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Nitrogen fertilization in pineapple crop (*Ananas comosus* L. Merr) at Paramo Negro community, Iribarren, Lara state

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Abstract

This research was done with the aim of characterizing the soils of the Páramo Negro area and evaluating the effect of the nitrogen fertilization in the yield of pineapple crop. Determination of texture, phosphorus, potassium, calcium, organic matter, electrical conductivity, aluminium and capacity of cation exchange were done to 17 samples of soil correspondent to a number of plots, and a multivariable statistical analysis was applied to the information obtained. Two plots of 42 m^2 were selected in two farms of the area, and different doses of nitrogen were applied (100, 200 and 300 $kg.ha^{-1}$) compare to a witness (0 $kg.ha^{-1}$) with a randomized blocks design. Results indicate that these soils have mild natural fertilization, acid pH and high aluminium content. Evaluating the yield, significant differences ($P<0.05$) were found between treatments and the witness, obtaining increases of 6520, 15827 and 10247 $kg.ha^{-1}$ in relation to the witness. To conclude must be mentioned that the production of fruits in the pineapple crop increases with the application of nitrogen fertilizers with a dose of 200 $kg.ha^{-1}$.

Key words: Natural fertility, soil management, yield, *Ananas comosus*.

Introduction

Pineapple crop has become in a very important income source and it is even the main economical activity of some communities of semiarid soils at Lara. In 2001, in the state were produced 151.476 TM (15) which represented an average of 50% of the national production, which is approximately 300090 tons (8). In the area the Española Roja cultivar is used, that characterizes by its adaptation to difficult agroecological conditions (16) and its fruit is very demanding in the local and national market where is consumed as fresh fruit.

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Pineapple is an extractor crop of nutrients, being potassium and nitrogen the elements used in higher quantities (1), therefore, a careful fertilization plan is required to restore in the soil the extracted nutrients and keep its fertility. However, in this production system an inadequate handle of the fertilization is done, which negatively affects the production of fruits and sons, and has caused an itinerant agriculture searching fertile lands with the consequent and irreversible environmental damage. On the other hand, the generated incomes by this crop derive firstly from the sell of the fruit and secondly, from the seed which is getting more limited in the area, and in these two aspects the nitrogen fertilization is essential since a deficiency generates small and narrow leaves, a slow growth, delay in the flowering of small fruits and reduction in the production of seeds which is necessary to future crops, and an excess generates well developed leaves in the fructification phase with big crowns and small fruits (11, 14). Besides, the risk of excessive succulence and burn of the fruit by the sun increases (21). An adequate substitution of nitrogen is essential to keep high rates of growth and to obtain high yields (1, 13).

The aim of the research was to determine the main physical and chemical characteristics of soils of Páramo Negro area, with the participation of a group of producers, and to evaluate different doses of nitrogen fertilization to improve the production of the crop and to guarantee the obtaining of enough propagation material to establish new plantations.

Materials and methods

This investigation was carried out in the agriculture community of Páramo Negro, Aguedo Felipe Alvarado parish of Iribarren municipality, Lara state. This is geographically located between coordinates 10º 15' and 10º 30' North and 69º 15' and 69º 30' West. It is a community committed to the pineapple crop from 1960, activity that supports the economy nowadays. The area belongs to the monte espinoso tropical, with annual average precipitations of approximately 600 mm and with land with slopes.

This research was done in 2003 and in the first phase samples of soils were taken in 17 plots in the pineapple crop at 20 cm deep where the following determinations in the laboratory were done: texture, organic matter, pH, phosphorus, potassium, calcium, electrical conductivity, aluminium and capacity of cation exchange. Samples were processed in the Soil Laboratory of INIA Yaracuy, following the methodology described by Gilabert and Pérez (10). These variables were submitted to an analysis of main components (ACP) using the PRINCOMP procedure of the statistical software SAS (Statistical Analysis System) (19).

Subsequently, in two plots

(locations) of the area two plots of pineapple were located, one in each farm, from six to eight months old, where plots of 42m^2 were delimited. The cultivar of pineapple used was Española Roja with a high diffusion in the area. These plots were established by the producer, using basal sons coming from its own farm, with a double-row plantation system and a sow distance of 0.3 m between plants, 0.5 m between rows and 1.5 m of street. The following treatments were applied:

T1: 100 kg.ha^{-1} of nitrogen

T2: 200 kg.ha^{-1} of nitrogen

T3: 300 kg.ha^{-1} of nitrogen

T0: 0 kg.ha^{-1} of nitrogen (witness).

With a complementary fertilization of 50 kg.ha^{-1} of phosphorus and 200 kg.ha^{-1} of potassium, minimum requirements according to soil analysis were done. Nitrogen was fractionated in 70% applied to the soil and 30% to the foliage. The first application of nitrogen was done by plant in the soil using urea and the rest of the nitrogen in three foliar applications, once a month through aspersions at 5% of concentrations. Pineapple plant has several adventitious coming from the epidermis of the stem as a particular characteristic; that condition and the corrugated shape of leaves allow the use of the foliar fertilization (1, 6, 16).

Plots were formed by five double rows of pineapple of 6 m length. An experimental design was used with blocks at random and four treatments and three replications in two locations. Pineapple crop to determine yield was done at intervals, for that all ripe fruits of each plot were sowed and weighted in a balance. This action was repeated until completely cultivate the plot. Once sowed all plots, the number of basal sons were counted per plot, considering the seed for future crops. The measured variables were yield in kg.plot^{-1} and number of basal sons. For the analysis of this information a variance analysis was applied using ANOVA procedure of the SAS software and the mean test using Tukey at 5%.

Results and discussion

Physical and chemical determinations of soils

According to results presented in table 1, pH values of these soils varied between 3.7 and 5.5, but most of them were values lower of 4.5 considered as extremely acid and were under the optimum rank for the crop between 4.5 and 5.6 (18). By the aluminium contents, which were between 0.05 and 4.18 meq.100g^{-1}; these were considered as soil with high aluminium content, because most of values were over 1.0 meq.100g^{-1}, which is not good for the plant because it precipitates the phosphorus depositing in the roots as crystals.

In relation to the content of organic matter, soils had contents from intermediate (2.3%) to high (6.3%). Regarding the electrical

Table 1. Physical and chemical determinations of soils at Páramo Negro

Sample	a	L	A	P	K	Ca	MO	pH	CE	Al	CIC
1	28.4	23.2	48.4	12	92	230	4.00	3.7	0.14	4.18	20.0
2	42.4	23.2	34.4	10	72	230	4.30	3.9	0.14	1.97	19.0
3	82.4	7.2	10.4	9	40	276	2.30	4.1	0.06	0.25	17.5
4	62.4	17.2	20.4	13	100	460	3.05	4.6	0.08	0.05	19.1
5	70.4	13.2	16.4	T	52	207	3.05	4.3	0.06	0.69	18.7
6	58.4	29.2	12.4	T	76	92	3.30	4.0	0.07	3.00	17.4
7	58.4	7.2	34.4	5	152	230	6.30	4.2	0.13	3.07	22.2
8	52.4	13.2	34.4	T	72	92	2.70	3.8	0.15	3.84	10.2
9	70.4	17.2	12.4	T	88	107	5.10	4.2	0.08	3.07	11.6
10	70.4	17.2	12.4	T	112	736	3.70	5.2	0.09	0.19	8.0
11	70.4	17.2	12.4	T	92	368	2.70	4.6	0.11	1.19	8.6
12	54.4	17.2	28.4	T	116	230	4.00	4.1	0.14	2.36	13.5
13	58.4	23.2	18.4	T	252	874	5.70	5.5	0.16	0.10	17.2
14	40.4	19.2	40.4	T	184	322	5.80	4.3	0.11	0.70	21.0
15	40.4	19.2	40.4	T	108	199	4.20	4.1	0.17	1.20	16.8
16	40.4	25.2	34.4	T	76	276	5.00	4.2	0.10	1.77	17.2
17	66.4	15.2	18.4	3	172	550	3.85	4.8	0.16	0.10	18.5

T= traces a= sand % L= lime % A= clay % P=phosphorus (ppm) K= potassium (ppm) Ca= calcium (ppm)
Mo= Organic matter (%) CE = Electrical conductivity ($dS.m^{-1}$) AL= Aluminium ($meq.100\ g^{-1}$) CIC= Capacity of cation exchange ($meq.100\ g^{-1}$)

conductivity, there were not salinity problems, since the obtained values were very low, being the 100% under $1 dS.m^{-1}$.

The extracted potassium was between intermediate values (40 ppm) and high values (253 ppm) being the most demanding nutritive element by the crop. Values of calcium varied between 92 and 874 ppm and lots of heterogeneity was observed in the information; however, it is an element required in low quantities by the crop. Phosphorus was the most limited nutrient in these soils, finding traces in most of samples and a maximum value of 13 ppm.

In soils, the critical values where began to evidence deficiencies of potassium, calcium and phosphorus were 60, 25 and 5 ppm respectively (13), and considering this in this research was seen that for potassium two plots had values under the critical level, for calcium even though its heterogeneity any plot was under that value, while for phosphorus 71% of plots were very under that critical value, which indicated that in these soils crops might present deficiencies of phosphorus if and adequate fertilization is not done. It is important to mention that when deficiency of phosphorus is very severe pineapple plant does not create fruits neither basal sons (14).

In relation to the capacity of cation exchange, soils had intermediate values in 70% of samples, with some low (12%) and high values (18%). These soils can be considered of mild natural fertility according to the nutrients content and their capacity of cation exchange. In this matter, Fuentes (9) indicated that a soil is fertile when its capacity of cation exchange was high, also when most part of its absorbed cation were basic. The best soils for pineapple are the sandy loamy, well drained and with a high content of organic matter (17); in this research was determined that the land, lime and clay percentages were changeable, therefore the texture of these soils, which was from sandy to clayey, affected the infiltration capacity of water in some plots, specially in these areas where rains were scarce and slopes are very market.

Analysis of main components

An analysis of main components was done to measure the association number between the different variables that characterized these soils. The results of this analysis are shown in table 2a, and indicated that the variable with higher association in these soils resulted to be pH, by presenting a positive correlation (95%) with the calcium content and a negative correlation (68%) with the content of exchangeable aluminium. That result indicated that in these soils the pH increased with the content of calcium and reduced with increases of the aluminium content. Hence, it can be said that in these soils the pH was correlated to the aluminium content due to most of them were extremely acid. There was also a high and negative correlation (73%) between the variables content of calcium and aluminium. The content of organic matter was other variable that presented a high association degree, by having a positive and high correlation to the content of potassium (66%) and to the content of clay (47%) and a negative correlation to the content of sand (48%). Contents of calcium and potassium had a positive correlation of 66%.

The variable electrical conductivity had a high number of association showing a positive correlation to the clay content (57%) and to the potassium content (56%). At the same time, it had a negative correlation to the sand content (53%). Sand content of these soils had a high and negative correlation with the lime (51%) and clay content (89%). Finally, the capacity of cation interchange presented its higher correlation with the phosphorus content in a positive way (40%), which is an indicative that for each increment of the content of this nutrient in the soil, improved the capacity of cation exchange of these soils and logically the natural fertility. These soils were mainly characterized by a low pH, which classified it as acid soils with high contents of aluminium being this the main supplier of acidified ions in the soil. Espinosa and Molina (7) mentioned that one of the main determinant factors of the soil acidity was the presence of aluminium and that each increment of acidity

Table 2a. Correlation matrix of the studied variables.

	a	L	A	P	K	Ca	MO	pH	CE	AI	CIC
a	1.0000	-0.5185	-0.8907	0.1351	-0.2100	0.2078	-0.4830	0.3200	-0.5315	-0.2714	-0.3183
L		1.0000	0.0731	-0.2387	0.1284	0.0831	0.1713	0.0871	0.0787	0.0534	-.0169
A			1.0000	-0.0307	0.1767	-0.2866	0.4722	-0.4195	0.5781	0.2882	0.3802
P				1.0000	-0.2268	0.0253	-0.2177	-0.1238	-0.1892	-0.2481	0.4095
K					1.0000	0.6618	0.6642	0.6577	0.5615	-0.3052	0.2450
Ca						1.0000	0.1660	0.9583	0.2092	-0.7332	-0.0819
MO							1.0000	0.1814	0.3508	0.1319	0.4139
Ph								1.0000	0.1089	-0.6800	-0.1598
CE									1.0000	0.0990	0.0262
AI										1.0000	-0.1720
CIC											1.0000

A= Sand L= Lime A= Clay P= Phosphorus K= Potassium MO= Organic matter CE= Electrical conductivity AL= aluminium CIC= Capacity of cation exchange.

caused more presence of aluminium.

The number of main components to be analyzed depends on the variation that each explains. To select the number of main components, must be considered 80% of variation accumulated and/or own values higher to the unit (12). The first main component only explained 30.19% of the total variance, the second component explained 29.72%, the third component 14.96% and the fourth component 9.46%. The fourth components, from a total of eleven, allowed to explain even 84.33% of the total variation (table 2b).

Variables of higher contribution to the formation of the first main component were the content of sand in a negative way (50%) and the one of clay (49%). The second component was defined by the content of potassium (50%) and of calcium (49%) both in a positive way. In the third component, variables with higher contribution were the phosphorus content (64%) and the capacity of cation exchange (61%) in a positive way. The fourth and last main component was defined by the lime content (82%) in a negative way (table 2c). It can be affirmed that the first and fourth main component were defined by the physical variables of these soils and the second and third component by the chemical variables in higher proportion. The results also indicated that the variable of higher influenced was acidity, by having the pH a high positive correlation with the calcium content and negative to the aluminium content. Pineapple crop is one of the most tolerant at high levels of saturation with aluminium (30%), just surpassed by cassava (60%) and pigeon pea (*Cajanus cajan* L.) (40%) (2). The organic matter by its high positive correlation with potassium was considered in these soils as its main source of natural fertility. Contrary results were reported by Betancourt *et al.* (3) indicating that after had done an ACP in degraded soils, contents of organic matter did not have high values of correlation with nutrients, and concluded that the organic matter just contributed a little bit in the fertilization of these soils.

Yield of the pineapple crop

The obtained yields were acceptable in all treatments, where the precipitation factor had a determinant effect. During the year of evaluation of the yield, the precipitation in the plots had an annual average of 618 mm, which is a good quantity for the area and acceptable for the

Table 2b. Own values of the correlation matrix in the first main components.

	Own value	Difference	Proportion	ccumulated
CP1	3.32061984	0.05103475	0.3019	0.3019
CP2	3.26958509	1.62401352	0.2972	0.5991
CP3	1.64557157	0.60504183	0.1496	0.7487
CP4	1.04052974	0.20294696	0.0946	0.8433

Table 2c. Correlation between original studied variables and main components.

	CP1	CP2	CP3	CP4
a	-0.503618	-0.610400	0.007137	0.269587
L	0.168547	0.109977	-0.281915	-0.820702
A	0.497793	0.012724	0.141563	0.121906
P	-0.103537	-0.084860	0.641613	-0.102338
K	0.126103	0.500901	-0.009005	0.171642
Ca	-0.214674	0.490238	0.011136	-0.037314
MO	0.330444	0.286659	0.046212	0.088834
pH	-0.255982	0.477317	-0.092307	-0.024831
CE	0.316862	0.251399	-0.116123	0.359508
A1	0.278543	-0.326200	-0.293130	0.195813
CIC	0.211538	0.077248	0.615219	-0.146580

development of the crop (figure 1). Pineapple crop had an answer to the nitrogen fertilization applied in different doses, for the production parameter of fruit in $kg.ha^{-1}$ (table 3). In this research significant differences were observed ($P<0.05$) between treatments in function of the witness, in the two evaluated locations. The best results were observed with the doses of 200 $kg.ha^{-1}$ of nitrogen, being statistically significant ($P<0.05$) compare to the witness treatment. The average values obtained showed an increment of 6520, 15823 and 10247 $kg.ha^{-1}$ of pineapple for treatments 100,

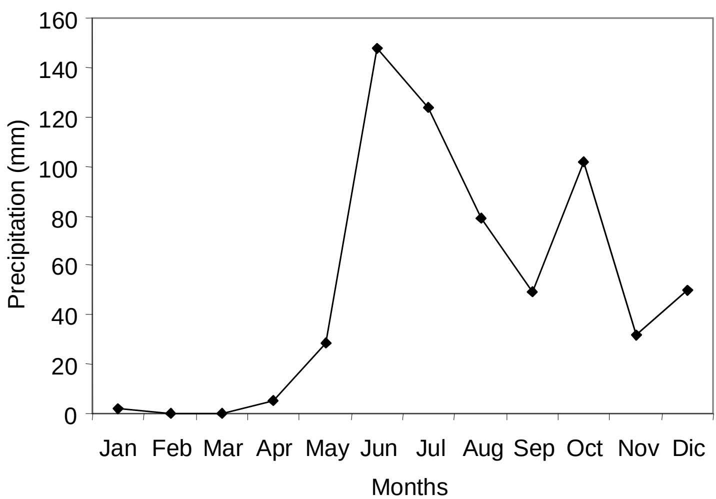

Figure 1. Precipitation in Páramo Negro area during 2003.

Table 3. Yield in fruit and seed of pineapple at Páramo Negro.

Treatment	Yield ($kg.ha^{-1}$)	Seed (N° of basal sons)	Incomes per family (Bs)
0 $kg.ha^{-1}$ of nitrogen	13609[b]	21810[a]	654030,00
100 $kg.ha^{-1}$ of nitrogen	20129[ab]	31528[a]	945840,00
200 $kg.ha^{-1}$ of nitrogen	29432[a]	27254[a]	817620,00
300 $kg.ha^{-1}$ of nitrogen	23856[ab]	24770[a]	743100,00

200 and 300 $kg.ha^{-1}$ of N respectively, compare to the witness. Even though significant differences were not observed between the applied doses of 100, 200 and 300 kg of nitrogen, the one of 200 $kg.ha^{-1}$ surpassed in yield in 18 and 31% the doses of 300 and 100 $kg.ha^{-1}$ respectively.

This result showed a positive answer in the nitrogen fertilization, and the obtained values in relation to yield were superior to the national averages reported by FAO (8), which reached 20000 $kg.ha^{-1}$ for 2002. These results also agree with those reported by Malezieux and Bartholomew (13) who indicated that a good replacement of nitrogen guaranteed high yields and good size of the pineapple fruit. The results of this research also agreed to those obtained in other studies in relation to the advantage of the foliar aspersions with urea (22, 23) and the improved answers with intermediate applications of nitrogen (4, 20).

Seed production

The production of sons by dissemination is a very important aspect in this area, due to it constitutes another source of incomes for producers, and it also represents a warranty of the reproduction of the production system. For some investigators the best sons for the cultivation were the basal, because generated fruits of a good size in an acceptable time (5, 16). Even though there were not significant differences ($P>0.05$) between treatments, it was observed a superiority of treatments with doses of nitrogen on the witness, agreeing with the reported by Malezieux and Bartholomew (13), who indicated that an adequate doses of nitrogen guaranteed the production of sons required for the new plantation. The dose of best results in seed production was the one of 100 $kg.ha^{-1}$ of N, presenting an increment of 30.8; 21.4 and 13.6 compare to the witness at 300 $kg.ha^{-1}$ and 200 $kg.ha^{-1}$ of N (table 3).

In case of discarding the seed to cultivate in the plot, the producer might obtain additional incomes selling it. Likewise, the producer might have additional incomes of 291.810,00; and 89.070,00 bolivars , implementing the fertilization practice in their smallholdings with 100, 200 and 300 $kg.ha^{-1}$ of nitrogen respectively.

Conclusions

The information obtained from this research allows to conclude:

Soils of Páramo Negro are characterized mainly by having high contents of aluminium, low pH and a market deficiency of phosphorus, as well as high contents of organic matter.

The pineapple crop in this ecological condition answered positively to the nitrogen fertilization and expressed its higher potential of yield with the dose 200 kg.ha^{-1} in a fractionated application to the soil and in foliar aspersions.

The nitrogen fertilization improved the production of basal sons in the pineapple crop in Páramo Negro, through doses of 100 kg.ha^{-1}, guaranteeing good quality material for future sows and additional incomes to the producer when are committed to the sell.

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