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A SURVEY OF SOME ATTEMPTS TO BREED CASSAVA-VARIETIES WITH A HIGH CONTENT OF PROTEINS IN THE ROOTS

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INTRODUCTION

Although the efforts mentioned in this article, concerning the breeding of cassava varieties with roots containing a higher than normal percentage of proteins, did not lead to positive results, nevertheless to my idea the negative outcome is important enough to warrant publication, especially for the benefit of the research workers interested in this problem. The author is quite aware of the great imperfections adhering to his work, since part of his data and all material were lost during the Japanese occupation op Java.

Cassava roots are, as KOEFOED, POSTMUS, VAN VEEN, TAHALELE and others have often underlined, a very incomplete food and wholly inadequate to serve as a staple-food. Raw and dried roots contain generally not more than resp. 0.7 and 1.5 % crude proteins, which are, however, of very poor quality as their biological value is much less than that of rice, sorghum, millet, etc. The quantity of crude proteins consumed in the daily rations of cassava roots must therefore be considered as being very insufficient and as a menace to the public health, especially in those regions of the tropics where cassava roots form the staple food for several months of the year. When KOCH (6) drafted his breeding program for cassava at Buitenzorg (Java), he considered the increase of the protein content of the roots as one of his most important aims. In taking over his work in 1932 I adopted his program in this respect without any modification.

RESEARCH DONE BY KOCH

KOCH (6) started his breeding work by having analyzed his entire collection of clones consisting of varieties from Indonesia and other varieties imported from different countries. To his great disappointment they did not yield a single clone with roots that contained a higher than normal content of proteins. Neither did he have any success with a great number of seedlings derived from hybridization, free fertilization and selfing of different cassava clones. Notwithstanding these disappointing results he thinks that success in this respect within the species *Manihot utilissima* must not be considered impossible. This view is possibly based on the high protein content he found in some clones he imported from Indo-China, which he however discarded on account of their low yields without using them for hybridization. With his species hybrids from the cross *Manihot utilissima* × *Manihot Glaziovii* he experienced however the same disappointments. The F_2 plants of these hybrids, which were grown by me, also yielded unsatisfactory results.

FURTHER RESEARCHES

After the above mentioned unsatisfactory results all breeding work in this respect was stopped until new possibilities appeared. This occurred in 1936 when LANJOUW (7, 8) found *Manihot saxicola* on the Voltzberg in Surinam. In the small roots from seedlings grown at Buitenzorg a crude-protein content of 2.3 % was found in the fresh roots which, at a dry matter content of about 22 %, corresponds to about 11 % proteins in the dry matter.

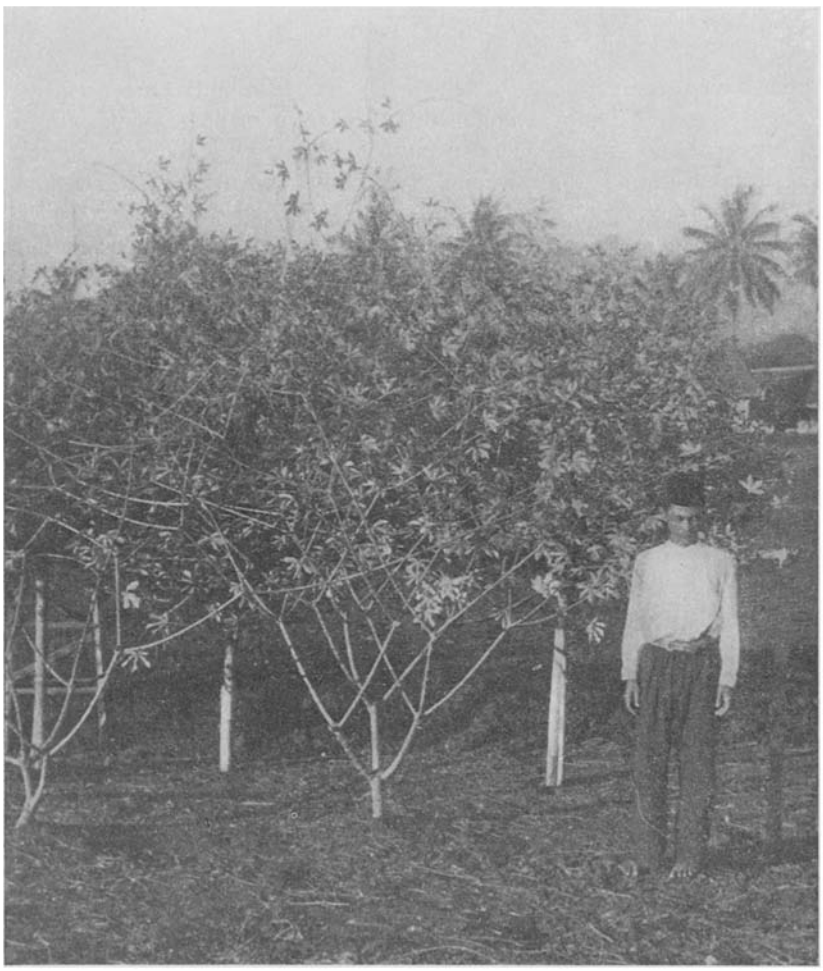

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FIG. 1. MANIHOT SAXICOLA, FOUND BY Dr LANJOUW IN THE NEIGHBORHOOD OF THE VOLTZBERG IN SURINAM. RAISED FROM SEED IN THE EXPERIMENT GARDENS OF THE AGRICULTURAL INSTITUTE AT BUITENZORG

This very high protein content was however accompanied by several undesirable characters, viz. heavy branching of the plants, long-stalked, small roots with a low

dry-matter content and an extremely high content of prussic acid (430 mgr HCN/kg). Nevertheless it was considered worth while trying to hybridize this new species with *Manihot utilissima* in the hope of finding useful hybrids with a high protein content in the roots. Hybridization with *Manihot utilissima* did not present any difficulties. The highly satisfactory results obtained even raised doubt if *Manihot saxicola* could be regarded as a new species (see BOLHUIS, 3). The first hybridization was made with the clone Basiorao, a good yielding, moderately poisonous import from Brasil. The reciprocal cross gave two sets of F_1 plants which sets differed greatly. Cross *Manihot saxicola* (*M. s.*) × *Manihot utilissima* gave plants that resembled very much the seedlings of *M. s.* and displayed the same susceptibility to *Fusarium* attack. The reciprocal cross gave F_1 plants from which several tended more to the normal cassava type. From the cross *M.s.* × Bas. finally remained only 10 plants with protein contents ranging from 0.64 to 2.06 % in the fresh roots. These rather favorable results were however not maintained in the clones from these F_1 plants. The protein contents in the roots from seedlings and clones are summarized in table I.

TABLE I. PROTEIN CONTENTS IN FRESH ROOTS OF SEEDLINGS AND THEIR CLONES FROM THE CROSS MANIHOT SAXICOLA × BASIORAO

Nr seedling	Protein content in fresh roots in %	
	seedling	clone
1	1.32	0.60
2	1.70	0.52
3	0.90	0.46
4	1.21	0.73
5	1.09	0.64
6	2.06	1.49
7	0.67	0.48
8	1.06	0.88
9	0.64	0.84
10	1.28	0.48

These figures show, as KOCH already found in other respects, a poor correspondence between the protein content of the seedlings and the clones derived from them. At the same time it became evident that size and form of the roots from all clones left very much to be desired.

The protein contents of the roots from the clones of the reciprocal cross are fairly comparable to those in table I, with the only difference that they are generally lower. Besides a favorable protein content in the roots the F_1 plants exhibited, however, a very dense branching and an undesirable form of the roots, which characters, with only one exception, were accompanied with a very high degree of poisonousness. The content of dry matter was always fairly normal.

Intercrossing and selfing of some of these hybrids gave rise to a great number of seedlings. Analyzed were only the roots of those seedlings that possessed reasonably thickened roots. The results obtained are summarized in table II. The harvest of these seedlings caused many difficulties and required much extra labor caused by the very heavy branching of most of the seedlings. After the seedling parents the protein contents of the roots are mentioned between brackets.

TABLE II. RESULTS OF THE INTERCROSSING AND SELFING WITH SEEDLINGS OF THE HYBRIDS FROM THE CROSS MANIHOT SAXICOLA WITH BASIORAO

Cross	Number of seedlings	Number analysed	Number of seedlings with protein content >1%	Highest protein content in %
M.s. × Bas./6 (1.49%) × M.s. × Bas./4 (0.73%)	263	47	7	1.51
M.s. × Bas./2 (0.52%) × M.s. × Bas./4 (0.73%)	226	43	7	1.51
M.s. × Bas./4 (0.73%) × M.s. × Bas./2 (0.52%)	210	8	1	1.17
M.s. × Bas./1 (0.60%) × M.s. × Bas./4 (0.73%)	137	24	1	1.02
M.s. × Bas./25 (0.81%) × M.s. × Bas./25 (0.81%)	148	24	3	1.55

From F_2 plants with a good yield and a favorable habitus clones were planted. When harvested not a single one was found with a higher than normal protein content in the roots, whereas the toxicity was always very high.

Some F_1 hybrids from the cross *M.s.* with Basiorao were backcrossed to cassava clone F 357, a variety with less than 50 mgr HCN/kg in the roots and that had also proved to be good parental material.

From the 211 seedlings obtained only 37 had roots that justified an analysis. From the results of these analyses and from a subsequent study of the planted clones it once more became clear that the high protein content in the roots of the seedlings gives no guarantee whatsoever that this will be the case also with the roots from the clones planted from these seedlings.

Among the seedlings 11 were found with a protein content in the roots higher than 1 %, from the clones only one reached this figure. Also a very high degree of poisonousness was found in most of them. A few, however, possessed such a low content of HCN in the roots that, as far as this feature was concerned, they could become useful for cultivation. Starting from this assumption crosses were made between clone F 357 and *M.s.* Of this cross 51 seedlings ultimately remained 5 of a *saxicola* type, 22 of an intermediate type with very heavy branching and 23 almost resembling the normal cassava type with moderate branching or none at all. Thirteen of these seedlings contained more than 1 % protein in their roots (1.02–1.48 %), the percentages of dry matter were fairly normal but the poisonousness was again very high (134–332 mgr HCN/kg). None of the clones planted from these seedlings gave a satisfactory yield and all displayed an unfavorable habitus. As all this material disappeared during the Japanese occupation, further particulars are not available.

In the discussion of KOCH's research, mention was already made of a number of Indo-Chinese varieties, that had a higher than normal content of proteins in their roots. When, from the first results of the *saxicola-hybrids*, it became evident that most probably the object could not be reached in a short time, new imports from Indo-China were made.

The 5 clones received were all poor yielders, but three had a protein content of more than 1 % in their roots. With the last three (nos 458, 459 and 460) a high number of crosses were made in 1941 (see BOLHUIS, 3), but due to the Japanese occupation no analyses were made of the roots from the seedlings obtained.

Discussion

Considering the high number of cassava clones the roots of which were analyzed for their protein content it does not seem probable that within the species *Manihot utilissima* varieties will be found in the future with a higher than normal protein content in the roots. The above mentioned Indo-Chinese varieties have not much value for cultivation owing to their poor yields.

Amman (1) mentions a number of seedlings that had a high content of protein in the roots, but further reports about the behavior of the clones derived from them are not available. Neither is any mention made of the yield of these seedlings.

Greenstreet and Lambourne (5) give no figures at all about the protein content in the roots of a great number of cassava clones they analyzed in Malaya.

In the reports of the Congrès du Manioc et des Plantes Féculentes held at Marseilles in 1949 not much is to be found about the protein content of cassava roots. Leroy and Francois (9) only point out that the amount of N-containing substances is unimportant in dried cassava roots used as cattle food.

In the study of Graner et al. (4) about the feeding value of cassava only the carbohydrates and minerals are mentioned. Indications concerning the proteins are conspiciously absent.

Much more promising seemed some figures in the Rapport Annuel pour l'Exercise 1950, Publication de l'I.N.E.A.C., where protein contents in cassava roots as high as 7.2 %, with an average of 4.2 % are cited. Further inquiries, however, failed to shed any light on these very high figures, which therefore must be considered as improbable, an opinion shared by Prof. Opsomer at Louvain (Belgium).

As proved in the preceeding pages, not much success either may be expected from the species cross *Manihot utilissima* with *Manihot Glaziovii*.

Treatment of cassava cuttings with colchicine lead to increased chromosome numbers but this was not accompanied with an increase in protein content in the roots (see Bolhuis, 2).

Possibilities for an increase of the protein content in cassava roots by hybridization of clones of *Manihot utilissima* with *Manihot saxicola*, notwithstanding the original expectations, do not appear very bright. Hybrids with a higher than normal protein content in the roots may be obtained, but undesirable characters exclude their possible use in cultivation. Nichols (10) reports the same results with his hybrids between *Manihot utilissima* and *Manihot saxicola*. I share, however, his opinion that it may be worth while to continue research in this direction, whereby cassava clones must be used that produce in their offspring mainly seedlings with a low degree of poisonousness. Further study of the variability of *Manihot saxicola* may disclose varieties of this species with less HCN in the roots than those used at Buitenzorg.

Conclusions

Little success may be expected from the search for cassava varieties with a higher than normal protein content in the roots. The hybrids from the cross *Manihot utilissima* with *Manihot saxicola* seem to offer the greatest possibilities although they are adversely affected by a high degree of poisonousness and unfavorable habitus. Further studies on the variability of *Manihot saxicola* must disclose whether within this species

a combination occurs of a high protein content in the roots with a low degree of poisonousness.

Crosses of good cassava clones with varieties with a high protein content in the roots from Indo-China must be repeated to determine the exact value of the latter in this connection.

SAMENVATTING

Overzicht van enige pogingen om cassave-rassen te kweken met een hoger eiwitgehalte in de wortels

Het zoeken naar rassen van cassave met een hoger dan normaal eiwitgehalte in de wortels leverde tot nu toe niet veel succes op. Binnen de soort *Manihot utilissima* werd geen enkele cloon gevonden die in dit opzicht iets beloofde en evenmin was dit het geval met hybriden van de kruising *Manihot utilissima* met *Manihot Glaziovii.*

De grootste kans hierop bieden waarschijnlijk de hybriden uit de kruising *Manihot utilissima* met *Manihot saxicola.* Hierin werden reeds een aantal gevonden met een hoger dan normaal eiwitgehalte in de wortels, maar andere ongunstige eigenschappen maakten hun waarde voor de practijk geheel denkbeeldig. Deze eigenschappen waren vooral te zware vertakking van de planten en een te hoge giftigheid van de wortels. Daar de te Buitenzorg gebruikte *M. saxicola* in zijn wortels zeer hoge giftigheden vertoonde, moet worden nagegaan of binnen deze soort vormen bestaan, die een hoog eiwitgehalte paren aan een lage giftigheid.

De kruising van goede cassave-clonen met rassen uit Indo-China, die een hoog eiwitgehalte in de wortels bezitten, moet worden herhaald om de juiste waarde van de laatstgenoemden in dit opzicht vast te stellen.

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