuani ICA V110
Amendment: 1085 kg/ha dolomite to decrease aluminum saturation to 70%
Fertilizers: K: 120 kg/ha as KCl
Micronutrients: B, Zn, Cu, Mn: 0.7, 2.2, 9, 2.4 kg/ha as Borax, zinc sulfate, copper sulfate and Microman
Insecticides: Lorsban, Hostathion
Sowing date: May 21, 1997
Harvest date: September 22, 1997

Table 1: Average field data for each treatment

P_2O_5 (kg/ha)	N fertilizer	N (kg/ha)	Grain yield (t/ha)	Days to silk	Plant hgt (cm)	Ear hgt (cm)	Ears/plt
150	Ammonium nitrate	50	1.06	64	122.5	55	0.77
		100	1.17	64.5	116.5	40	0.73
		150	1.74	64	130	47.5	0.80
	Ammonium sulfate	50	2.11	55	133.5	50	0.93
		100	2.61	56.5	127.5	50	0.95
		150	1.88	59.5	125	47.5	0.79
	Urea	50	1.65	57	146.5	60	0.75
		100	3.08	55.5	152.5	70	1.03
		150	2.24	57	155	63.3	0.67
100	Ammonium nitrate	50	1.23	61	130	51	0.76
		100	1.80	58	135	57.3	0.85
		150	1.95	57.7	141.7	50	0.91
	Ammonium sulfate	50	1.50	59.7	135.7	50	0.74
		100	2.62	56	140	56.7	0.98
		150	2.58	56.7	145	56.7	0.88
	Urea	50	1.44	58.3	142	51.7	0.73
		100	2.24	57.3	149.3	61.7	0.88
		150	2.20	59	146.7	60	0.89
50	Ammonium nitrate	50	1.28	62	119.3	46.7	0.68
		100	1.34	61	123.3	46	0.87
		150	1.77	60.3	116.7	46.7	0.84
	Ammonium sulfate	50	1.57	61.3	116.7	43.3	0.79
		100	1.31	59.7	107.7	41.7	0.82
		150	1.52	61	125.7	45	0.79
	Urea	50	1.26	60.3	128	51.7	0.77
		100	1.66	60	130	48.3	0.91
		150	2.00	58.7	135.7	56.7	0.88

Table 2: Average field data for each level of the factors

	Grain yield (t/ha)	Days to silk	Plant hgt (cm)	Ear hgt (cm)	Ears/plt
P dose (kg/ha)					
50	1.52	60.5	123 b	47	0.82
100	1.95	58.2	141 a	55	0.85
150	1.95	59.2	134 ab	54	0.82
Nitrogen fertilizer					
Ammonium nitrate	1.48 b	61.4 a	126 b	49 b	0.80
Ammonium sulfate	1.96 a	58.4 b	129 b	49 b	0.85
Urea	1.98 a	58.1 b	143 a	58 a	0.83
N dose (kg/ha)					
50	1.45 b	59.9 a	130 b	51	0.77 c
100	1.98 a	58.7 b	131 b	52	0.89 a
150	1.99 a	59.3 ab	136 a	53	0.83 b

Within column, means followed by a different letter differ significantly at $P<0.05$ by LSD range test. Means not followed by a letter did not show difference.

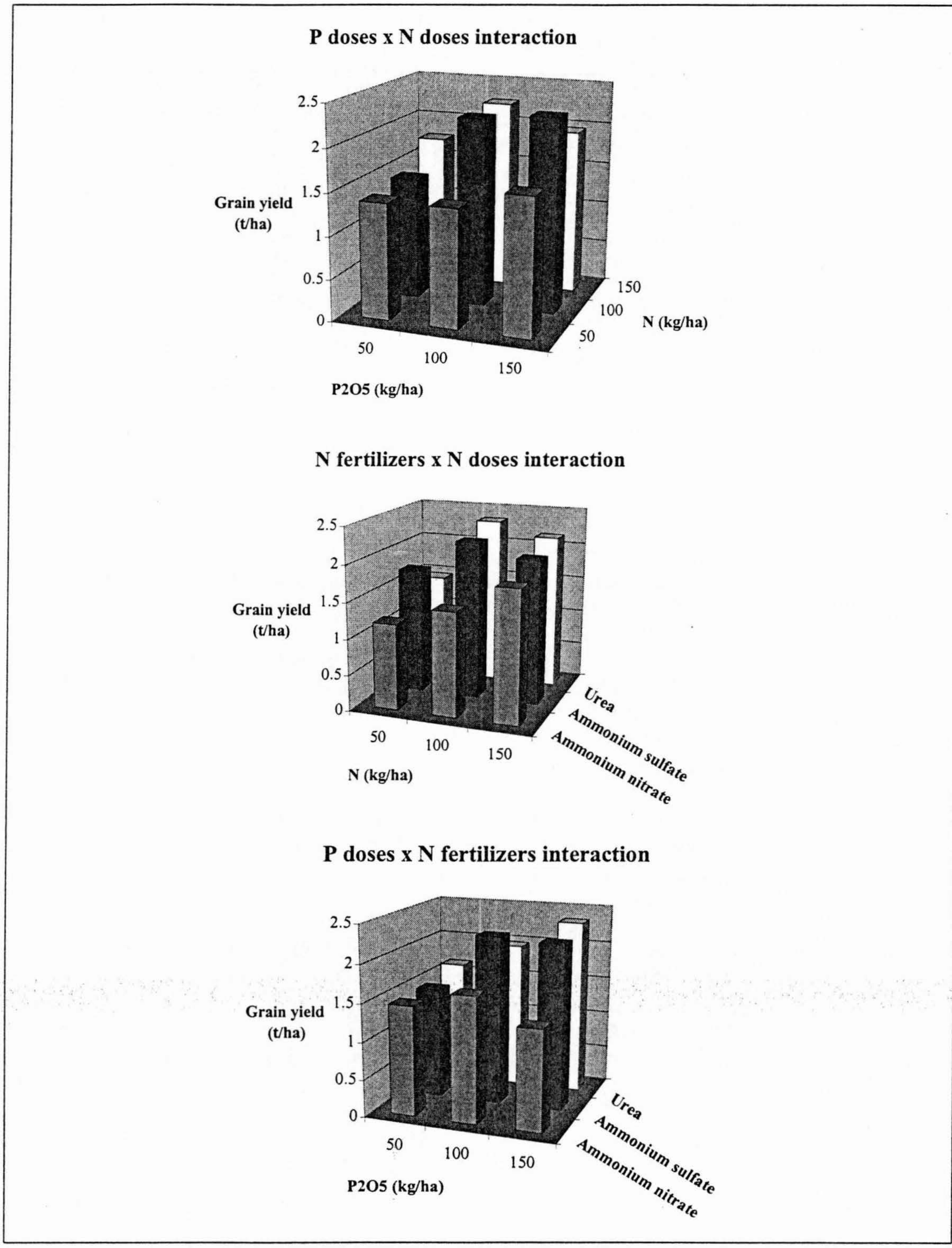

Fig.1: Diagrams of the significant interactions between factors for grain yield

Table 3: Mean squares of the field data ANOVA

Source	df	Grain yield (t/ha)	Days to silk	Plant hgt (cm)	Ear hgt (cm)	Ears/plt
Reps	2	0.37	26.9	21	39	0.01
P doses	2	1.64	35.7	2265	455	0.01
Pooled error 1	4	0.43	56.6	349	151	0.03
N fertilizer	2	2.16 ***	89.1 *	2212 ***	762	0.02
P doses x N fertilizer	4	0.68 **	43.1	293 *	132	0.01
Pooled error 2	12	0.13	14.5	94	26	0.01
N doses	2	2.52 ***	8.6 *	214 *	19	0.10 ***
P doses x N doses	4	0.53 **	8.5 *	42	82 *	0.03 *
N fertilizer x N doses	4	0.40 *	3.4	43	55 *	0.02
P doses x N fertilizer x N doses	8	0.24	4.0	101	50 *	0.02
Pooled error 3	36	0.11	2.3	48	17	0.01

*,**,*** Significant at 0.05, 0.01 and 0.001 probability levels, respectively.

Discussion: Yields were low with a trial average of 1.8 t/ha. In spite of the high level of fertilizers applied, Sikuani yielded a maximum of 3 t/ha, whith aluminum saturation corrected to 70%.
Concerning the grain yields, the means per factors of the Table 2 show:

1- There was no statistically significant difference between phosphorus doses, due to the split-plot design. Meanwhile it is clear that 50 kg/ha P2O5 was insufficient to assure a correct growth of the maize. On the other hand it appears that it was not necessary to apply 150 kg/ha P2O5, as we did in the other trials. 100 kg/ha P2O5, or 200 kg/ha TSP, appeared to give the same average yield.
2- Ammonium nitrate gave lower yields than ammonium sulfate or urea. This is probably due to the fast leaching of the nitrate, becoming unavailable to the plants.
3- The efficiency of the nitrogen applied is very low. One hundred kg/ha N was necessary to reach an average grain yield of 2 t/ha. The upper N dose of 150 kg/ha did not result in any additional yield.

The Table 3 shows significant interactions between the factors tested. P doses x N fertilizers interaction was due the absence of yield response of ammonium nitrate factor to P doses (Fig. 1). P doses x N doses interaction was due to the absence of reponse to P doses of the treatment with 50 kg/ha N. N fertilizers x N doses interaction was due to the yield decrease of ammonium sulfate and urea treatments when applied at the higher dose. On the contrary yield continued to increase when ammonium nitrate is applied at the higher dose.