REGENT ADVANCES IN THE STUDY OF THE MINERAL NUTRITION OF COTTON IN BRAZIL[1]

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RESUMO

No presente trabalho os autores relatam os mais recentes avanços da pesquisa no setor da nutrição mineral do algodoeiro no Brasil.

Abordam primeiramente dados referentes às quantidades de nutrientes absorvidos, assim como, as épocas prefenciais de sua utilização pela cultura. Descrevem sintomas de carência dos macro e micronutrientes, completando as informações com dados analíticos das fôlhas e pecíolos.

Apresentam igualmente recomendações de aplicação de fertilizantes de acôrdo com o tipo de solo.

INTRODUCTION

Due to the great economic importance of the cotton crop to Brazil, a systematic series of research work has been carried out in recent years dealing with its mineral nutrition and fertilization.

It is well known that low soil fertility represents commonly the limiting factor in growing such a crop. Work in these lines is therefore of importance to complement research on bredding of better verieties, pest and disease control.

A summary of recent finding is given in the following sections.For a broader review, see MALAVOLTA et al. (1962).

1 Accepted for publication December 4,1968.Most of the work was carried out with the help of the National Research Council, Foundation for Support of Research and Rockefeller Foundation. Seminar presented by H.P.Haag at the 26th Plenary Meeting of the International Cotton Advisory Committee, Amsterdam, Netherlands, June 1967.

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Mineral nutrient requirements

A program for the fertilization of a given crop has to take into account several questions, the commonest being: the determination of the amounts of elements takes up and exported as harvested product; the assessment of the stages of development in which the need for the elements is higher.

SARRUGE et al. (1966) have determined the amounts of both macro and micronutrients absorbed and exported by the variety IAC 11 when grown under field conditions. The results are given in Table 1. It is clear that the total requirements of macronutrients obey the following decreasing order:nitrogen, potassium, calcium, sulfur, magnesium and phosphorus. When considering, however, only the quantities actually exported as seed cotton, the situation is changed: nitrogen, potassium, calcium, sulfur, magnesium and phosphorus. With regards to the micronutrients, the needs are much lower, as expected; they follow the order: iron, boron, manganese, zinc, cooper and molybdenum.

TABLE 1 - Amounts of macro and micronutrients take up and exported by 25,000 cotton plants given an yield of 1.4 tons of seed cotton per hectare.

Element	Part of the plant			
	Roots	Tops	Reproductive	Total
		kg/ha		
Nitrogen (N)	6	49	29	84.0
Phosphorus (P)	0.2	3.9	4.0	8.1
Potassium (K)	3	39	24	66.0
Calcium (Ca)	1	49	11	61.0
Magnesium (Mg)	0.7	7.2	4.9	12.8
Sulfur (S)	0.8	22	10	32.8
		g/ha		
Boron (B)	5	117	43	165
Cooper (Cu)	2	44	13	59
Iron (Fe)	262	1.113	316	1.691
Manganese (Mn)	5	106	19	130
Molibdenum (Mo)	0.2	1.0	0.2	1.4
Zinc (Zn)	2	42	16	60

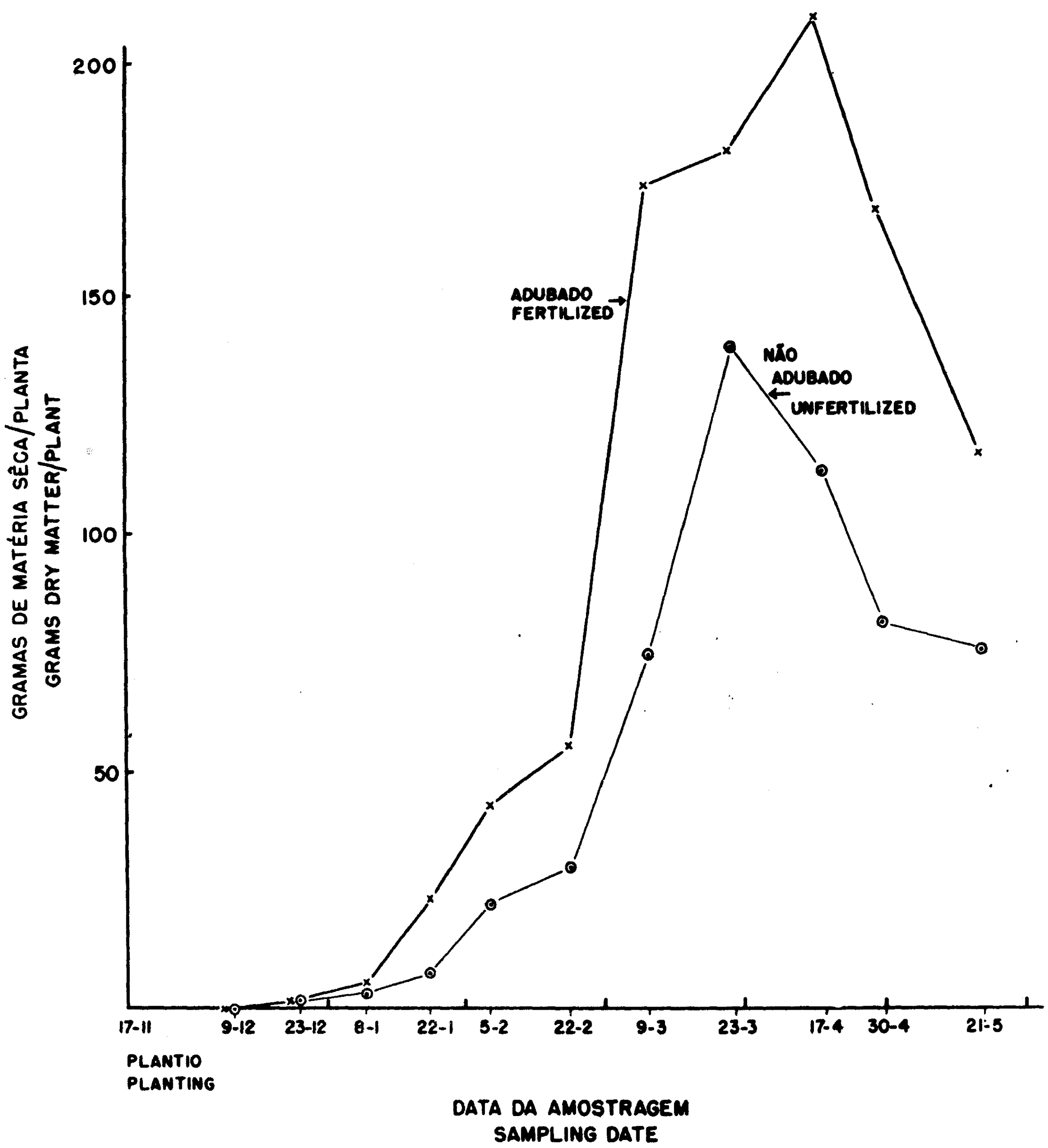
The uptake of macronutrients by the cotton crop, as a function of time development, was studied by SARRUGE et al. (1963) through systematic sampling and analysing of field grown plants under two treatments, namely: (1) NPK + lime and (2) no fertilizers. It was found that the initial rate of growth of the cotton plant, judged by the determinations of dry weight, is rather slow. Seven weeks after planting and again five weeks later, two distinct periods of rapid growth take place as shown in Figure 2-1. The data in Table 2.2 shows that the uptake of minerals is rather small until the first flowers showup; from then on the absorption is intensified; from the time in which fruits are being formed to full maturity, the crop draws from the soil nearly 75 per cent of the total amount of elements required to complete the life cycle. Similar results were obtained previously by MENDES (1960) who followed the depletion of the nutrient solution where cotton was grown under controlled conditions.

The data in Table 3 show that generally the peak of absorption ocurred between the 20th and 60th day for all nutrients.

Table 2 - Proportion of elements absorbed in several periods of the life cycle (absorption in 3/9/62 = 100)

DATE	Stages	N	P	K	Ca	Mg	S
12/9/61		0.24	0.46	0.27	0.20	0.40	0.30
12/23/61	bracts	1.17	1.23	0.65	1.20	1.74	0.75
1/8/62		4.50	5.52	3.12	3.92	4.65	3.50
1/22/62	blossoming	21.82	25.59	14.6	24.28	25.61	13.95
2/5/62	bolls	35.19	33.77	27.6	32.28	34.13	22.95
2/22/62		52.80	33.46	32.4	36.84	34.92	31.95
3/9/62		100.00	100.00	100.00	100.00	100.00	100.00

FIGURE 2.1 - Growth curves of cotton crop, mean dry weight per plant (grams) fertilized and unfertilized



N-P-K uptake was higher during the early square and early boll stages with a secondary peak observed 20 to 50 days after these stages. It follows from the examination of Table 2-3 that the uptake both of N and K proceeded at nearly the same rate, whereas that of phosphorus remained a little behing. Of pratical importance is the fact that about 50 per cent of all nutrients are absorbed in the well defined period which runs from flowering to maturity.

Table 3 - The uptake of macronutrients by cotton plants growing in nutrient solution

10 days period	(Element absorbed as per cent of total taken up)					
Ist	1.0	1.1	0.6	1.7	6.3	-
2nd	3.6	4.5	2.3	4.0	13.3	6.5
3rd	14.9	13.2	11.3	13.3	24.0	20.6
4th	25.8	24.4	27.9	27.3	32.3	29.8
5th	37.9	33.9	42.8	43.8	41.1	48.7
6th	49.6	40.4	49.3	48.3	45.6	53.2
7th(peak of blossoming)	57.6	47.4	57.9	57.8	49.6	58.9
8th	64.5	55.4	63.4	65.8	55.9	66.9
9th	73.7	64.6	73.2	75.1	63.4	75.0
10th(opening of bolls)	78.7	70.3	77.9	79.0	68.7	79.3
11th	85.9	78.4	86.3	85.5	76.6	85.1
12th	88.2	85.2	89.3	86.9	89.5	88.7
13th	90.7	89.5	92.8	88.0	93.3	91.0
14th	94.2	95.0	95.3	95.7	95.5	95.0
15th	100.0	100.0	100.0	100.0	100.0	100.0

Diagnostic techniques for mineral nutrient deficiencies in cotton

Several approaches can be tried in order to determine nutrient deficiencies of a crop bearing in mind the assessment of soil fertility status and the need for fertilizers.

Hunger signs or deficiency symptoms, when properly identified, will give a valuable clue as to what is lacking in the soil. By growing cotton plants, variety IAC 11 in nutrient solution from which macro and micronutrients were omitted individually, MALAVOLTA et al. (1964, 1965) were able to obtain clear cut symptoms of deficiency: the observations were assembled as key to be use for the identification of symptoms which may appear under field conditions:

A. Initial symptoms localized on the whole plant

Nitrogen a) Uniform chlorosis, gradually becoming more evident on the older leaves: reddish and afterwards brown spots appear in the region of the angle formed by the lobes; the older leaves wither and are shed prematurely; dwarfed appearance of the plant; few fruits.

Phosphorus b) Darker green colour of the leaves followed by a brownish due turning yellowish-brown. Rusty spots irregularity distributed on the margin giving the leaf a scorched appearance. Plants stunted, slow growth; few or no bolls.

Potassium c) Yellowish-white mottling of the leaves. The blade changes to a light yellow-green colour and yellow spots appear between the veins. The centres of these spots die and numerous brown specks occur at the tip. around the margin and between the veins. The tip and the margin break down, first resulting in a downward curling; the edges are torn and ragged; the withered leaf is shed prematurely;many bolls fail to open.

Calcium d) First curvature and later collapse of the petiole takes place resulting in marked defoliation; the few leaves which remain attached to the plant exhibit a reddish colour; plants are stunted and show poor root development.

B. Initial symptoms localized on terminal growth

Sulphur a) Marked chlorosis on the apical leaves, progressing rapidly to the older ones below; lemon-green colour; the leaf blade is shiny at the beggining; in advanced stage, however, it loses its polished appearance; dwarfed appearance of the plant;reduced number of bolls; vegetative buds in the lower part of the plant start growing.

Copper b) Wilting of petioles; large chlorotic spots in the leaf blade irregularly distributed; sometimes a large chlorosis area in one side of the leaf near the angle formed between petiole and blade.

Iron c) Light chlorosis in the upper leaves at first; after a few weeks all the leaves in the top half are pale green; the veins form a darker network; as the deficiency progresses; the leaves become whitish-yellow; the bottom leaves are shed prematurelly.

Boron d) Dieback involving terminal buds, resulting in a many branched plant; the young leaves are yellowish green, the flower buds chlorotic.

Manganese e) Leaves yellowish green with green veins and many brown spots; the apical buds remain alive.

Zinc f) Younger leaves become extremely chlorotic, with areas of dead tissue; the veins are darker in colour.

C. Initial symptoms localized in the lower two-thirds of the plant

Magnesium a) Discoloration of the blade between the veins,which are surrounded by a normal green band; later, the veins remain green shilst the blade is purplish red in striking contrast; bottom leaves ares shed prematurely; bolls fall off the plant.

Molibdenum b) Curling of the leaf blade in wards; diffuse chlorosis resemblering lack of nitrogen.

Complete analyses of the leaves were also made thue giving standard information to evaluate the nutritional status of the cotton crop. The results are given in Tables 4 and 5.

TABLE 4 - Contents of macronutrients percent of dry matter found in leaves of normal and deficient plants

Element	Normal Plants	Deficient Plants
Nitrogen (N)	2.39	1.12
Phosphorus (P)	0.25	0.13
Potassium (K)	3.91	0.52
Calcium (Ca)	2.47	0.65
Magnesium (Mg)	0.15	0.05
Sulphur (S)	1.34	0.16

TABLE 5 - Levels of micronutrients in p.p.m. found in normal and deficient leaves

Element	LEVEL FOUND (p.p.m.)	
	Normal leaves	Deficient leaves
Boron (B)	130	33
Copper (Cu)	7	3
Iron (Fe)	401	289
Manganese (Mn)	75	6
Molybdenum (Mo)	1	0.09
Zinc (Zn)	31	26

Chemical analysis of leaves showed a sharp drop in the content of the particular element which has been omitted from the nutrient solution.

Symptoms caused by disease of several origins may change the pattern of nutrient deficiencies thus making difficult the visual diagnosis. Plant analysis is indicated in such cases to differentiate the origin of the observed symptoms.

Very recently HAAG and BALMER (1967), conducted several experiments in order to study the effects of the "Wilting diseade", caused by the fungus *Fusarium oxysporum* F. *vasinfectum* (Atk) SNYDER & HANSEN on complete solution and inoculated or not with an active culture in the lower part of the stem. After harvest the leaves analysed and some of the preliminary results are shown in Table 6.

TABLE 6 - Proportion of elements content in leaves of healty and diseased plants (Complete = 100%)

Treatment	ELEMENT				
	N	P	K	Ca	Mg
Complete	100	100	100	100	100
Complete + fungus	70	161	106	98	95

Due to the incidence of the disease the content on nitrogen, calcium and magnesium was reduced in 3, 2 and 5%. On the orther hand, the fungus caused an increase on phosphorus and potassium content, of the order of 61 and 6%, respectively.

A physiological-economic concept of foliar diagnosis has been developed in Brazil by MALAVOLTA & PIMENTEL GOMES(1961) based on a new definition of the so called "critical level"-"the point or rather the level of a given element in the leaf beyond the use of fertilizer is no longer economical". The application of such a concept - or any other - to a particular crop depends largely on the establishment of sound criteria for sampling plant parts. To do so basic work was carried out by MELLO et al.(1959-a,b; 1960). The main findings were as follows: (1) leaf blade values show stronger correlation with yield index than the petiole composition; (2) sampling shoud be done at the time of early blossoming; (3) leaves could be collected either from the stem ("unproductive leaves") or from the side of flowers ("productive leaves"); (4) normal values for nitrogen (N), phosphorus (P) and potassium (K) are, respectively, 3.9%, 0.2% and 1.4%, found in the "productive" leaves.

VERDADE et al. (1965, 1966) conducted in the cotton belt of the State of S.Paulo about 400 factorial experiments of the type 3x3x3 using nitrogen, phosphorus and potassium.

The results obtained from the fertilization indicate that the mayor reaction is for potassium in less than 5% of the whole of the treatments. When studying the contents of phosphorus soluble in H_2SO_4 0,05 N, it was possible to differentiate two types of reaction one for sandy soils and the other for the clay soils, thus establishing the respective levels of fertility. It was possible to establish statistically the ratio between the contents of phosphorus of the soil and the percentages of yield. The correlation was highly significant, giving an explanation for the linear being about 50% and the quadratic on less than 10% for the soils of "arenito Bauru".

It was also found that there is a relation between the pH of the soil and the reaction to phosphorus fertilization, lessening its action with the raising of the pH.

The results permitted NEVES et al. (1965) and FUZATTO (1966) to prepare tentative recommendations for fertilizer application of general use according to soil type. The results are summarized in Table 7.

TABLE 7 - Recommendation for fertilizer application, according to soil type

	Lime	kg/ha, at planting time			kg/ha dressing*
	t/ha	N	P_2O_5	K_2O	N
Massapê	2.0-2.5	0-10	40-65	15-40	0-35
Terra roxa	2.5-3.0	0-10	40-75	20-60	0-35
Roxa mist. and glacial	2.2-2.7	0-10	45-75	25-70	0-35
Arenito Bauru Superior	2.0-2.5	0-10	30-60	15-40	0-35
Arenito Botucatu and Bauru inferior	1.0-1.2	0-10	45-75	20-45	0-35

* 45-60 days after seeding.

SUMMARY

Due to the great economic importance of the cotton crop to Brazil, a systematic series of research work has been carried out in recent years dealing with its mineral nutrition an fertilization.

A summary of recent finding is given in the following sections.

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