Effect of Potassium and Bacterial Blight on the Yield and Chemical Composition of Cassava Cultivars

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Studies on cassava cultivars having different levels of susceptibility to bacterial blight caused by *Xanthomonas manihotis* revealed that the infection exerted differential influence on the mineral nutrient and starch contents of the cultivars. The disease caused a reduction in the macronutrient content, led to a higher accumulation of micronutrients in the diseased leaves, and adversely affected the tuber quality by lowering the percentage starch content. Despite the relatively greater tolerance of the 60506 cultivar, bacterial blight significantly reduced its tuber and starch yields.

Cassava is an important source of food energy for millions of people in the tropics, and there is an ever-increasing demand for cassava starch in the textile and chemical industry. It is also used as livestock feed. To maximize yields it is imperative to have adequate knowledge of the factors limiting production. Thus concerted efforts are being made to better understand the nature and action of cassava bacterial blight, the most devastating of the several bacterial diseases of cassava.

CBB is now recognized as one of the most important factors limiting cassava production. It was first recorded in Brazil (Bondar 1912) and has since been reported in several other countries in South America and Africa (Lozano 1973). Its occurrence in Nigeria was first observed in 1971, and has since assumed epidemic proportions in certain areas of the southern part of the country, especially in the East Central State. Between 1972 and 1973 loss of crops due to this disease was estimated at about 25 million Naira (about $39 million US) (Ene and Agbo 1974). In Nigeria and Zaïre, where cassava production is highest in Africa, bacterial blight is a potentially more serious disease than mosaic, which might not result in complete loss of the crop.

The symptoms were similar everywhere the disease had been observed, including angular leaf spotting and blight, wilting, tip dieback, copious gum exudation and vascular necrosis of stem and roots (Anon 1973). Cassava blight bacterium is host specific (found only on cassava). Its spread may be related to rainfall patterns (Arene 1974), but the epidemiology in Nigeria is as yet unknown.

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Materials and Methods

Our observations were made on a cassava fertilizer experiment with potassium started in 1973. The detailed procedure was described by Adeniji and Obigbesan (1975). It involved two cassava cultivars, 53101 and 60506, of varying susceptibility to bacterial blight. Observations were made and records were taken between October and November 1974 when the incidence of infection was most severe at the site.

The following symptoms are characteristic of the disease: angular leaf spotting, wilting, gum exudation from the node at the base of petiole, defoliation and tip dieback. These were used in assessing the degree of infection. Since mainly the top portions of the plants were affected, observations were made beginning at the second point of bifurcation of each stem. The number of infected branches on each plant, as well as the total number of branches per plant, were recorded. There were a total of 32 plots. The treatments were four levels of potash (0, 60, 90, and 120 kg K_2O/ha) with two cassava cultivars and four replications. Percentage infection of the plants in each plot was calculated. The degree of infection in the four replicates of each treatment was then computed to obtain the final mean estimate of infection. The plants were harvested in December 1974 (age 15 months) and the tubers, stems, and leaves in each plot were weighed. The nutrient content in the leaves and starch content of the tubers were determined by conventional methods.

Since the disease is fairly new in Nigeria, it is not clear what time is the most appropriate to collect data. We therefore concentrated on areas where infection was most severe. Dur-

Table 1. Influence of CBB on starch content and yield of two cassava cultivars.

53101			60506		
Degree of infection (%)	Starch content (%)	Yield (t/ha)	Degree of infection (%)	Starch content (%)	Yield (t/ha)
62	24	25	36	23	38
66	22	24	39	20	33
69	21	20	48	19	31
70	22	20	51	21	32

ing the 2-week observation period, we noted that some infected plants developed new leaves. We assumed that branches with new growth were infected.

Results and Discussion

Tuber Yields

Table 1 shows the yield of the cassava cultivars in relation to the severity of bacterial infection. The data reflect the obvious greater susceptibility of the 53101 (mean infection 67.2%) compared with 60506 cultivar (mean infection 43.9%), as well as the relatively higher tuber yield potential of the latter (mean yield 33.8 t/ha) compared with the former, 53101 (mean yield 22.2 t/ha). The negative correlation coefficient between the intensity of bacterial blight and tuber yields ($r = -0.13$ for 53101 and $r = -0.60$ for 60506) with a pooled average of $r = -0.70$, indicate that increasing bacterial infection significantly depressed cassava yields.

In the absence of cassava bacterial blight, mosaic disease probably reduces cassava yields by about 30% in Nigeria and by up to 43% in East Africa (Beck and Chant 1958). Currently cultivated cassava varieties in the country are not free from mosaic disease but yield losses through bacterial infestation could still be determined since mosaic disease is a common factor among them. Tuber yields of 53101 were not significantly reduced by blight although the plants showed a higher percentage of infection than the 60506 cultivar.

Starch Content

The starch content of the cassava tubers in relation to bacterial infection is shown in Table 1. There were negative correlation coefficients, $r = -0.59$ (53101) and $r = -0.24$ (60506) between the percent infection and tuber starch content, thus indicating that bacterial blight reduced the starch content in the tuber of both cassava cultivars. This reduction in starch content had hitherto not been reported, although Lozano and Sequeira (1973) observed that the bacterium hydrolyzed starch and gelatin. The reduction in tuber starch content was significant at the 5% level in 53101 while it was not significant in 60506 ($p_{0.05} = 0.4973$). Under the circumstances, the relationship between the bacterial blight infection and percent tuber starch content (Y) was given by the linear regression equations,

$Y = 28.15 - 0.08X$ (53101) and

$Y = 22.34 - 0.03X$ (60506), where X is the percentage of plants showing characteristic blight symptoms.

Further evidence that the bacterial blight in effect lowered the percentage starch content of cassava tubers at 15 months is provided in Table 2, at 12 months harvest when there was no incidence of infection. The starch content of cassava increases with the age of the crop, and reaches its maximum after 15–18 months (Obigbesan and Agboola 1973; Rosanow 1973). There was an average reduction of between 5% (53101) and 7% (60506) in tuber starch content of CBB-infected plants (Table 2).

The effects of potash and bacterial blight on the starch yields of the cassava cultivars harvested at 12 and 15 months after planting are presented in Table 2. The decrease in percent starch content ultimately led to a reduction in starch yields (Table 2). The data in this table also show that only at 90 kgK_2O/ha was there no yield reduction. The highest starch yields were also produced at this K fertilizer level which suggests that the deleterious effect of CBB could be reduced.

Nutrient Content of Leaves

The mineral contents of randomly sampled healthy and diseased leaves showed that

Table 2. Influence of K and potash and CBB on the starch yield of cassava cultivars.

	Influence of K on percent starch content of peeled tuber				Influence of potash on starch yields (kg/ha)			
Age at harvest:	12 months		15 months		12 months		15 months	
Cultivar:	53101	60506	53101	60506	53101	60506	53101	60506
Incidence of infection:	None	None	67.2%	43.9%	None	None	67.2%	43.9%
0 kgK_2O/ha	29	28	21	20	3770	5610	3505	5430
60 kgK_2O/ha	29	29	22	21	4260	6020	3658	5955
90 kgK_2O/ha	26	28	24	23	4360	6025	4886	7350
120 kgK_2O/ha	24	27	22	19	4690	5590	4300	5010

the healthy leaves contained higher amounts of macronutrients (N-P-K-Mg) but lower amounts of micronutrients (Fe, Zn, Mn) than the diseased leaves.

Lower concentration of macronutrients in the infected leaves should obviously be expected since the acropetal transportation of nutrients would be disrupted, among other things, by the gum exudates oozing out of the node at the base of the petiole. More work is needed to explain the higher concentration of micronutrients in the same diseased leaves. Both phenomena, however, point to the physiological disorder the disease imparts to the plant itself.

Conclusion

The observations reported in this paper are in no way exhaustive. They do illustrate the fact that CBB is a seriously devastating disease which does more than reduce crop yield. Tubers of infected plants showed lower starch content. This is most undesirable because the starch and chip industries require tubers with high starch content. The disorder in nutrient status (nutrient imbalance) of infected leaves, resulting from a drastic reduction in the concentration of macronutrients (N content was reduced by about 12%, P by 24%, K by 17% and Mg by 7%) and higher accumulation of micronutrients (e.g. Zn content rose by about 23%, Mn by 7%), may lead to toxicity and decreased resistance to other diseases. The different cultivars exhibit different degrees of tolerance to blight. Thus a combination of blight-tolerant (resistant) varieties and disease-free planting material would reduce losses in large-scale cassava production.

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World Distribution, Identification, and Control of Cassava Pests

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Numerous insect and mite pests have been identified as attacking cassava. These pests represent a wide range of insect fauna; more than 100 species have been recorded. Many of these are minor pests and cause little or no economic losses. However recent research has shown that several pests can cause crop losses and must be classified as major pests. These include mites, thrips, stemborers, whiteflies, hornworms, scale insects, and whitegrubs. Many pests, such as mites, whiteflies, scales, whitegrubs, stemborers, ants, termites, are distributed world wide. Others are local pests or limited to one or two continents. Chemical control of cassava pests is uneconomical in many areas where it is a low value crop. Pesticides are expensive and their continual use is impractical for a long season crop such as cassava. Emphasis should be directed toward the use of resistant varieties, biological control, and improved cultural practices. Strict quarantine practices should be enforced to prevent the spread of cassava pests into areas where they are not present.

Insects and mites are limiting factors in cassava production. The recent introduction, and consequent outbreak, of the mite *Mononychellus tanajoa* in West Africa has caused serious crop losses. This is ample evidence for the need for extensive research on cassava pests, knowledge of their geographic distribution and the damage they cause, and the establishment of an effective pest-management program.

CIAT has been able to collect much of the available literature on cassava, and it is now possible for us to get a global view of pest problems. There are numerous pests that attack cassava and they represent a wide range of insect fauna. Many are of minor importance and cause little or no economic losses, while others can cause considerable damage.

Insects Attacking Vegetative Planting Material

Cassava is propagated by vegetative stem cuttings. The planting of insect-free and undamaged cuttings is most important.

Infestation of cuttings by white scale *Aonidomytilus albus* can reduce germination up to 50%. Infested cuttings were dipped in insecticide solutions, but they still germinated poorly. We recommend that scale-infested cuttings not be used as propagation material.

The cassava fruitflies *Anastrepha pickeli* and *A. manihoti* cause damage to stems by introducing secondary bacterial rots, which may cause reduction in yield and the loss of stake planting material. Infested stakes are easily distinguishable by the darkened and rotted pith region of the stem. Infected cuttings should not be used as propagating material.

Pregermination and Postgermination Damage to Cuttings and Young Plants

Stem cuttings and young germinating plants are subject to attack by several insects, including whitegrubs (*Leucopholis rorida* and *Phyllophaga* sp. (Coleoptera Family Scarabeidae, Cerambycidae)). They destroy the bark of planted cuttings which may then rot and die.

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