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IDRC REPORT TO CIDA

TRITICALE AND CASSAVA/SWINE PROJECTS

~~BY N.D. / 1987/12/1~~

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PROGRESS REPORT TO THE
CANADIAN INTERNATIONAL DEVELOPMENT AGENCY

TRITICALE AND CASSAVA/SWINE RESEARCH PROJECTS

INTERNATIONAL DEVELOPMENT RESEARCH CENTRE
OTTAWA, ONTARIO, CANADA
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TRITICALE AND CASSAVA/SWINE PROJECTS
PROGRESS REPORT FROM THE
INTERNATIONAL DEVELOPMENT RESEARCH CENTRE TO THE
CANADIAN INTERNATIONAL DEVELOPMENT AGENCY

1 JANUARY TO 31 DECEMBER 1973

I N T R O D U C T I O N & S U M M A R Y

The history of the CIDA/IDRC involvement in the Triticale Project at the International Maize and Wheat Improvement Centre (CIMMYT) and in the Cassava/Swine Project at the International Centre for Tropical Agriculture (CIAT), supported by research in several Canadian universities, was comprehensively documented in the report submitted to CIDA early in 1973. This report covers the period 1 January to 31 December 1973.

As was described in the earlier report, in the case of Triticale, CIDA and IDRC gave support to an established working team at CIMMYT and Manitoba, a team which had identified many of the major problems to be solved. In the case of Cassava/Swine, the project objectives had to be identified, a research team assembled, and links established between CIAT and the Canadian institutions, principally the University of Guelph. Manitoba had been growing triticale for several years before the project started; on the other hand, cassava was completely unfamiliar to many of the scientists at Guelph. Consequently, the early progress in the two projects was of a different kind and a different order.

By the end of 1972, the CIMMYT-Manitoba team had made significant progress in overcoming several of the constraints to the successful development of triticale. The growing of triticale lines alternately in Canada in summer and in Mexico in winter nurseries, made possible the selection of varieties insensitive to day length and which could be grown over a wide range of latitudes. The discovery of the cross X308 which gave rise to the Armadillo strains, marked a turning point in the quest for inheritable fertility and, in consequence, made possible a significant improvement in yield capability. Progress had also been made towards overcoming the problems of late maturity, grain shattering, pre-harvest sprouting and poor tillering.

However, up to the end of 1972, yields were not of the order sought; kernel characteristics were highly variable with large proportions of shrivelled and poorly filled endosperms in evidence. Lodging, particularly under heavy nitrogen fertilizer application, was still a major problem.

Though none of these difficulties has been totally resolved, much improvement is apparent from the 1973 results. For the first time, both at CIMMYT and Manitoba, the best triticales out-yielded the best wheats. Kernels are still not as uniformly plump as one would eventually hope for, but a marked improvement is evident. Research to shorten straw length and strength will, it is confidently believed, eventually eliminate the problem of lodging.

At the outset of the project it was agreed among all concerned that the objective was to create a new cereal grain for human consumption, a cereal that would grow on lands ill-suited to other grains, a cereal with a superior nutritional composition. Some of the early, and even some comparatively recent statements made extravagant claims for the biological value of triticale. Many of these claims were based upon a faulty methodology. IDRC therefore sponsored a series of activities to try to clarify the matter. The first was a subcommittee on biological evaluation. The second was a comparative examination of several laboratory animals, one of which, the field vole, was being used both by CIMMYT and Manitoba as a device for screening triticales for superior biological value. The third was a publication of a critical summary of all the available knowledge relevant to the nutritive value of triticale and of its parents, wheat and rye. The outcome of these initiatives are described in the later text.

A fourth IDRC sponsored activity will, we believe, be of significant importance not only to the Triticale Project but to other cereal plant breeding programs. A committee of scientists of recognized competence is being assembled by the United Nations Protein Advisory Group, the International Unions of Nutrition Sciences and Pure and Applied Chemistry, and IDRC to study and recommend upon

methods of selecting among cereal breeding lines for improved protein value. The first meeting will be at Ciudad Obregon in Mexico at the time triticale and other cereals are being harvested and will benefit from the input of both CIMMYT and Manitoba scientists.

Among the advanced triticale lines at CIMMYT are several which, compared with wheat, show high lysine and high protein values. In a few instances, triticales with a higher than 13% protein content contain lysine proportions equivalent to those of high lysine maize. IDRC has encouraged Manitoba to screen some 3,000 in-bred rye varieties in the hope of finding additional sources of high lysine germ plasm.

A winter triticale program, to be financed partly by CIDA and partly by IDRC, is expected to begin at the University of Guelph in the very near future.

An international committee, sponsored by IDRC and the International Union of Food Science and Technology (IUFoST), will examine the potential utilization of processed triticale in the traditional foods of many nations.

The progress in improving triticale plant characteristics is at a point where the outreach research program network financed by IDRC can now be significantly expanded. Outreach project requests have been approved or are being processed from Ethiopia, Algeria, India, Kenya and Chile and more are expected from other Near Eastern, African, Asian and Latin American countries. The Manitoba and CIMMYT breeders are visiting several countries where triticale yield nurseries give hope of success to formulate additional projects for IDRC support.

The Triticale Advisory Committee met once, in Mexico, following the IDRC financed International Triticale Symposium and a copy of the minutes are attached as Appendix "A".

All considered, it has been a good year for triticale. Progress at CIMMYT and Manitoba is encouraging though there are still many more improvements possible. There were six international meetings devoted to triticale in various parts of the world during 1973 and another is scheduled to be held in New Orleans early in 1974.

The Cassava/Swine Project has also made notable strides forward. In the report for 1972, attention was drawn to the emphasis devoted to clearly defining the objectives of the programs at CIAT and mention was made of the important role played by the IDRC Advisory Committee. Attention was also drawn to the definition of appropriate inputs from Canadian institutions into a research project which dealt with a commodity, cassava, with which very few Canadian scientists were familiar. The initial report mentioned that the swine program was an on-going concern and the major input into this from IDRC's management was to assist in internationalizing the research that had been done at CIAT. In contrast, the cassava program had not only to be defined, but a research team had to be assembled so that by the end of 1972, it was still not fully underway. Particular attention was drawn to the difficulties experienced by the Advisory Committee during the early stages in reaching a full accord on a policy statement with the management of CIAT.

During the year 1973, virtually all of these problems have been overcome. In March, when the Advisory Committee met at CIAT, they agreed upon a program policy statement for cassava which was published in August as a CIAT document. The Committee recommended that IDRC should approve the budgets presented to it, with a small number of minor changes which CIAT adopted. The Committee also agreed that having spent three meetings discussing the CIAT program in depth and having reached full agreement with CIAT on the overall research policy for cassava, they should thereafter not examine the CIAT program in depth again for two years, by which time it would be possible to evaluate research progress within the context of the overall program. In the case of the swine program, the Committee felt that it did not have sufficient expertise to evaluate this program in depth and they recommended to IDRC that it would be desirable to obtain a separate consultant or consultants for this purpose. The minutes of the meeting are attached as Appendix "B".

In November, when the Committee met in Ottawa, they devoted the major part of the meeting to an indepth review of eight projects at Canadian institutions which were being financed by CIDA. The Committee was impressed with the progress made and with the extent to which these projects were coordinated with the CIAT program. The Committee recommended to IDRC that they should not meet again until the early part of 1975 when they would review both the CIAT and the Canadian components of the program. The timing of this review would be such that it would enable IDRC to report to CIDA prior to CIAT's 1975 Board meeting, so that CIDA would be in a position, if they so wished, to intimate to CIAT whether CIDA funding of the cassava and swine projects could be expected to continue beyond the end of 1975. The Committee suggested that it should not have to meet in the Spring of 1974 to review the CIAT 1975 budget proposals but should do this by correspondence. The minutes are attached as Appendix "C".

During December, members of the cassava team presented nine research papers at the 3rd International Symposium on Tropical Root Crops, held at IITA. IDRC funds enabled 16 scientists working in tropical root crops to participate in the meeting. Subsequent to the meeting, the root crop scientists of IITA and CIAT met with a number of interested scientists to have preliminary discussions regarding the establishment of an international program for comparative testing of cassava cultivars. There are major plant quarantine problems in the way of proceeding with this idea, but the meeting did enable a useful dialogue to be established and put the root crop staff of the two international centres in touch with a number of young scientists from Africa, Asia and Latin America.

Relations between the Canadian and the CIAT components of the cassava program have strengthened considerably and at the end of the year a senior Canadian scientist began a sabbatical year at CIAT.

In the initial report on the Cassava/Swine Project, attention was drawn to the fact that IDRC funds were being used to generate outreach programs for both the cassava and the swine components. This action has continued during 1973. In January an International Workshop was held in England to study chronic toxicity in cassava. As a result of this Workshop, a grant from the CIDA funds was given to the University of Guelph to work in this field. Both IITA and CIAT modified their own work programs to screen cultivars for cyanide level since the Workshop concluded that low cyanide cultivars were likely to exist and could be further developed through a breeding program.

In June 1973, IDRC sponsored another International Workshop to which importers, exporters and economists associated with the cassava industry around the world were invited. At the Workshop, held in Ottawa, they reviewed the draft report on the CIDA funded study in cassava marketing which was carried out under contract by the Agricultural Economics Department of the University of Guelph. The draft report was revised as a result of this Workshop and will be released in book form in March 1974.

In September 1973, IDRC's Board of Governors approved a grant of \$195,000 to CIAT for the purpose of developing collaborative swine programs with Bolivia, Costa Rica and Nigeria and to provide a specialist to coordinate outreach work in the swine program. Support is also being given for root crop research in Malaysia and Indonesia.

During the course of the year, the IDRC staff concerned with the management of the Cassava/Swine Project made six visits to CIAT. Visits were also made to IITA, USAID in Washington, the Tropical Products Institute in London, the University of Wageningen in Holland and the German Ministry of Economic Cooperation in Bonn. All of these institutions are contributing in some form or other to the global cassava research network whose core is the CIDA supported program at CIAT.

In summary, it is the opinion of IDRC and its Advisory Committees that all who have been concerned with the Triticale and the Cassava/Swine Projects can derive considerable satisfaction from the progress made during 1973. IDRC will continue to support a wider outreach network with particular encouragement for research and demonstration projects which are concerned not only with adaptation and agronomic improvement of the crops in question, under a variety of environmental conditions, but also with the systems of processing which are economic and applicable among the communities where the crops are grown. Attention will continue to be given to the needs and responses of consumers and target markets.

It is probable that a modest extension of both projects will be required to bring them to a satisfactory completion and this matter will again be brought forward for consideration by CIDA towards the end of 1974.

What follows is a more detailed progress report of the Triticale and Cassava/Swine Projects together with a series of five tables in which the various projects committed using CIDA and/or IDRC funds are listed, and a statement of actual and predicted cash flows shown.

Immediately following the main descriptive text (p 44), the reader will find five tables:

TABLE I - lists by title, amount committed and status, each of the separate cassava/swine projects financed from CIDA funds;

TABLE II - lists the cassava/swine projects financed by IDRC;

TABLE III & IV - present respective to Tables I and II, essentially similar information for triticale projects;

TABLE IV - presents a summary of the CIDA approved allocations, commitments and actual and estimated cash flows in respect of the two projects.

THE TRITICALE PROJECT

1. CIMMYT PROGRAM

(a) Widening the Germ Plasm Base

In 1973 scientists at CIMMYT felt that the existing germ plasm base for advanced lines of triticales was too narrow and therefore they initiated a program to try to produce new hexaploids which could be fed into the breeding program. Major difficulties had been encountered in producing primary hexaploids because the triploid plants produced after crossing had to be grown as embryos on a culture medium. Then they had to be treated with colchicine to double the chromosome number to produce the hexaploid. One senior CIMMYT scientist concentrated on this program during 1973 and has developed new techniques of embryo culture together with more effective methods of colchicine treatment. As a result, a very large number of new amphiploids (which are fertile) have been produced thus widening the germ plasm base considerably. Also, use has been made of winter triticales which had previously not been used in the cropping system because of the difficulty of getting them to flower at the same time as the spring types. This problem seems to have been solved by growing both types at the high altitude station Toluca, during the winter season. One of the benefits has been the reduction of pre-harvest germination among these winter triticales crosses.

(b) Yield

During the 1971-72 and 72-73 seasons, for the first time, the best triticales varieties out-yielded the highest yielding wheat varieties in both the summer and winter CIMMYT nurseries in Mexico. The highest yield of 8,352 kg/ha was produced by Triticale variety #312 compared with 7,245 kg/ha for the top yielding wheat variety in the same trial. A summary of the yields obtained is given in the Table on page 9.

Although the yields shown in the Table represent the results of only a limited number of trials, and therefore should be viewed with some caution, it is clear that the yield potential of the best triticales strains selected by the plant breeders does seem to be increasing relative to the bread wheat checks in the latest trials.

Yields of the best Triticale strains compared with the best wheat varieties in tests at CIANO, Navajoa, El Batan and Toluca in Mexico.

<u>Location</u>	<u>Year</u>	<u>Triticales Yield of top strain Kg/Ha</u>	<u>Wheat Yield of top variety Kg/Ha</u>
CIANO	67-68	3196	5207
CIANO	69-70	4990	6220
Navajoa	69-70	6282	6491
Toluca	70	4853	3716
El Batan	70	5193	4786
Navajoa	70-71	6320	6600
El Batan & Toluca	71	4590	4610
CIANO	71-72	5388	6457
Navajoa	71-72	5443	5339
Toluca	72	4738	4669
CIANO	72-73	8352	7245

It is significant that all the highest yielding strains were derived from crosses between hexaploid triticales and either Mexican bread wheats or octoploid triticales which were produced from Mexican bread wheats. They all possess an additional dwarfing gene, the one contributed by Armadillo.

The ultimate yield potential to be exploited by further breeding is illustrated by the fact that these new lines out-yielded the best wheat checks in spite of a higher incidence of lodging and inadequately filled kernels among the triticales.

Steps are being taken to overcome the lodging by incorporating further dwarfing genes into the triticales from the dwarf rye "Snoopy" and from other dwarf wheats. A systematic search is also being made for additional short straw rye varieties for use in new crosses. There is a tendency for some of these dwarf selections to be more sterile than the taller selections from the same parents, so strong selection is being applied for high fertility at the same time as the dwarfs are being selected. The marked improvement in fertility which resulted from the development of the Armadillo line has already

been mentioned but there was at first an unfavorable consequence in the reduction of spike length in the Armadillo selection. In 1973, selections were found which combined long spike length with high fertility and these are now being incorporated into the breeding program.

(c) Disease Resistance

Although certain triticales strains do possess considerable resistance to some diseases, an important aspect of the program is the testing of new strains for disease resistance. Fortunately, the high altitude summer nurseries in Mexico are very suitable sites for the development of leaf diseases including stripe rust, (Puccinia striiformis) and others, also the new strains are exposed to different diseases in several of the nurseries being grown in cooperating countries. Additional disease resistance is being incorporated in the new strains both from rye and from the dwarf wheats, particularly to bacterial stripe (Pseudomonas striifaciens), leaf blight (Fusarium nivale), and leaf rust (Puccinia recondita), as well as to other diseases.

(d) Agronomic Studies

Although in some instances the agronomic practices developed for wheat can perhaps be adapted to triticales without too much difficulty, it is important that packages of suitable practices be developed for growing triticales in all the areas where they are to be grown. In particular, there are indications that early planting may be of greater importance with triticales than with wheat varieties. Also, it is particularly important to investigate the adaptation of triticales strains to such stress conditions as continuing or intermittent drought, and to light, sandy and acidic soils. There are indications from India that triticales may give much higher yields than wheat on soils with acidity below pH 6.5. Certain triticales also appear to perform better than wheat on high aluminum soils and at higher altitudes where low night temperatures are common. Since little reliable information is

available at this time about the performance of triticales under drought conditions, CIMMYT has decided to expand considerably the agronomic program and is investigating seed rate, row spacing, response of strains of triticales to nitrogen, the use of herbicides to control weeds and their phytotoxicity to triticales.

Other studies are planned to investigate the use of triticales for forage and as feed grains for farm animals.

(e) Kernel Characteristics

The problem of shrivelled grains found among many of the early triticales varieties has already been mentioned. Shrivelling and low fertility are often associated with intergeneric crosses. Based on the improved plumpness of the Armadillo selections considerable progress has been made in the last year in selecting for plumper grain. Whereas many of the early triticales strains had test weights of about 60 kg/hl, the latest high yielding varieties such as #312 have test weights greater than 70 kg/hl. The objective is to produce triticales which compare well with the wheats with a bulk density close to 80 kg/hl. To achieve this goal further improvements in kernel plumpness is essential.

Various methods have been used at CIMMYT for fractioning according to kernel plumpness, including mechanical separation, flotation studies using liquids of different densities, and an air separation method. CIMMYT and the University of Manitoba have now adopted a gravity table method of separating grains of different sizes.

The department Agriculture Canada proposed a project to assist the research at CIMMYT on grain plumpness but the project could not be put into effect because of administrative difficulties. CIMMYT scientists believe that although further progress is desirable and possible, the present level of grain plumpness would be sufficient, if incorporated with other desirable characteristics, to make triticales acceptable as a grain crop.

(f) International Testing Programs

The triticales program has benefited enormously from CIMMYT's world-wide network of scientific contacts developed in connection with its bread wheat program. This has aroused wide spread interest among scientists of many nations. In 1973 CIMMYT distributed seed to 52 countries. This seed was distributed as International Triticale Yield Nurseries (ITYN), and International Triticale Screening Nurseries (ITSN). For the first time, in 1973, the ITSNs were divided into two groups of strains, one adapted for irrigated growing, the other group adapted for dry land conditions. Also, seed bulks for the F_2 generation were sent to some countries. Excellent examples of the adaptation of the triticales have been reported from the Himalayan foothills in India, from Njoro and Molo in Kenya, and in the highlands of Ethiopia.

The CIMMYT international and cooperative triticales testing program now expands over many countries in all the major continents. In 1973 the ITYNs included 41 countries of North, Central and South America, Europe including the USSR and several of its associates, the Indian subcontinent, South and Southeast Asia and Oceania. The ITSNs included 29 and 30 countries where superior segregating triticales lines were grown under irrigated and dryland conditions respectively.

2. UNIVERSITY OF MANITOBA

(a) Widening the Germ Plasm Base

Since the facilities at the University of Manitoba permit the pursuit of more fundamental studies than those at CIMMYT, an important aspect of their program is the introduction of more variability and a wider gene base into the current triticales. Therefore, in 1973, a total of 1,200 wheat-rye crosses were made in the field and some 56 new amphiploids were synthesized from previous crosses, 24 of these were hexaploids, the remainder octoploids. New techniques for the improvement of embryo culturing and the doubling of the chromosomes in young embryos are continually being sought. One technique which seems to show promise is the incorporation of the colchicine in the culture medium for the embryos. Other aspects of the program included

the incorporation of large spike type associated with high fertility and the introduction of foreign germ plasm from *Agrotriticum*. A further program involved the screening of rye varieties for ergot resistance, and their incorporation in the breeding program. A very large number of selections were made from this material and will be evaluated in future years.

(b) Yield

Annual mean yields of triticales at the University of Manitoba have risen from around 78% of the bread wheat checks in 1956 to 105% of the checks in 1973. Thus there already seems some advantage in yield for the most advanced triticales lines over the bread wheat checks, and this advantage is expected to increase in the future. A cooperative program with the University of California at Davis has given the highest yields of triticales with over 6,400 kg/ha.

(c) Disease Resistance

Although the incidence of ergot has declined as the fertility of the new triticales strains has improved, an intensive search for resistance to ergot is being carried out. Approximately 15 tetraploid and hexaploid wheats with a high level of tolerance to ergot have been identified and this material is being incorporated in the breeding program. Another fundamental study is being carried out on the inheritance of stem rust in triticales in order to facilitate breeding for appropriate resistance. This complements the leaf rust study already completed last year.

(d) Cytogenetic and Biochemical Studies

Several basic studies have been undertaken at the University of Manitoba on both the fertility and the grain shrivelling problems. Indications were obtained that the longer meiotic time in diploid rye than that in diploid and tetraploid wheats might interfere with the meiotic stability of the amphiploid crosses. This meiotic instability would cause low fertility. Biochemical studies indicated a significant correlation between alpha-amylase activity and grain

density. In shrivelled grain alpha-amylase activity continued to increase for a longer time than in unshrivelled kernels. This amylase activity which is often associated with premature germination may cause a breakdown of starch kernels in the endosperm thus inducing kernel shrivelling. Genetic studies of the same problem appear to indicate that certain specific chromosomes of rye, may be associated with kernel shrivelling. The gravity table is being used to screen relatively large quantities of segregating populations for grain plumpness. The plump and shrivelled kernels are then examined for biochemical and cytogenetic differences. The University of Manitoba scientists believe that considerably more work is required in the field of embryo and endosperm developmental physiology in order to elucidate this problem.

3. IDRC ADVISORY COMMITTEE

The fourth meeting of the IDRC Triticale Advisory Committee, held at El Batan, Mexico on 5 October 1973, recommended two new projects. One of these was a spring rye improvement project to be conducted at the University of Manitoba. This involves the screening of over 3,000 varieties of rye, already maintained at Manitoba, for: (i) protein and lysine content; (ii) height and adaptability; (iii) combining ability.

This program is designed to select improved varieties of rye with high protein and lysine contents, also with additional dwarfing genes, and with specific combining ability with wheat parents, which can be used in the crossing program to produce improved triticales.

The second project is to be undertaken at the University of Guelph because it has been found that winter triticales will survive at Guelph whereas the winters are too harsh to allow them to survive in Manitoba. Although winter and spring triticales have been produced at both CIMMYT and the University of Manitoba, the winter types have not yet been fully evaluated. Therefore, it is intended to evaluate this material from CIMMYT and Winnipeg and from other countries such as Hungary and Sweden, and to make crosses among the best selections

at Guelph. Hopefully, some of this material would provide high yielding strains which could fit into various ecological conditions requiring winter triticales. It is believed that winter triticales would have a particularly useful application in a number of Near Eastern countries.

Other possible projects at the University of Manitoba on utilization and on drought resistance were also put forward for consideration at the meeting. It was agreed that further consultation was necessary on these two projects.

4. RESEARCH AND RELATED IDRC FINANCED ACTIVITIES

(a) Outreach

In addition to its management of the CIDA financed Triticale Project, IDRC is also financing certain outreach projects directly. The first of these, in Ethiopia, is already underway and requests have been received from Chile, Algeria and Kenya for project support. In preliminary trials at several locations in the Central Himalayan region in India, triticale has yielded over 4 t/ha whereas the wheat check gave a yield of only 2.3 t/ha. IDRC expects to receive in the near future a sizable triticale project request from the Indian Council for Agricultural Research. The research would be undertaken at G.B. Pant University at Pantnagar and would include an adaptive breeding and testing program over a range of agroclimatic conditions. It would also include food technology and home economic studies into the utilization of triticale in traditional Indian foods.

In consultation with the scientists at CIMMYT and the University of Manitoba, IDRC is exploring where additional triticale outreach research projects can be established in the near future.

In 1970 the first International Triticale Screening Nursery was grown in Ethiopia and the results were so impressive that it was decided to expand the program considerably. In 1973, triticale was grown at 17 locations in the country and several hundred lines were planted. High yields were recorded in many of the trials and in

every trial conducted so far, triticales out-yielded the bread and durum wheats by from 5 to 31% and in some of the nurseries by well over 100%. Mean yields of the present triticales are running at about 4 t/ha. A particularly important point is the fact that in Ethiopia the triticale yields are more stable and the varieties more widely adapted than wheats. Their performance at marginal locations where other cereals often give unreliable yields is particularly impressive. Some disease problems have been encountered but selection for disease resistant material is in progress. Preliminary utilization studies have shown that injera, the traditional bread of Ethiopia, can be made using a 50-50 blend of triticale and teff. Many of the other local cereal food products can be prepared entirely from triticale. Scientists at the Ethiopian Nutrition Institute are expanding their studies on the utilization and nutritional value of cereal foods made with triticales. It is hoped that as soon as the new selections have been evaluated and found suitable for human consumption a larger scale outreach program can be carried out.

(b) Symposiums

(i) International Triticale Symposium

An International Triticale Symposium, financed by IDRC, was held from 1-3 October at CIMMYT. Accounts of progress in triticale research were given by scientists from 15 countries. Seven papers were presented on cytogenetic or biochemical aspects of triticale improvement, two on diseases, one on agronomy and physiology, five on various aspects of the breeding program, and two on approaches to human or animal nutrition and utilization. A complete list of the authors and papers presented is attached as Appendix "D". The proceedings of this symposium will be published by IDRC.

(ii) St. Louis Symposium

As a part of the 58th Annual Meeting of the American Association of Cereal Chemists, the AACC and IDRC jointly sponsored a Symposium on the Biochemistry, Nutrition and Utilization of

Triticale 1. Attached as Appendix "E" is a list of the papers presented at the Symposium and their authors. The proceedings are to be published in book form by the AACC.

(c) Working Groups and Committees

(i) Triticale Utilization

In cooperation with the International Union of Food Science and Technology (IUFOST), IDRC has now established an International Working Committee on Triticale Utilization which so far has membership from almost 20 countries. The Working Committee will explore the possible use of triticale in a wide range of traditional and new foods. The Committee's continued findings and recommendations will be published by the IDRC in cooperation with IUFOST.

(ii) Methods of Analysis and Biological Evaluation

In cooperation with the United Nations Protein Advisory Group (PAG), the International Union of Pure and Applied Chemistry (IUPAC), and the International Union of Nutrition Sciences (IUNS), IDRC has formed a Working Group to study and recommend upon Methods of Analysis and Biological Evaluation of the protein of cereal grains, and in particular, triticale. IDRC will finance the first meeting to be held at CIMMYT in April 1974. This is the first occasion that these three important international bodies have met together to consider the methodology by which cereals of improved biological value can be identified and selected. The meeting will take place at Ciudad Obregon, Mexico at the time when triticales are ready to be harvested.

5. THE BIOLOGICAL VALUE OF TRITICALE

The nutritive value of triticale has been of great interest from the outset of the project. The primary objective of the CIMMYT-Manitoba Triticale Project is to develop a new grain which will significantly increase the cereal crops available to people in the less developed countries of the world. Consequently, in addition to the necessity of developing a grain with a high yielding capacity, a wide adaptability (particularly to marginal lands unsuited to other cereals), disease resistance and all of the other properties essential in a commercially acceptable cereal grain, it is equally important that it have a superior biological value. Some early claims for the nutritive value of triticale were wildly exaggerated, having been based on testing with the field vole (Microtus pennsylvanicus), which in subsequent studies, sponsored and directed by IDRC, was shown to be a totally unsuitable test animal. Very briefly, it was demonstrated that the vole gave a very high rating to all cereal grains and gave indications that they were superior in biological value to milk proteins. Some of the exaggerated claims for triticale appeared in the literature and on one occasion were repeated by a Canadian Cabinet Minister. What is more important, until the IDRC sponsored study, both CIMMYT and the University of Manitoba were using the vole as a method of selecting triticales. Both institutions have now ceased to do so.

Because of the importance of the subject and the publicity given to it, IDRC decided that as one of its contributions to the management of the project it would prepare and publish a comprehensive review of all that is presently known concerning the nutritive value of triticale and the proteins of its parents, wheat and rye. The review, under the authorship of J.H. Hulse and E.M. Laing, has been published as a book entitled "Nutritive Value of Triticale Protein" and a copy is enclosed.

At this point, it may be helpful to review briefly the subject of nutritive value. As was described above, and in the earlier report, the early lines of triticale produced a high proportion of shrunken and shrivelled kernels. The kernel of a cereal grain,

such as wheat and triticale, consists of three major components: (1) the germ which is the embryo of the new plant, (2) the endosperm, comprised of starch cells of various sizes embedded in a matrix of protein the endosperm being the source of food for the new plant and, (3) the seed coats, or bran, which surround and protect the germ and endosperm. Expressed on a total dry weight basis, the protein content of the germ and bran are significantly higher than the protein content of the endosperm. Consequently, if the endosperm is small, the ratio of bran plus germ to endosperm will be high and the total protein content, expressed as percent protein of total dry matter, will appear to be exceptionally high. Such is the case with shrivelled kernels and some of the early lines of triticale in which the proportion of shrivelled kernels was high showed protein figures in excess of 17%. As the kernel characteristics have been improved and the endosperm size increased, the protein expressed as a percent of dry matter tended to decrease and the percentage of starch to increase. It must be emphasized however, that it is the protein as percent total dry matter which is falling; the protein expressed as weight of nitrogen per individual seed remains roughly constant for any given cultivar.

It is because the kernel characteristics have improved that the average protein figures in the advance lines of triticale are of the order of 13.5% but, as indicated above, the quality of the seed and the bulk density has improved as the endosperms have been gradually filled out.

The nutritive value of cereal protein, in common with all other protein sources, is dependent upon the relative proportions of the essential amino acids each protein contains. Cereals as a class tend to be deficient in the amino acid lysine. One of the exciting features of certain of the advance triticale lines at CIMMYT is that the lysine content is significantly higher than the general average for wheat. In fact, several triticale selections have been reported with lysine contents roughly equal to those of high lysine maize. Bearing in mind that the total protein content of the triticale

lines is significantly higher than the total protein content of high lysine maize, there appears to be good reason to believe that there is a distinct opportunity of producing triticales the protein of which is equal to the best cereal proteins known.

The matter is being pursued both at CIMMYT and the University of Manitoba, the Manitoba group having been encouraged to make a thorough search for high lysine varieties among a large collection of rye varieties. Rye is in general superior to wheat in protein quality but comparatively little comprehensive research has been undertaken into the biological value of rye protein. It is hoped that superior varieties of rye can be identified for crossing into the triticales program.

6. UTILIZATION OF TRITICALE

Though the main purpose of the CIMMYT-Manitoba research effort is to breed triticales of improved agronomic characteristics, IDRC is taking a particular interest in the utilization of triticales on a world-wide scale. The scientists at CIMMYT have tested a number of triticales flours in Mexican cereal foods including tortillas and in India triticales has been tried in chapatis. As previously mentioned, the triticales proposal from India would place a significant emphasis upon a study of both agronomic characteristics and those properties which affect utilization. In Ethiopia tests are continuing using triticales in the traditional bread injera. In all of these instances the initial reports are very encouraging.

Now that the plant breeding situation is so well advanced, IDRC is making a major push in the area of utilization. As mentioned above, an international committee has been formed, in cooperation with IUFOST, to explore on an international scale the future possibilities for triticales as a supplement to other cereals in the human diet.

IDRC is supporting two studies in processing of triticale in Canadian institutions; one at the University of Manitoba concerned with the use of triticale flours in bread and one at the Prairie Regional Laboratory concerned with the processing of a variety of cereal grains and grain legumes including triticale by new techniques of milling and protein fractionation.

The results of the Manitoba research are encouraging and a paper, jointly authored by W. Bushuk and J.H. Hulse has been presented to the American Association of Cereal Chemists for publication. The paper describes a comparatively simple method in which normal fermentation in bread making is replaced by mechanical development of bread doughs which makes possible the incorporation of significant quantities of triticale flour into conventional bread.

In one series of studies it appears that triticale is amenable to protein shifting by air classification. As mentioned above, the endosperm consists of starch granules embedded in a matrix of protein. If the endosperm is very finely ground, the finest particles in the resulting flour consist of small fragments of protein. By applying a centrifugal force to this flour stream and opposing it by a controlled centripetal air drag, it is possible to separate the predominantly light from the heavier particles and thereby produce fractions high in protein. Considering the possibility of producing triticales of high protein quality it is worth exploring simple mechanical methods of protein concentration in order to provide, hopefully, high protein foods for infants and other vulnerable groups entirely from the one cereal grain. This whole matter of developing technologies designed to make the maximum use of triticale in human foods will be pursued during the next year with IDRC financing.

THE CASSAVA/SWINE PROJECT

1. CASSAVA PROGRAM

As mentioned in the Introduction and Summary to this report, the CIAT cassava program which occupied a great deal of IDRC's management input in 1972, developed to our satisfaction early in 1973. For this reason, whereas our major management involvement in 1972 was associated with the development of the policy and program in the core activities at CIAT and in the identification of appropriate Canadian collaborators, emphasis in 1973 has moved towards ensuring an effective dialogue with the Canadian component of the program and in developing third country links through the sponsorship of meetings and development of outreach activities.

By the end of 1973, CIAT was being recognized as the hub of global research on cassava. Furthermore, the workers in the cassava program, both in Canada and at CIAT, began to function as an integrated team. A very effective network, involving most workers and institutions involved with cassava, and a number of private sector and aid programs interested in this crop, has been established.

Undoubtedly, the key feature of this development was the fact that the CIAT cassava team started to deliver solid and worthwhile research results. Considering that the program only started effectively early in 1972, this represents no mean achievement.

A full report of CIAT's work progress will be presented in their Annual Report, to be published in May 1974. IDRC's report therefore will only touch on the highlights of the cassava program research.

(a) Plant Physiology

The plant physiology research has paid particular attention to the relationship between leaf area index (LAI) and yield, and has shown that after six months the LAI declines. When this happens, dry matter production increases much more slowly.

Increasing the plant population increases yields up to a plateau where high plant populations lead to a decrease in root size. This effect may have a practical application in terms of producing roots of certain size for a specific market.

Forty-four varieties were tested for yield and in an unreplicated trial, the highest yielding variety produced 66 t/ha/yr. On a larger scale, replicated plots yielded 46 t/ha/yr. These figures are considerably higher than those for average farm production in Latin America which tends to range from 5 to 15 t/ha/yr. The highest yielding types at CIAT tended to be short, with little stem. They had a high harvesting index, combined with the ability to retain a large leaf area index at six months after planting. A number of techniques have been used to study the leaf fall which takes place after six months. It was thought that this might be due to the rapid movement of minerals through the roots from the leaves but experimental work indicated that this is not the case.

Studies on daylight length and temperature have indicated that cassava produces less roots on long days. This is apparently due to a decrease in the size of root rather than in the number of roots and it appears that varieties to be grown in the more extreme latitudes of the tropics need to be carefully tested for their daylight length response.

Following the Cyanide Toxicity Workshop, the germ plasm collection was screened for cyanide level. It was much easier to do this using leaves rather than roots when it was found that low leaf cyanide tended to be associated with low root cyanide. No zero cyanide plants were found but root cyanide levels ranged from 160 down to 10 parts per million. Some of the highest yielding varieties tested were low in cyanide which contradicts the traditional view that high cyanide varieties are the highest producers.

Some interesting preliminary work has been done on using cassava as a forage. Using 90 day cuttings, yields of 6 tons of dry matter with a protein content of 20% have been harvested. It is possible

that cassava has a potential use as a forage crop, however, more studies are required to determine its nutritive value before this can be confirmed.

One of the most valuable pieces of work carried out in the program so far has been the development of a system for the rapid propagation of cassava using green shoots as cuttings. Traditionally one cassava stake will provide 12 to 15 cuttings which are used as planting material. The new technique developed at CIAT enables 18,000 cuttings to be produced from one plant stake in a year under field conditions. This number can be increased if properly equipped greenhouses are available. This technique obviously has important implications in terms of the speed of diffusion of new genetic material.

(b) Breeding

The cassava breeding program began formally in 1973. The principal objective was defined as the selection of varieties with a high starch yield per unit of time, a low cyanide content, disease and insect resistance, easy harvesting and a wide adaptability. The program has the secondary objective of supplying genetic material for other cassava breeding programs elsewhere in the world and of establishing efficient breeding methods for cassava.

The work to date has concentrated upon evaluating the CIAT germ plasm collection, which contains about 2,700 clones of cultivated cassava from eight Latin American countries. A significant part of the collection was destroyed because of the presence of diseases and at the end of the year, the total number of entries was 2,129. The collection is particularly deficient in Brazilian material. Although a rich selection of material exists in that country, current quarantine regulations make it difficult to increase the genetic base in Colombia.

Great genetic variation appears to exist in root yield and in harvesting index at six months and there are a number of entries which appear capable of out-producing what CIAT has previously considered as their best two varieties. A number of practical problems were identified in working with such a large mass of

material and some progress has been made in defining experimental methodology for working with a collection as large as that at CIAT. In particular, the effects of inter-genotypic competition have been looked at in some depth and it has been established that there is a significant competitive interaction between yield at six and at twelve months so that the best types at the earlier time are not necessarily the best several months later.

Further work on experimental design has indicated that field experiments utilizing randomized complete blocks should contain at least six duplicates and that the harvested area should be surrounded by at least two border rows on all sides to avoid interactions.

Preliminary work on hybridization has started and about 8,000 F_1 seeds out of some 500 different cross combinations were produced by artificial pollination of female flowers. There was a considerable variation in seed fertility and later work has therefore been carried out using partially covered pollination in which the female flowers are first artificially pollinated and then left open for natural pollination. At present, about 4,000 seedlings, half of controlled pollination and the rest from open pollination, are growing in the field and a method of establishing pedigree selection is being pursued.

(c) Pathology

Studies on cassava bacterial blight (CBB) were directed toward the etiology of the casual agent in Africa and America and studies on the dissemination, survival, control and estimation of losses due to the American disease were also carried out. The results of this work have been published in a bulletin produced by CIAT. Probably the most important aspect of the work was the demonstration that the use of infected cuttings is largely responsible for the propagation of the disease. By rooting shoot tips it has proved possible to produce bacteria free material which could provide the basis for a cassava seed certification program. If this is used, in conjunction with the techniques developed at CIAT to eradicate

bacterial blight from infected plantations, it should be possible to reduce considerably varietal differences in susceptibility to CBB. The germ plasm collection is being examined for this characteristic.

Work has also been carried out on *Phyllosticta* leaf spot and superelongation disease. The latter is a relatively new condition about which little is known but, once again, varietal resistance has been encountered in the CIAT collection. Three types of leaf spot have been encountered in cassava at CIAT and this condition sometimes causes considerable reduction in yield. Work to date is concentrated on identifying the causal organism which has been shown to be a fungus. Future work is planned to assess varietal resistance.

For the first time, global information on cassava diseases, including the less important ones, is being brought together for a CIAT publication.

The pathology program has studied the effects of various treatments on cassava cuttings, in order to reduce the disease risk when these are used as seed material. It was shown that hot water and microwave treatment seriously reduced germination but ultraviolet light for seven hours did not. The ultraviolet light had a limited impact on some of the diseases whose control was being attempted but from the practical standpoint, none of these techniques appeared to be effective.

(d) Entomology

Traditionally, cassava was reputed to be fairly free from insect problems. However, when its cultivation is carried out at an intensive level, it does appear that a number of organisms and insects have the potential to reduce yields and quality of planting material. During the year an entomology program on cassava was begun. The most important insect pests appear to be thrips and spidermites. Both of these can be controlled by the use of chemicals or by the production of resistant varieties and work to date indicates that 29% of the germ plasm bank contains substantial resistance to thrips. This resistance appears

to be associated with the hairiness of the leaflets when they are still folded, since the thrips live in growing points.

Several species of spidermites attack cassava in the dry season. Thirteen cultivars from the germ plasm collection have been evaluated for mite resistance. So far, none of them have been found to be totally resistant. However, in about one third of the varieties the mite damage was very small. An interesting observation was the correlation between mite damage and cyanide level, which indicated that plants with the highest cyanide levels were damaged most by the mites.

A number of other insect pests of cassava have been studied, but none of them appeared to be as important as thrips and mites.

(e) Weed Control

The cassava weed control program at CIAT continued to evaluate the competitive effects of weeds in cassava and to develop safer herbicide systems for chemical weed control. An experiment on the critical period of weed competition, referred to in the CIAT 1972 Annual Report, was completed and the results showed that serious losses occurred when weeding operations were not performed at the right time. The degree of weed competition was affected by crop density and weed population. Studies are being carried out on the interaction of plant spacing and the weed control system. Preliminary results show two findings: (1) varietal differences, and (2) that 12 months after planting, cassava plots that had been weeded at 30 days or at 30 and 60 days after planting yielded more at higher than at lower population densities. In some weedy plots the cassava made a notable recovery after 12 months and this may be the reason why harvesting is delayed beyond the 12 month period in some parts of the world where early weed competition may delay cassava root production.

Herbicide research has shown that some common herbicides can cause severe injury to the cassava plant. It appears that this risk is greater if the herbicides are allowed to come into contact

with the growing shoot; thus, by directing the herbicide to the base of the plant, the risk of injury is much less, particularly in very young plants. However, even when the plant appears to be severely damaged by an herbicide, it seems to have a tremendous recovery potential and the effects of herbicide damage on yield may be less severe than one might expect from the initial appearance of the plant. It does appear that herbicides are capable of considerably reducing the cost of cassava production, although at the same time, their use substantially reduces the employment opportunities presented by the weeding.

(f) Post-Harvest Storage

An important finding of the cassava program during the course of the year was that post-harvest deterioration in cassava roots can be considerably retarded, up to a period of three to four months, by storing fresh roots in European-type potato clamps. Further work on this storage technique is necessary to improve ventilation in hot regions and drainage in wet ones. Roots stored for three months in these clamps passed local freshness tests, however, the roots in the clamp do undergo some biochemical changes in which the starch is broken down to sugar. This sweetening does not appear to be of importance if the roots are to be used for human or animal feed, but it is obviously of significance if the roots are being produced for industrial starch.

It has been observed that after storage in the clamps, the shelf life of the roots is much longer than that of freshly harvested roots. This raises the possibility that it may be advantageous to temporarily store roots in clamps in order to cure them, prior to storing them in a simple building, in boxes, rather than leaving them in the ground for a longer period.

Work has been carried out to study the improvements that may be made in present cassava chip drying methods by changing both particle form and size and drying systems under different

climatic conditions. The most rapid, simple-drying system identified has a chip form with a small section and high porosity and uses vertical trays. It was found that at least 50% of the initial moisture must be lost within 24 hours if the product were not to be spoiled. Calculations have been made to relate this finding to a practical shape in terms of different climatic conditions.

(g) Production Economics

The economics program on cassava has made a study on labor use of 300 Colombian producers scattered throughout the country. It was found that the labor needed to produce a ton of cassava was about 7 man-days if machines were used for land preparation, and 9.6 man-days if the land was prepared manually. This labor requirement, although in line with that reported from Northeast Brazil, is somewhat less than that required in Jamaica. The major labor activity was found to be weeding, followed by harvesting and land preparation.

A second major focus in the economics program was an agro-economic description of the cassava production process in Colombia. The overall objective was to make information available to support decision making on the allocation of resources in research, extension, production and public policy, with respect to cassava. The cassava study involves 300 cassava producers from five different areas and each producer is visited three times during the growing season by a team of agronomists and economists. This team is describing the technological characteristics of the production process, including an estimation of the quantity and quality of the production factors used and their cost. It is also identifying the varieties presently grown and is tabulating the biological factors limiting yields, such as specific diseases and insect pests. The economic data should enable total and net returns to the producers to be determined. At the end of the year a report was published relating to the first visits to 120 producers. This initial information has provided some useful data on the incidence of various diseases and insect pests,

and this should provide a base on which to assess the possible economic benefits from both the pathology and entomology research programs.

2. SWINE PROGRAM

(a) Nutrition

Major emphasis in the swine program at CIAT has continued to be in the nutrition field. As in previous years, a number of experiments have been carried out with cassava. Particular emphasis has been given to studying the role of cyanide. It has been found that a major cause of retardation in the growth of pigs on rations rich in cassava, containing a high level of cyanide, is due to the reduced level of feed intake. Cyanide also utilizes essential amino acids such as methionine for detoxification. This induces a methionine shortage which, unless the ration is compensated, results in lower weight gains. A number of experiments have provided quantitative data relating to cyanide levels. Attempts to reproduce the thyroid changes seen in man in Zaire and attributed to high cassava diets, have proven unsuccessful in laboratory rats.

During the year, work was carried out using yams as an animal feed component. It appeared that raw yams contained an anti-digestive factor which led to gastrointestinal disorders. The effect of this was much less when the yams were cooked. Yam-soybean meal combinations supported growth equal to that of corn-soybean diets in rats, but the efficiency of feed conversion was much less and it is suggested that this is also attributable to the presence of an antidigestive factor.

Work was continued with maize, comparing traditional types with Opaque-2. It was shown that vitreous endosperm (VI-21 maize) was significantly superior to common maize and had a nutritional quality very similar to Opaque-2. However, the vitreous endosperm maize was slightly low in lysine. It was also much less susceptible

to damage by weevils so that it may have a significant role to play both in human and animal nutrition in the tropics.

The work on cowpeas has continued and clearly shows that boiling is the preferred method of processing to destroy the antidiigestive factors present. A series of studies to measure the variety of the amino acids in cowpeas has been completed. A diet of cassava and cowpeas is not very effective. When supplemented by 0.2% methionine, performance in rats more than doubled over unsupplemented cassava-cowpea diets. A cowpea-Opaque-2 maize diet is more adequate nutritionally than cowpeas with common maize. Methionine is the first limiting amino acid in this diet whereas in cowpea and common maize diets, lysine is the limiting factor. The addition of cowpeas to a sorghum diet for rats stimulated more than a sixfold improvement in performance, although this diet was also improved when methionine was added. Cowpeas with rice were also used successfully as a rat diet. It appears from these series of studies that there is a need to identify high producing cowpea varieties which contain higher levels of methionine and, to a lesser degree, lysine.

Damaged and weevil infected beans appeared to have only about 40% of the nutritional value of sorghum and were again deficient in methionine. Studies were also carried out to develop an on-the-farm processing method for converting cottonseeds into a useful protein supplement. In general, the results were not satisfactory even when the cottonseed was treated with ferrous sulphate to bind up the toxic gossypol in the cottonseed. Where the techniques were satisfactory, they were generally too complex to be applicable at the small farm level.

(b) Animal Health

The animal health component of the swine program has worked closely with 20 large pig farms in the CIAT area with a total population of about 14,500 swine. The program has studied a

number of major diseases such as hoof and mouth disease and it appears to be developing some useful data on the economics of disease control. However, a major component of the program seems to be in the form of providing a diagnostic service and it is not very clear how this differs from national programs in providing a unique 'international' component.

(c) Small Farm Swine Production Systems

The program on swine improvement on the North Coast of Colombia working with small farmers has been continued. A number of new housing and nutrition practices have been introduced and it appears that the quality of the swine on the participating farms has improved considerably. However, none of the input to this program appears to have been economically evaluated and some of the CIAT economists have doubts regarding the economic and developmental merit of this type of approach. The program is now receiving an economic look from the farming system team at CIAT and a long overdue look at the relation of the swine component to the agronomic component of the 'total system' on the small farms should appear in 1974.

The doubts raised in some people's mind regarding the economic justification of the North Coast program relates directly to the Advisory Committee suggestion that IDRC should conduct an in-depth review of the swine program in the spring of 1974. Steps are in progress to bring this about and it is anticipated that not only will the research program at the central CIAT station be examined but that the North Coast program and the collaborative program with Ecuador will also be visited by a review team.

(d) Training and Outreach

During 1973 four trainees worked in the swine program and one of them, a Costa Rican, gained an MSc. from the University of Florida. By the beginning of 1974 it is expected there will be six new Latin American trainees in the program.

Up to the beginning of 1973, the outreach program had been confined to Ecuador. In 1973, funds were provided by IDRC to support programs in Bolivia, Costa Rica and Nigeria which would be initiated by trainees from those countries who had studied at CIAT. Preliminary discussions are presently underway with regard to outreach programs in Peru and Guatemala.

It is IDRC's opinion that the priority thrust in the swine program should now be to develop outreach programs in other Latin American countries; to promote the CIAT philosophy with regard to research on unconventional sources of swine feed and to increase efforts to promote the acceptance in other Latin American countries of technologies that have already been developed and accepted by CIAT. Much of the research activity in the basic swine program at CIAT can now be safely left on a maintenance basis.

3. CANADIAN INSTITUTIONAL SUPPORT PROGRAMS FINANCED BY CIDA

During 1971 and 72, eleven projects totalling \$255,759 were committed from the CIDA grant of \$750,000 for Canadian institutional support.

In 1973, a further nine projects totalling \$395,795 were approved. six of these, totalling \$201,437 were actually committed as of December 31, 1973. (See Table 1).

Of the \$750,000 CIDA grant, there remains \$292,804 available for new commitments, including \$194,358 for the four projects approved but not yet committed.

(a) Tissue Culture Studies (PRL)

The first major grant for Canadian institutional support programs was to the Prairie Regional Laboratory in Saskatoon to study the propagation of cassava plants by tissue culture procedures. This project is intended to provide propagation of disease free plants, since it has been shown in other species that mosaic-type infections,

which are major problems of cassava in Africa, can be eliminated from plant material by the tissue culture process. This technique is also of interest for other reasons. Firstly, it enables the very rapid propagation of a small amount of plant material and, secondly, through the rapid propagation and the possible production of virus free material, it may be possible to facilitate the shipment of vegetative cassava material around the world. The team working on this project has developed a successful technique for propagating cassava plants from apical meristems and they are making progress also in producing plant calluses from small groups of cells.

This grant is due to terminate in mid 1974. At the Advisory Committee meeting in November 1973, it was recommended to IDRC that the grant should be extended for a further year to enable the PRL group to continue this work with particular reference being devoted to: a) ensuring that plants produced by tissue culture were genetically stable; and b) growing tissue culture material derived from plants affected with different strains of cassava mosaic from different parts of the world.

(b) Chemotaxonomic Studies (McGill University)

The first two grants to McGill University were for feasibility studies regarding the possibility of a chemotaxonomic classification of cassava. The objective was to determine whether the large collection at CIAT, which includes some 2,500 Latin American cassava cultivars, could be classified on the basis of the phenol content of the plant and whether the chemical compounds in the plants which were identified by the chromatographic analysis of dried leaf could be correlated with agronomic and disease resistance characteristics. This was an innovative high risk project and before going ahead on a large scale, it was decided to carry out a small feasibility study. The results of this feasibility study were sufficiently promising that in November 1972 the grant was amplified and extended for a year to enable a larger scale study.

The study has looked at some cassava varieties from other parts of the world in order to see how they related to the Latin American collection. By the end of 1973, over 1,000 cultivars had been looked at, including a small number from Africa and Asia. The work indicated that the CIAT collection could be classified into distinct groupings and that both African and Asian material contained chemical constituents different to those from Latin America.

The work on relating the phenolic constituents to production and disease resistance characteristics has made limited progress, largely because only in 1973 did CIAT acquire a plant breeder for the cassava program. He instituted a new and more comprehensive evaluation of the production characteristics of the CIAT material. Hence, a large supply of material for correlation studies will not become available until 1974. At the same time, the work at McGill has not covered as many of the CIAT cultivars as originally intended, partly because the Advisory Committee had some reservations earlier in the year about the technique and requested the grantee to give more emphasis to correlation studies to assess the amount of variation in the technique. When the Advisory Committee reviewed the work done, at their meeting in November 1973, they recommended that the grant should be continued through a further year in order to: a) extend the analysis of the CIAT material; b) carry out more comparative studies with the cassavas from other parts of the world; and c) enable in depth correlation studies to be carried out between the McGill groupings that are emerging from the plant breeder's classification at CIAT.

This project has received a major input from the Statistics Section in the Canada Department of Agriculture, who have worked closely with the McGill grantees in the development of complex statistical techniques for handling the large amount of data which arises from this subject.

(c) Cassava Mosaic Disease (McGill University)

In 1972 it became clear that one of the major constraints to cassava production in Africa was mosaic disease. A variety of the same disease exists in Brazil, but has not yet been detected in Colombia. For the long-run internationalization of the cassava program, it was clear that some more work would have to be done on this mosaic disease in order to overcome the concern of plant phyto-sanitary authorities regarding the transfer of material from country to country. Reference has already been made to the tissue culture program which is directly related to this issue. However, the tissue culture program faces a problem in that the causative organism of African cassava mosaic has not been positively identified.

At the IDRC sponsored Cassava Mosaic Workshop held at IITA in December 1972, top priority was given to discussion of research priorities in relation to African cassava mosaic. It was agreed that there was an immediate need to characterize the causative organism. As a result, IDRC provided a grant to McGill University's Plant Pathology Department in March 1973 to enable them to work on characterizing the causative agent. By the end of 1973 a variety of different cassava types were growing at McGill and a number of transmission and electron microscope studies were under way. The project at McGill is being carried out in close collaboration with the PRL whose work was referred to earlier. It is an exceedingly difficult area of study and a number of workers have previously failed to identify the causative organism which is believed to be virus or virus-like.

(d) Solar Drying (McGill University)

Dry cassava chips and pellets are now becoming a major commodity in international trade. The standard method of drying the fresh material in the tropics is by solar radiation. The efficiency of such drying techniques does not appear to be particularly high and during rainy weather there is considerable spoilage and loss. It is hoped that solar drying techniques can

be improved. The Brace Research Institute at McGill University expressed an interest in this field and were provided with a small grant to carry out a pilot study on solar drying of cassava. Their work had only just begun at the end of the year but results are anticipated early in 1974.

(e) Cyanide Toxicity Studies (University of Guelph)

At its first two meetings the Advisory Committee was unable to reach a satisfactory conclusion regarding the significance of cyanide toxicity in the cassava root. They were not, at that time, prepared to agree that study into this field was a priority that could usefully be supported through the Canadian institutional research part of the program. The lack of accord was not so much a disagreement on whether a study was required but rather that perhaps more knowledge of the problem should be obtained first. To this end, IDRC sponsored an international Workshop in London England in January 1973. Prior to the Workshop IDRC provided a small grant to the University of Guelph's Nutrition and Horticulture Departments to enable them to provide input to the Workshop with respect to: a) the difficult issue of evaluating various techniques of producing and measuring the toxic components from cassava; and b) determining the significance of cassava toxicity in domestic animals.

The findings of the Workshop, which have been published, suggest that a continuation of work in the chemical field is not warranted but that the animal toxicity studies justify continuation in order to establish whether toxicity is due to breakdown products of the cyanogenic glucosides themselves. This project is currently under way, but is experiencing some difficulties since it is exceedingly difficult to obtain supplies of the pure glucosides.

It is interesting to note that the Workshop indicated that animal toxicity from cassava was of very little significance since animals are usually fed on the commodity for only a limited period.

On the other hand, for humans consuming large quantities of cassava for 30 or 40 years, there were important chronic toxicity problems affecting the thyroid gland and the nervous system. Subsequent to the Workshop, IDRC's Population and Health Sciences Division provided support for a project in Zaire which will conduct research into the thyroid problems associated with high cassava diets.

(f) Cassava Micronutrient Studies (University of Guelph)

In June 1972, IDRC agreed to support a study to determine and record critical levels and symptoms caused by typical deficiencies of important macro and micro-nutrients in cassava. This is a subject on which very little information was available but it was agreed that the research could be more easily carried out in artificial soil in growth chambers in Canada, than under natural conditions in Colombia. The University of Guelph's Department of Natural Resources was therefore chosen as the site and the work was done as an MSc. thesis which was largely completed by the end of 1973. The project is producing a series of color photographs showing the effects of mineral deficiencies and toxicities in cassava and these photographs will be used in a book CIAT is producing dealing with diseases, pests, deficiencies and toxicities in the crop.

(g) Cassava Growth Studies (University of Guelph)

A small grant was given to the University of Guelph's Crop Science Department in the summer of 1972, in order to enable them to use their growth chamber and plant physiology facilities to familiarize themselves with the crop and to identify, in conjunction with CIAT, possible collaborative programs in the crop science field. This was essentially a seeding study which led to the development of a larger project at the end of 1973 for studying tuberization and photosynthesis in cassava. This is a two year project. During the first year, a senior Canadian scientist will be located at CIAT in order that the basic studies on physiology and growth which are being carried out in the climatic chambers at Guelph can be closely related to field work in Colombia. Since the project started, in the latter

part of 1973, an exceptionally strong research team has been assembled.

(h) Cassava Marketing (University of Guelph)

Another grant to the University of Guelph relates to a study of the world market prospects for cassava and cassava products. This project terminated in May 1973 with the production of a major report. In June 1973, IDRC held a Workshop in Ottawa to which were invited a number of persons prominent in the cassava import and export business, together with commodity economists from several international organizations. Over a two day period the group discussed the cassava study in some depth and suggested modifications and additions. As a result, it was decided to extend the grant to Guelph until September 1973 from funds still available from the original budget. A revised study was submitted to IDRC in September and will be released as an IDRC publication in February 1974. Both the Workshop and the publication were financed from IDRC's budget.

(i) Agro-economic Studies (University of Guelph)

One of the findings to emerge from the marketing study was the virtual absence of sound agro-economic production costings for cassava which would enable governments to have information on comparative advantages of producing the crop. This appears to be important since the marketing study showed a substantial scope for increased exports of cassava chips and pellets and a number of countries have expressed interest in entering this market. More information on production costs would also be desirable from the standpoint of identifying research priorities, since it appears that production bottlenecks differ in various parts of the world.

It is for these reasons that a further grant will be provided to the University of Guelph's Agricultural Economics Department which will enable them, over a two year period, to coordinate a collaborative agro-economic study involving agencies in Colombia, Brazil, Thailand, and Nigeria, and possibly Zaire and the Caribbean. This is expected to start in February 1974 and to terminate at the end of 1975.

(j) Microbiological Enrichment of Cassava (University of Guelph)

It has been known for some years that cassava, which is a rich source of starch, will provide a suitable substitute for the growth of micro-organisms. In August 1972, a grant was given to the University of Guelph to enable their Microbiological Department to explore the possibilities of: a) enriching cassava silage by microbiological action; and b) enriching simulated starch factory sludges with micro-organisms. Both of these objectives would be of particular interest from the standpoint of small farm production, since cassava is fed extensively to livestock but its high energy, low protein nature limits its value as a food.

The project to produce microbial protein enrichment of cassava silage has been proven unsuccessful, since it appears exceedingly difficult to identify bacteria which will multiply rapidly in the oxygen-free atmosphere of silage. This aspect of the microbiological project has therefore been closed.

The work at Guelph has been remarkably successful in identifying a microorganism which enables the protein content of cassava sludge to be raised from 2% to 15%. The process involved is particularly interesting since it takes place at a very low pH and at a temperature of about 15°C. The low pH reduces the danger of contamination by pathogenic organisms and the low temperature avoids the need for cooling, a major cost element in this type of microbiological process.

The work at Guelph began on a very small scale but has now been scaled up to use fermentors of 100 litre capacity. The Advisory Committee was sufficiently impressed by the progress being made that in November 1973 they recommended an extension of this grant, with adequate funds to enable a 600 litre fermentor to be installed at CIAT in order that swine feeding trials can be carried out where there are ample supplies of fresh cassava. Preliminary tests have shown that the product from the fermentor is non-toxic but during the first six months of 1974 these tests will be repeated and

amplified prior to commencing the large scale feeding of swine with the cassava product.

A particularly interesting feature of the microbiological study is that it involves the participation of three overseas graduate students (one on a CIDA grant) who are working for higher degrees in Canada.

(k) Liaison Officer at CIAT

During 1972, as the Canadian institutional projects built up, it appeared that CIAT was not able to provide the data and fresh material required for servicing these projects in Canada. A small grant was given to CIAT to enable them to provide a liaison officer for this purpose during 1973. It was pointed out that, as outreach programs developed, this sort of service would be needed for institutions other than those in Canada, and that CIAT would need a core budget person for this task. The grant was therefore restricted to the year 1973. From 1974 the liaison scientist is being financed from CIAT's own budget.

4. CASSAVA/SWINE PROJECTS FINANCED BY IDRC

In 1971 and 1972, IDRC allocated \$136,000 for five projects providing outreach and other research support related to the CIDA funded work. (See Table II). A further seven projects were approved in 1973 totalling \$395,000 bringing the total IDRC Cassava/Swine program support to \$531,000.

Reference has already been made to the Workshops on Cyanide Toxicity and Cassava Marketing. The proceedings of these have been published by IDRC. A further Workshop, financed by IDRC, will be held in Thailand in April 1974 and will deal with processing, drying and storage of cassava. This Workshop will bring together the findings and experiences of the work in these fields which has been carried out by CIAT, and related work in a number of Southeast Asian countries where drying, processing and storage represent major problems.

The cassava outreach program with Brazil was terminated earlier than expected since results at CIAT enabled anti-bacterial treatment research to be curtailed there. With consequent savings it was possible to bring a Nigerian PhD. student into the plant pathology program at CIAT. This establishes another link with an African country in which cassava is a dominant crop. A new cassava outreach program presented to IDRC requests support for a collaborative program in cassava agronomy and variety testing in Peru and another for a one month training course for a group of 20 Brazilians from government institutions, universities and the private sector who would study experimental methodology and interdisciplinary research at CIAT in the summer of 1974. These programs were under consideration at the end of the year.

IDRC has approved support for a microbiology program at the University of Malaysia related to the one at Guelph. This is of significance since it has been estimated that 300,000 tons of starch factory cassava waste is available for animal feeding in Malaysia at the present time. Another Asian cassava program supported by IDRC is at the University of Brawijaya in Java where, with a support component from Dutch aid, some multidisciplinary research will look at an innovative technique of cassava production.

IDRC provided 16 travel fellowships for the Third International Symposium for Tropical Root Crops at IITA in December 1973 which enabled a number of developing country root crop workers to come together with the CIAT and IITA teams as well as participate in a post-conference seminar.

At the end of 1973 IDRC also had under consideration a project proposal for biological control of cassava mites to be carried out at the West Indies station of the Commonwealth Institute of Biological Control. The mite in question had been accidentally introduced from South America to Uganda two or three years ago. The mite appears to be controlled by natural predators in Latin America and the Caribbean.

In the absence of these predators, it appears to be causing major losses to the cassava industry in Uganda and to be spreading rapidly across Africa. The grant will enable the Commonwealth Institute of Biological Control to identify natural parasites of the mite in the Caribbean region and to supply these to Uganda where their behaviour will be evaluated as a possible control measure for the disease.

In last year's report, reference was made to the support being given to CIAT for the training of swine specialists from other Latin American countries, as a means of transferring CIAT's results into national programs elsewhere in the region. This support was amplified in September 1973 when IDRC granted CIAT a further \$195,000 for a three year extension of this program. This extension will enable persons from Costa Rica and Bolivia trained at CIAT to establish their own programs in their own countries after they return from Colombia. It will also enable two Nigerian PhD. students from the University of Ibadan to undergo a period of training at CIAT and it will finance their research projects based on this training when they return to Nigeria to complete their theses. A major component of the grant will provide for a swine outreach specialist to work with CIAT for two years in guiding and coordinating the activities of trainees in developing national programs when they return to their own countries and in identifying other potential outreach support centres in Latin America.

TABLE 1 Cassava/Swine Projects financed by CIDA as of 31 December 1973

Project Title	Amount Committed	Date Committed	Estimated Completion Date
Cassava/Swine Research (CIAT) SUB TOTAL	\$2,500,000	Sept. 1/72	Sept. 1/76
Preliminary Studies (McGill)	3,000	Dec. 31/71	Completed
Cassava Classification Feasibility (McGill)	9,890	June 6/72	Completed
Cassava Chemotaxonomic Classification (McGill)	44,624	Nov. 15/72	Completed
Exploratory Research in Cassava (Guelph)	5,000	Jan. 13/72	Completed
Microbiology Studies (Guelph)	82,114	July 26/72	June 30/74
Marketing Study (Guelph)	39,169	July 26/72	Completed
Micronutrient Study (Guelph)	10,170	June 26/72	June 30/74
Cassava Growth Response (Guelph)	8,310	July 26/72	Completed
Cyanogenic Glycocides (Guelph)	7,682	July 26/72	Completed
Plant Development of Cassava (PRL)	35,800	June 26/72	June 30/74
Liaison Officer (CIAT) SUB TOTAL	255,759 10,000	Nov. 15/72	Completed
Cassava Mosaic Study (McGill)	94,234	June 12/73	Dec. 31/76
Linamarin Study (Guelph)	18,054	Aug. 2/73	June 30/75
Marketing Consultancy (Phillips)	2,829*	July 19/73	Terminated
Growth Physiology of Cassava	38,152	Sept. 7/73	June 30/75
Solar Drying (McGill)	4,353	Sept. 13/73	Jan. 13/74
Growth Physiology Study (CIAT) SUB TOTAL	201,437 43,815	Nov. 20/73	Dec. 31/74
Virus-Free Cassava (PRL)	32,000**		
Cassava Chemotaxonomic Classification (McGill)	27,858**		
Cassava Production (Guelph)	65,000**		
Cassava Microbiology (Guelph) SUB TOTAL	194,358 69,500**		

* The amount shown is the amount committed less the funds left unspent.

**Approved but not yet committed

GRAND TOTAL \$3,151,554

TABLE II Cassava/Swine Projects financed by IDRC as of 31 December 1973

Project Title	Amount Approved	Date Approved	Estimated Date of Completion
CIAT Outreach Program - Phase I	82,000	Sept. 19/71	Completed
Root Crops Symposium (Nigeria)	30,000	June 24/72	Completed
Cassava/Swine Advisory Committee	6,800	June 8/72	Completed
Cassava Mosaic Workshop (Nigeria)	5,673	Oct. 13/72	Terminated
Cassava Toxicity Workshop (England)	11,503	Oct. 19/72	Terminated
SUB TOTAL 135,976			
Cassava Production in India (Hone)	558*	Jan. 10/73	Terminated
Cassava Marketing Workshop (Ottawa)	8,951*	May 22/73	Terminated
Cassava/Swine Advisory Committee	10,500	Apr. 18/73	Early 1974
Microbiological Enrichment (Malaysia)	86,700	June 4/73	Aug. 22/76
CIAT Swine Outreach - Phase II	195,000	Sept. 20/73	Dec. 18/76
Cassava (Indonesia)	90,000	Sept. 20/73	Nov. 15/76
Cassava Processing Technology (Manurung)	3,125	Nov. 28/73	Completed
SUB TOTAL 394,834			
* The amount shown is the amount committed less the funds left unspent			
GRAND TOTAL <u>\$530,810</u>			

TABLE III Triticale Projects Financed by CIDA as of 31 December 1973

Project Title	Amount Committed	Date Committed	Estimated Completion Date
Triticale Research CIMMYT	\$2,500,000	Sept. 1/71	Sept. 1/76
Triticale Research (Manitoba)	500,000	Sept. 15/71	Sept. 15/76
Kernel Shrivelling (Manitoba)	50,000	Sept. 16/72	Sept. 16/75
Biological Evaluation (Bio Research Lab)	1,250*	C/A ^(a)	Terminated
Spring Rye (Manitoba)	64,000**		
Winter Triticale (Guelph)	133,800**		

* The amount shown is the amount committed less the funds left unspent

(a) All funds were administered by IDRC

** Approved but not yet committed

TABLE IV Triticale Projects Financed by IDRC as of 31 December 1973

Project Title	Amount Approved	Date Approved	Estimated Completion Date
Bread from Composite Flours (Manitoba)	\$ 20,000	May 3/71	Completed
Triticale Advisory Committee	13,500	June 8/72	Completed
Triticale Outreach (Ethiopia)	82,290	June 24/72	Aug. 16/76
Triticale Bibliography	27,000	Sept. /72	Completed
Triticale Workshop (CIMMYT)	26,500	June 11/73	Completed
Triticale Advisory Committee (Mexico)	5,330	Aug. 23/73	Completed
Triticale (Algeria)	35,400*	Sept. 20/73	
Winter Triticale (Guelph)	15,000**		
Triticale (India)	240,000**		
Triticale (Chile)	91,300**		
Triticale (Kenya)	82,500**		

***Not yet committed**

**** Proposed for 1974**

Summary of Cassava/Swine and Triticale Projects
 TABLE V Financed by CIDA as of 31 December 1973

	<u>Cassava/Swine Program</u>		<u>Triticale Program</u>		<u>Total</u>
	<u>CIAT</u> \$000	<u>Canadian Institutions</u> \$000	<u>CIMMYT</u> \$000	<u>Canadian Institutions</u> \$000	
Total approved allocation	2,500	750	2,500	750	6,500
Total commitments	<u>2,500</u>	<u>485</u>	<u>2,500</u>	<u>749</u>	<u>6,234</u>
Balance available for commitment	<u>-</u>	<u>265</u>	<u>-</u>	<u>1</u>	<u>266</u>
<u>Cash Flow</u>					
1971 actual	150	-	210	42	402
1972 actual	275	137	135	115	662
1973 actual	500	167	235	125	1,027
1974 estimated	750	114	549	177	1,590
1975 estimated	800	52	526	185	1,563
1976 estimated	-	15	280	104	399
	<u>2,475</u>	<u>485</u>	<u>1,935</u>	<u>748</u>	<u>5,643</u>

IDRC ADVISORY COMMITTEE ON TRITICALE RESEARCH

FOURTH MEETING - OCTOBER 5, 1973

CIMMYT - EL BATAN, MEXICO

IN ATTENDANCE

Members of the Advisory Committee:

- | | | | |
|----|---------------------|---|----------------------------|
| a) | Dr. K. W. Finlay | - | CIMMYT |
| b) | Dr. F. J. Zillinsky | - | CIMMYT |
| c) | Dr. E. Larter | - | University of Manitoba |
| d) | Dr. M. McLaughlan | - | Health & Welfare Canada |
| e) | Dr. J. W. Morrison | - | Agriculture Canada |
| f) | Dr. H. A. Steppler | - | Macdonald College and CIDA |
| g) | Mr. J. H. Hulse | - | IDRC |
| h) | Mr. G. R. Bourrier | - | IDRC |

Invited Observers

- | | | | |
|----|--------------------|---|------------------------|
| a) | Dr. R. D. Hill | - | University of Manitoba |
| b) | Dr. P.J. Kaltsikes | - | University of Manitoba |
| c) | Dr. P. Gustafson | - | University of Manitoba |
| d) | Dr. G. Anderson | - | CIMMYT |
| e) | Dr. G. Dion | - | CIDA |

1. CHAIRMAN'S INTRODUCTION

- 1.1 In his opening remarks the Chairman conveyed Dr. Doggett's regrets at being unable to attend this meeting. He pointed out that Dr. Doggett is now living at ICRISAT where he is helping to set up the cereals program. Another plant scientist will be appointed to assist Dr. Doggett and will maintain a close interest in triticales.
- 1.2 The Chairman suggested and it was agreed that the agenda Item 4 be reversed with Item 5.
- 1.3 On the recommendation of one of the committee members, the Chairman proposed and it was agreed that invited observers attend during discussion of agenda Items 1, 2 and 3 and that Items 4 to 8 be restricted to members of the Advisory Committee. /
- 1.4 The Chairman welcomed Dr. J. M. McLaughlan of Health and Welfare Canada who replaces Dr. J. A. Campbell on the Advisory Committee. Dr. Campbell is now employed with the Caribbean Food and Nutrition Institute in Jamaica.
- 1.5 On behalf of the other members of the Advisory Committee and IDRC, the Chairman congratulated and thanked the CIMMYT representatives for the excellent arrangements made for the International Triticale Workshop. The Workshop had provided a comprehensive review of progress in triticales research and adaptation and, therefore the Advisory Committee probably would not need to spend so much of its time in a review of technical progress..

2... REVIEW OF MINUTES OF LAST MEETING:

- 2.1 The Chairman proposed and it was agreed, that items arising from the minutes of the Third Meeting, held in August 1972 at Manitoba, could best be dealt with later. It was moved by Finlay and seconded by Steppler that the minutes be accepted as circulated.

3. PROGRESS REPORTS:

- 3.1 The Chairman commended both CIMMYT and the University upon the clarity and detail of their reports. Taken together they present an encouraging account of progress and give cause for considerable degree of future optimism.

a) CIMMYT

- 3.2 Dr. Finlay proposed that, in view of the detailed presentations made by CIMMYT staff during the International Triticale Symposium, the detailed contents of Research Bulletin No. 24, and the demonstrations provided during the group's tour on 4 October, that the CIMMYT report be tabled as circulated and that no formal presentation be made. This was agreed.

- 3.3 During the ensuing discussion, Dr. SteppTer raised and questioned CIMMYT's continuing use of the vole since this matter arose in the minutes of the last meeting and since only CIMMYT appear to be still employing the vole.

3.4 Dr. Finlay replied by asking whether evaluations of early generations by test animals are really necessary, or can early lines be screened by chemical analyses for protein and lysine. He stated that CIMMYT is currently undertaking an in depth in-house review of its screening methods and one of the matters to be decided is whether vole assays should be continued.

3.5 Dr. Anderson stated that several of the voles had rejected some of the newer maize lines. CIMMYT staff were therefore considering dividing the voles into (a) "high accepters" (of maize) and "low accepters" and (b) those showing a high rate of weight gain versus a low rate of weight gain.

3.6 The purpose of such a segregation was questioned by several members in view of the strong evidence that the vole is not suitable for selecting between cereal grains of high and low biological value. Furthermore, if CIMMYT base their selection decisions upon vole assay, it is unlikely that their results, relating to biological evaluation, will be accepted by the international community of human and animal nutritionists. Vole assay could therefore prove detrimental to the acceptance of triticales, in spite of the fact that it is a grain of superior biological value when evaluated by generally accepted methodologies.

3.7 Dr. Anderson suggested that in-bred lines of rats do not accurately represent the variability in nutritional response which appears among different humans.

3.8 Dr. McLaughlan and the Chairman pointed out that the biological test is intended to rank the triticales cultivars in order of the biological quality of their proteins. There was sufficient evidence with in-bred rats to indicate good correlation between ranking of proteins by rat growth and nitrogen retention assays and human response. Voles, on the other hand, as shown by Dr. McDonald's results, did not rank cereal proteins in the same order as do human subjects - the voles rated almost all cereals as superior to casein, in addition to which the standard error with the voles (greater than 50% of the means) made it impossible to draw any reliable conclusions concerning the biological ranking of the proteins tested.

3.9 In reply to a question, Dr. Zillinsky stated that all CIMMYT lines that enter yield tests, and all entries in the crossing block are analysed for protein and lysine, and at present CIMMYT does not discard high yielding lines purely as a result of a chemical analysis. Dr. Dion suggested that CIMMYT continue its chemical analyses but that it sub-contract its bio-assays to some other agency. Dr. Finlay stated this course of action is under consideration. He said he felt that the vole assays had introduced some red herrings into the picture particularly when it was suggested that the lack of correlation between the vole assay and chemical analysis was attributable to resorcinol derivatives and possibly other anti-nutrients.

3.10 Dr. Zillinsky asked if a rat assay should be used where the grain is intended in animal feeds. Mr. MacLaughlan replied that, where intended for animal feed, the triticales should be tested on the animal for which it is intended.

3.11 The Chairman said he hoped some of the earlier work on hog and poultry feeds would be repeated under more carefully controlled conditions and using advanced triticales generations.

3.12 Dr. Zillinsky said CIMMYT is planning hog and poultry trials in Mexico and Dr. Larter agreed that the hog feeding research at Manitoba reported in the 1960s certainly needed to be repeated.

3.13 Dr. MacLaughlan, in response to Dr. Finlay's earlier question, recommended that screening of early generations be restricted to

- (a) total protein nitrogen by micro-Kjeldahl
- (b) lysine by autoanalyser or ion-exchange chromatography,
- (c) limiting amino acid by Chemical Score; and,
- (d) a Net Protein Ratio using a small number of rats over a ten-day period. (To be undertaken only where sufficient sample is available).

3.14 Specific recommendations by Drs. MacLaughlan and Campbell will appear in an IDRC publication which deals with the biological value of triticales. This publication will be circulated to members of the committee before the end of the year.

3.15 The Chairman sympathised with the plant breeders in their need for rapid, economical and reliable methods of screening. He stated that IDRC has persuaded the United Nations Protein Advisory Group (PAG) and the International Unions of Pure and Applied Chemistry and Nutrition Sciences to form a working group to recommend acceptable methods for cereal and food legume breeders. It has been suggested that one of the PAG's first meetings be held at CIMMYT in order to brief the analysts and nutritionists upon the precise nature and extent of the selection problem.

3.16 Dr. Zillinsky asked Dr. MacLaughlan what degree of error in selection might result from a total reliance on chemical assays for early generations. Dr. MacLaughlan stated he would estimate that a chemical analysis of protein and lysine would rank the samples correctly in 9 out of 10 instances and that even the tenth case would not likely be wildly abnormal. He did urge, however, that a biological evaluation as described in the IDRC publication be used as a final check of advanced lines.

3.17 It appeared as the Advisory Committee's consensus that reliance upon the vole be immediately discontinued. Dr. Finlay took the Committee's recommendations under advisement and promised an early decision within CIMMYT. He said he felt the discussions had been helpful to CIMMYT.

ITE: Subsequent to the meeting, Dr. Finlay advised the secretary that CIMMYT has decided to discontinue its vole laboratory. In future, CIMMYT will rely on chemical testing in the early stages of selection for protein quality.

b) University of Manitoba

3.18 Dr. Larter then presented his progress report on the University of Manitoba component of the triticales program. He made specific reference to advances and progress made relating to seed type and yield. In this regard he pointed out that 60% of the advanced lines (F6&F7) were yielding better than Rosner and that 60 lines will go into the International Triticale Screening Nursery (ITSN) as Manitoba's first input into the outreach program. Additionally, two to four lines will go into the International Triticale Yield Nursery (ITYN) this year. He further pointed out that all lines submitted for the international program are day length insensitive. Sufficient F2 material to plant 6 hectares has been sent to N'joro, Kenya this year and in the opinion of Dr. Wobwota of Kenya, some of this material is ready to go out to farmers.

Dr. Larter pointed out that the University of Manitoba is looking at additional testing sites and in particular the Teuly Lake station of the University of California. Additionally, he feels that some testing should be done under drought stress conditions in order to broaden the adaptability range of triticales and in particular suggested that Swift Current should be used as it is one of the few areas within the University of Manitoba's reach which has the characteristics required for drought resistance testing. Dr. Larter also said that Manitoba is putting emphasis on breeding for ergot resistance, though there was some difficulty in the past in isolating strains with genetically controlled resistance to ergot. Now several tetraploid and hexaploid wheats with inheritable resistance to ergot have been identified.

The more fertile Armadillo progeny also show a higher resistance to ergot. They have identified 600 embryos which display significant ergot resistance.

3.19 | Dr. Kaltsikes, the cytogeneticist working on the Triticale project at the University of Manitoba, spoke to his written report. He stated that seed shrivelling is one of several aspects of cytogenetics being studied. He described several major differences among lines which show shrivelling. For example many of those prone to shrivelling appear to develop their endosperms most rapidly. The origin of shrivelling revolves around the aneuploidy of triticale. They are also examining alpha-amylase distribution in the grain. Alpha-amylase moves from the pericarp and produces pockets in the endosperm. He suggested that better seed types might be developed if triticale was grown at lower temperatures.

3.20 Dr. Hill then spoke to his report on the biochemistry of kernel shrivelling. He pointed out that this project was scheduled to start in January of 1973, but due to visa difficulties encountered by the PDF selected to work on the project, a five month delay occurred.

3.21 He then reported that shrivelling may be due to premature germination in triticale. In studying the location of alpha-amylase activity, he noted that there is higher alpha-amylase activity in the pericarp of shrivelled seeds than non shrivelled seeds. The level of alpha-amylase is not as high in the aleurone and endosperm in more advanced less shrivelled lines. He is now studying the influence of rye chromomomes upon alpha-amalyse and seed characteristics. They have looked at the levels of

free aspartic and glutamic acids but found no significant difference between triticales and the rye and wheat parents. They are also determining (by GLC) gibberellic acid during seed development in shrivelling and non-shrivelling types. G A appears to influence the signal sent to the aleurone layer to stimulate alpha-amylase activity immediately prior to germination. They are examining the alpha-amylase isozymes, those which appear to be involved in germination and those which relate to carbohydrate conversion.

3.22 Dr. Larter stated that one of the PDF's at Manitoba was attempting to identify the chromosomes which influence kernel shrivelling. So far, he has indicated that there are at least three types of chromosomes involved.

3.23 In the ensuing discussion that followed these reports, Dr. Steppler surmised that there are at least two kinds of shrivelling:
(a) a shrivelled endosperm (b) a shrivelled pericarp around a plump endosperm. He questioned the objectives of the kernel shrivelling research and wondered whether CIMMYT may be trying to produce a "wheat like" kernel. He questioned the significance of trying to produce a seed with a non shrivelled pericarp when the most important consideration is to produce a seed with a plump endosperm and a high nutritional value. Dr. Anderson replied that developing countries also identify quality with well developed kernels and will reject cereals which consistently display a shrivelled appearance. Dr. Finlay asked what are the chances of selecting for plump grain with a high alpha-amalyse activity. Dr. Hill

replied that it is unlikely that high alpha-amylase will be combined with plumpness but that plumpness could be combined with good malting characteristics. After 30 days, shrivelled varieties begin to lose water and the pericarp begins to collapse.

3.24 | Dr. Zillinsky then mentioned that in his opinion progress on overcoming seed shrivelling will not come about as fast as expected. He questioned what help the plant breeder can get from the cytogeneticists and the biochemists.

3.25 | Dr. Anderson recommended attention be given to the properties of the starch component of triticales endosperms. Crystalline starch is more resistant to insect attack. Therefore a plump grain with a crystalline starch endosperm is likely to be most attractive in many tropical countries.

3.26 | Dr. Larter stated that while much more cytogenetic and biochemical research is needed, the Manitoba scientists are beginning to see some concrete relations. Dr. Steppeler supported the continuation of the Manitoba program stating that even if the understanding of shrivelling comes after the plant breeder has practically eliminated shrivelling, the work will not have been in vain. Dr. Dion felt that the options in the program should be kept open. Triticale may have many different end uses in different countries. Dr. Anderson stated that to produce a full satisfactory kernel in combination with other desirable qualities may take a long time and the Committee should not become impatient. Dr. Morrison reemphasised his concern with the ergot problem and questioned whether Manitoba has really found true varietal resistance to

ergot. He recommended that Manitoba examine Dr. Jack Fisher's results on long-spiked heads. Dr. Finlay considered that the progress in improving kernel quality had been phenomenal and that we should not shift focus in the program every year.

3.27 / It was generally agreed that though little tangible progress has been made to date in basic research such as biochemistry and cytogenetics of seed shrivelling, such basic research should continue along with the current extensive applied research programs. Meanwhile, the breeders will continue to attempt to solve the seed shrivelling problem.

3.28 Dr. Hill concluded the discussion on this subject by stating that his goal is to get sufficient information about the biochemistry of seed shrivelling to give practical prediction tests which will help the plant breeder in solving the kernel shrivelling problem.

3.29 The University of Manitoba and CIMMYT reports were accepted by the Committee and recommended for approval by IDRC.

3.30 During the general discussion on the CIMMYT and University of Manitoba progress reports, Dr. Steppler again raised the question about the techniques of measuring progress in triticale research. He suggested that the following criteria might be considered in measuring progress:

- a) rate at which material moves into different ecological zones;
- b) degree of adaptability to different climatic conditions;
- c) tolerance to extremes, for example, of drought;
- d) response to agronomic inputs; and,
- e) nutritional characteristics.

He stated that we will not exploit triticales to the fullest if we simply compare it with wheat. We must seek new criteria for evaluation.

3.31 Dr. Stepler raised the subject (Item 6.11 of previous minutes) of the suggested involvement of the Canada Department of agriculture (CDA) in a "Research project to improve the plumpness and density of triticales seed". The Chairman reminded the Committee that, as they had individually been informed some time ago, the project proposed was not implemented because of administrative difficulties within CDA.

3.32 Some discussion ensued concerning the separation of triticales seeds according to kernel characteristics using new techniques, some of which employ media of different densities. Dr. Larter reported that, for all practical purposes, the University of Manitoba finds a modified gravity table quite satisfactory. Dr. Zillinsky stated that CIMMYT was unable to procure the organic liquids of varying densities prescribed by CDA. As an alternative they prepared and tested inorganic salt solutions of different densities. Possibly because of interactions between the dissolved salts and the triticales seeds, these did not prove satisfactory. Dr. Stepler described briefly a gravity separator developed at the University of Oregon which is commercially available and appears potentially useful. In response to questions he agreed to send the relevant literature to both CIMMYT and Manitoba. The Oregon vibrator is claimed to effect a satisfactory separation using small quantities of seed.

- 3.33 Dr. Steppler raised the question of his original suggestion that Drs. Burrows and Fisher be involved in studies relating to seed separation. Dr. Morrison pointed out that both Burrows and Fisher are fully committed and their time is fully occupied with their responsibilities to CDA.
- 3.34 It was agreed by the Committee that CIMMYT and Manitoba would examine the utility of the Oregon gravity separator and if it was considered necessary by either cooperating agency to seek the advice of Drs. Burrows and/or Fisher, they could do so.
- 3.35 The Chairman requested that some discussion be directed to drought tolerance in triticales. He noted that in Table 2 (page 5) of the CIMMYT report to the Committee, thirty of the countries listed were involved in the 5th ITSN(Dryland) trials. The Chairman asked what range of precipitation was included under "Dryland". Dr. Anderson replied that "Dryland" meant "rainfed" as distinct from "irrigated" and included virtually every known condition of rainfall from zero precipitation to "drowned". Selection is made between those lines which respond best to irrigation and those which perform well under rainfed conditions. One important criteria is resistance to lodging. Drought tolerance is identified in bulk F2 populations grown in the ITYN.
- 3.36 Dr. Steppler expressed reservations at using the Toluca station as a selection site since this station cannot be used for selecting for adaptability to irrigated versus dryland types. Dr. Anderson then pointed out that in order to bring out all of the potential

characteristics of triticales, an ideal environment had to be used and this is the function of the Toluca site. Once the grain's total potential is developed, it is then exposed to different stress situations in the ITSN where selection for various characteristics including drought resistance is done.

3.37 | The Chairman referred briefly to a workshop on drought tolerance convened by IDRC. Though the group which had met was concerned mostly with millets and sorghums it is hoped that, consistent with IDRC's policy of financing fundamental research in Canadian universities in support of the applied research it finances outside Canada, it hopes to encourage a Canadian research initiative in drought tolerance in cereal grains.

3.38 | As a general question, the Chairman asked how much regular liaison takes place between CIMMYT and Manitoba in matters relating to fundamental research including cytogenetics, biochemistry etc. as distinct from the well established liaison between the breeders at the two institutions. It was strongly urged that a close working liaison among the different disciplines involved could prove valuable to the project as a whole.

4. PROGRAM OF WORK AND BUDGET 1974

a) CIMMYT

4.1 Dr. Finlay reported that CIMMYT intend to employ a pathologist to work full time on the disease problem. Additionally, Dr. McMahon a new addition to the team, is now starting agronomic research. Additional attention will be placed on getting more material out to the ITSN and

the ITYN in order to determine how triticales performs under a wide range of climatic and geographic conditions. The program will also be expanded into countries where wheat is not grown.

4.2 Regarding the extent of work being done on winter triticales, it was mentioned that CIMMYT is not doing any basic work in this regard other than using winter triticales as breeding material. If a program were developed, an immediate application could be found in the Near East.

4.3 Dr. Finlay then made a few statements on the budget in which he pointed out that a net five year savings of over \$500,000. is envisaged over the original projection. This, he pointed out, is due to their hiring less senior but equally qualified scientists and to the fact that the physiology and entomology work is being done on a consultancy basis rather than through full time staff.

4.4 Dr. Finlay then asked if some of the budgetary savings could be used for training additional students from the less developed countries. This suggestion was accepted in principle. However, it was recommended that a detailed breakdown of this proposal be circulated to the committee. Another area which is being considered, and which could be possible because of the latitude of the budget, is the training of trainers who could train students on site in the less developed countries. This idea was also accepted in principle, subject to the same conditions as above.

b) University of Manitoba

4.5 In his initial remarks on the 1974 program of work and budget, Dr. Larter pointed out that the budgetary heading entitled "Research Associates" refers to technicians working on the project. This designation is used due to union regulations which prohibit the term employment of technicians.

4.6 Dr. Larter then submitted two new projects for consideration by the committee. The first project relates to a modest program involving the screening of some 3,000 in-bred rye lines for high lysine characteristics. A copy of the proposal was circulated to the committee. During the discussion on this proposal it was suggested that in addition to the proposed study of rye varieties, a study of winter type triticales should also be undertaken and the University of Guelph was suggested as the most suitable for this activity. Dr. Larter was asked to visit Guelph and subsequently to draw up a new proposal to be integrated with a separate complementary proposal from the University of Guelph. These project proposals will be circulated to the Committee members for their comments and recommendations to IDRC.

4.7 A second University of Manitoba project proposal was presented by Dr. Larter on behalf of Dr. Bushuk. This proposal relates to the processing of triticale for food and feed uses. A draft proposal was circulated to Committee members during the meeting. During the discussion that ensued it was suggested that while research on utilization is considered valid within the mandate given to IDRC by CIDA, the proposal as presented

required a greater degree of detail both with regard to objectives and methodology. The Committee recommended that the proposal be carried back to Dr. Bushuk for redrafting and that it be circulated to the Committee for its comments and recommendations to IDRC.

4.8 Dr. Stepler recommended and it was agreed, that all new project proposals be circulated to the Committee membership in advance of future meetings in order to permit members to prepare themselves for a meaningful discussion. It was also recommended that all such new proposals should contain a clear statement of objectives, and methodology together with the underlying philosophy and the justification for the proposal submitted.

4.9 Dr. Larter then brought up two points: a) The University of Manitoba program is now operating at full physical capacity and facilities are taxed to the limit. He asked the opinion of the Committee regarding possible additional funding for a new building to help alleviate this problem. b) In view of the interest and wide adaptability of triticales, Dr. Larter suggested that additional work should be done on testing for drought resistance. He pointed out that Swift Current is probably the location in Western Canada best suited for these tests.

4.10 On point (a) the Chairman stated his view that the funds provided for the Triticale Project were not intended to provide capital for permanent buildings. However if a small structure is demonstrably essential to the furtherance of the project, sympathetic consideration might be given to either an inexpensive prefabricated structure or to the short-term leasing of an existing facility.

4.11 On point (b) it was suggested that Zillinsky and Larter discuss the matter of drought tolerance in greater detail and possibly together, or separately, visit overseas locations where triticales is likely to be grown under low rainfall conditions. Dr. Zillinsky pointed out that possibly 80 per cent of the triticales overseas will likely be grown under rainfed conditions.

4.12 In concluding the discussion on the Manitoba budget the Chairman pointed out that all projects approved at Manitoba, including Dr. Hill's research and any of those under consideration which are approved, should be included in the same Manitoba budget document.

4.13 The programs of work and budget were accepted by the Committee and recommended for approval by IDRC.

5. OUTREACH AND INTERNATIONAL NETWORK OF TRITICALE PRODUCTION AND UTILIZATION RESEARCH

5.1 Dr. Anderson emphasized that CIMMYT does not "sell" outreach projects. Rather, he suggested that CIMMYT responds to requests which arise out of successes achieved through the International Triticale Yield Nursery program. He pointed out that Ethiopia and India are interested and have modest research programs underway. Results obtained on acid soils at low temperatures in the India Himalayas could have a direct application to such countries as Nepal, Pakistan and Afghanistan where similar conditions are to be found. He then stated that there is a need for greater exposure to the International Triticale Yield Nursery program before Brazil and

Argentina are ready for their own projects. It was then mentioned that there is a need for the senior triticales scientists from the University of Manitoba and CIMMYT to visit different countries to determine the potential for triticales as food and feed and to encourage additional interest.

- 5.2 Dr. Anderson and Dr. Finlay emphasized that, consistent with IDRC's policy and style of operation, CIMMYT strongly favours an outreach program carried out by plant scientists in and of the developing countries. The system of sending expatriates to direct and implement triticales outreach activities is not destined to be successful. Outreach projects will only succeed when governments of the LDCs are sufficiently dedicated to the establishment of triticales as a significant crop in their countries to involve their own scientific manpower and resources. CIMMYT and Manitoba can provide training facilities and technical backstopping but the initiative, direction and major effort in growing and using triticales must rest with the developing countries.

6. BUDGET FOR OUTREACH

- 6.1 The Chairman warmly welcomed CIMMYT's definition of the outreach program. He said that IDRC is already committed to triticales projects in Ethiopia and Algeria, and expects to receive requests from Chile, Kenya, India and possibly Egypt. It is IDRC's wish to support these outreach activities in very close liaison with CIMMYT and Manitoba. IDRC's chosen role is to support applied research in the developing countries and to assist the International Agricultural Research Centres and Canadian

institutions to give technical guidance, assistance and training to scientists of the LDCs in support of their indigenous research programs. IDRC looks to CIMMYT and Manitoba for guidance and advice in the outreach projects it should support. IDRC will be glad to respond to the recommendations of CIMMYT and Manitoba as they relate to expanded outreach, training and applied research activities linked with the Triticale Project.

- 6.2 The outreach program as envisaged by CIMMYT, the University of Manitoba and IDRC was endorsed by the Committee.

7. OTHER BUSINESS

- 1 It was mentioned that there is a definite need for a triticale information system to maintain a link among the scientists throughout the world who are working on this crop. Dr. Finlay stated that triticale will be included in CIMMYT's Newsletter. The Chairman explained the cassava information network system developed at CIAT with IDRC support. It was agreed that Dr. Finlay should look at the CIAT information system to see if a similar triticale information system could usefully be developed at CIMMYT.

- 7.2 Dr. Finlay raised the subject of the three year review which was called for in the original contract. The proposed review is to indicate to CIDA what course of action should be taken following completion of the present five-year contract. Dr. Finlay indicated that CIMMYT would probably not expend all of the funds allocated. The Chairman stated that a run-over beyond the middle of 1976 was already anticipated.

The Chairman undertook to consult with CIDA concerning the proposed review and to determine, if such a review is desirable, when it should take place.

8. NEXT MEETING

8.1 The next meeting of the IDRC Triticale Advisory Committee will be held at the University of Manitoba on August 12 and 13, 1974.

8.2 The Chairman closed the meeting by expressing his thanks, on behalf of the Committee, to CIMMYT for hosting this activity.

IDRC

CASSAVA/SWINE ADVISORY COMMITTEE

Report of Third Meeting held at CIAT,
Cali, Colombia March 19-21, 1973.

Committee Members Present:

B. Nestel, (Chairman)	E. Weber, (Secretary)
H. Stepler	D.G. Coursey
F.W. Martin	W.E. Tossell
E. Wells	E. Alvarez

Advisers and Observers (from CIAT unless noted otherwise)

U.J. Grant	H. Albrecht (IITA)	J. Maner
J. Cock	A. van Schoonhoven	D. Wholey
C. Lozano	G. Roa	G. Gomez
C. McClung	P. Andersen	R. Booth (TPI)
K. Kawano	D. Leatherdale (IDRC)	F. Monge
J. Woolston (IDRC)		

1. Opening Remarks.

The Chairman welcomed Dr. Herb Albrecht, Director-General of IITA to the meeting as well as Dr. Eric Wells (acting for Dr. Ned Raun). At the same time he expressed the Committee's concern for Dr. Raun's well-being in relation to his current ailment.

The purpose of the first day's deliberations was a technical discussion and review of CIAT's work program. It was noted that this was the first time the Committee had the opportunity of reviewing a full year's research and its results and the Chairman invited CIAT staff to comment on the type of review being conducted by the Committee in terms of its usefulness to CIAT.

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Dr. U.J. Grant, Director-General of CIAT, expressed CIAT's welcome to the Committee members and especially to Dr. Albrecht who was visiting CIAT for the first time. He introduced the staff members present at the meeting, particularly those new members who had joined the cassava team during the past six months.

2. Swine Program.

Dr. Wells presented the swine program briefly and then turned the discussion over to Dr. J.M. Maner, leader of the program. Dr. Maner's presentation was based on the swine progress report prepared for CIAT's 1972 annual report. Major activities during the past year had involved the preparation of research facilities on the experimental station and the beginning of a breeding program.

Dr. Maner drew particular attention to the CIAT activities involving swine production on small farms in the North Coast of Colombia. He pointed out that 75 - 80% of the 220 million head of swine in the lowland tropics of South America are being produced by small farmers. Most of this production is at a very low level and slides were shown to illustrate pigs of 9 months or more in age which weighed no more than 15 - 20 kilos. It was felt that the potential for gain in indigenous stock needed to be exploited more thoroughly and Dr. Maner indicated that plans are under way for some experiments at the Turipana Experimental Station of ICA to determine more precisely what the range of this potential might be. He did indicate that the local, hairless types do not have the growth potential that imported stock have but are adapted ecologically to local conditions. The meat quality is poorer in these animals with a much higher fat to muscle ratio but crossing them with better imported boars could provide possibilities for some improvements. Two Duroc boars had been introduced but the results were not outstanding. Management practices are very important and it was noted that growth rates of local stock could be improved 6 to 8 times by improving management practices.

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In the interesting discussion on Dr. Maner's presentation four issues emerged. The first of these was that CIAT was pioneering studies of swine systems on small farms and this is an area that apparently needs further understanding. Secondly, it was apparent that while CIAT had made progress in developing a technology, progress in the transference of this technology was limited. It was stressed that there is a need for a social anthropology input to the program which might be provided by CIAT's forthcoming entry into a farming systems program. Thirdly, local agency (ICA) support for this program was very weak and it was questioned whether CIAT should attempt this type of program without a heavy commitment from the local agency most directly involved. Fourthly, the issue was raised as to whether CIAT should be involved in delivery systems at all.

The Committee generally commended what they considered a first attempt to carry programs all the way through to an applied approach and noted that moves in this direction were very encouraging. A learning process for all is involved in facing up to the fact that it is not only an animal problem that is being solved and CIAT scientists are being confronted with basic applied issues important to gaining a more global perspective of what needs to be done in developing new technology. At the same time a note of caution was expressed in defining what CIAT's role should actually be in the transfer process since this is a move away from tradition. While this departure is a welcome one, it was felt that CIAT must still consider how much it can do along this line and how diverse it should let its involvement become.

In summing up this part of the discussion, Dr. Nestel suggested that three points had come to the fore: 1) the Committee seemed to be in general agreement that CIAT had developed a first class program and was now in a position to disseminate some of its results beyond the confines of CIAT itself. 2) It appeared to be questionable as to how much further progress could be made in solving swine production problems without an

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integrated system involving socio-economic variables and 3) it was apparent that any major impact from the swine program needs the involvement and strong support of local institutions.

2.1 Swine Feeding Systems and Animal Health

Feeds and swine feeding systems were discussed by Drs. G. Gomez and J. Maner who reported on work with bananas, cassava, maize, cotton-seed, pigeon peas and cow peas (details of this can be found in the animal report). Initially Dr. Gomez presented the latest work on Opaque II where he drew particular attention to the more promising results being obtained by using the newest Mexican crystalline opaque. Gomez drew attention to the differences between using endosperm and whole kernel of this variety in swine rations.

Maner then reported the latest work from Ecuador on banana use and suggested that in fresh green bananas intake and protein digestability was reduced by the high tannin content so that if fresh green bananas were to be used they should be cooked or dried first. On the other hand, cooking or drying of ripe bananas (which contain much less tannins) causes a browning reaction so that ripe bananas are best used fresh.

Work on cassava in 1972 had continued and the studies of methionine supplementation and toxicity were expanded. The toxicity results presented were similar to those in Maner's paper at the London seminar. Maner also presented revised figures on the total energy and digestible energy values of cassava which were respectively 4050 and 3750 kilocalories/kg. The final part of the nutrition presentation dealt with work on grain legumes, particularly cow peas where Maner showed that there were significant differences in digestability between rats and swine. It appeared that germinated cow peas plus corn with minor additions of methionine provided an adequate ration.

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The animal health component of the swine program was then presented by Eric Wells who stressed that at the present stage, the program was largely a service one which was studying the epizootology and control of diseases in swine in the north coast project and on a group of 16 large pig farms in the Cauca valley area. The program had identified a number of parasitic worms hitherto unknown in the area and had also investigated problems of abscess formation and had established the presence of transmissible gasteritis which was probably associated with a stock importation. There appeared to be differences in disease tolerance between native and imported stock but these had not been investigated in detail. The program is not yet functioning in/delivery^{health} service activities but such action is foreseen once a better understanding has been attained of the basic structure of small farm swine production.

The outreach and training activities of the program were noted in the annual report but were not discussed in detail. Discussion did take place on the agricultural economics program which concentrated on two main aspects, one the analysis of feed trials and two, the development of an analysis of swine feeding systems. A linear programming model is presently being tested on a number of feeds. Some discussion took place as to how far CIAT should go into this type of activity and it was generally agreed that it should be limited to methodological research rather than trying to investigate case studies on a very large scale, however, for this to be done, considerably more information on the chemical composition of the feeds being used was needed from the swine research team.

2.2 Economic Evaluation of Swine Feeding Systems

Dr. Per Andersen presented the agricultural economics aspect of the program. He described the development of models for the evaluation of feedstuffs and work on the economics of swine production systems on both large and small farms. Preliminary indications were that the swine

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production on small farms was not an economic enterprise although it provided a readily available source of cash income. An attempt was made to establish a viable credit program for swine production on small farms, The end product was not very attractive but was, nevertheless modified and used by the Caja Agraria.

Support was expressed for the idea of making methodology and techniques available for the evaluation of other situations which might be similar but distinct from those in which the particular models were developed. Questions were raised regarding who the clients would be for the results of this work as well as about the orientation of the work to small farm production systems. The applicability of linear programming to small farm systems was questioned, however, it was suggested that this approach was useful for backstopping and developing viable recommendations for new production systems.

3. Cassava Program

The cassava program was introduced by Dr. E. Alvarez who noted that CIAT now had a definite policy of assigning not less than half a man year to any particular program in order to orient programming more along commodity lines. He then turned the presentation over to Dr. J. Cock who discussed the general background and development of the program up to the present. He noted that until June 1972 it was almost a one man program but that now a team was established and was actively pursuing fairly well defined objectives. These objectives can be found in the first section of the cassava work document which was circulated to the Committee before the meeting.

It was stated that if an ideal plant were to be produced, it should be able to fit into a rapid production system with low cost inputs and be easily harvested. Since it is not possible to produce systems of cassava production for all ecological zones, the focus of the work is to be on

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principles which can be useful in developing applicable production systems in many areas.

Each member of the cassava team then presented a report of his specific part in the overall program. These reports followed very closely the written version to be found in the document, "Cassava Progresss Report", which had been circulated to the Committee earlier.

3.1 Pathology Work

Dr. C. Lozano presented the pathology work results and described a number of diseases found in cassava. There was some discussion on the subject of bacterial blight disease and Dr. Lozano indicated that he felt the disease could be controlled using a technique he had developed. He was not sure if it is spread by insects, however, it is not residual in the soil. The fact that infected plants in the germ plasm collection could not be destroyed on the experimental farm for fear of losing valuable genetic material made the problem of its control much more difficult. Dr. Albrecht commented on a problem in Zaire in which many plantations of cassava had been completely destroyed and a very serious problem was developing. Dr. Lozano suggested that the cause of this loss might be the same bacterial disease with which he is working.

A second disease receiving attention at CIAT is a super-elongation disease caused by a fungus. This disease has not been recognized or identified outside of Colombia and not much progress has been made as yet on its control. It has only been under study for about three months. It was noted, however, that control through breeding looks promising. Mention was made of leaf spot diseases, root rot conditions and mosaic virus diseases. A discussion of the latter was post-poned until the agenda item on the mosaic seminar. Dr. Albrecht commented on the pathology program at IITA indicating that the program was still in a very nascent stage. A question was raised regarding the distribution and importance of plant diseases as a basis for determining work priorities in plant pathology. CIAT staff felt that this was difficult and some diseases are now only being recognized, therefore,

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priorities are set by working on things which seem most important at a specific time.

3.2 Entomology

The entomology work was presented by Dr. A. von Schoonhoven. He considered that thrips were the most important problem. In order to determine priorities for entomological work, it was suggested that it must first be determined which pests cause what damage. Dr. Albrecht reported that they have thrips, white fly and spider mites in Nigeria. The ecological adaptation of insects and plants to HCN was discussed and it was reported that there is a horn worm specific to cassava which may have some relation to the plant's HCN content. It was suggested that if it was possible to get an HCN-free cultivar, this could eliminate the horn worm which thrives on the HCN, on the other hand the plant might then attract other insect pests which are now kept away by the toxic content of the cassava plant.

3.3 Physiology

The physiology program was reported on by Dr. Cock who noted that no relationship had yet been observed between yield and plant type. He reported on a condition in which the leaves of certain cultivars fall off at a time when it appears the plant has not yet reached its full growth potential. There was some speculation as to what caused this condition. It was commented that in looking at the production of cassava plants consideration must be given to marketable yield not just the total yield of a plant. A high yielding variety which dropped its leaves at 6 months might very well be a useful plant under certain conditions and therefore the fact that the leaves drop off in certain species at an early age is not necessarily an undesirable trait. Dr. Albrecht queried whether the shape and size of roots for mechanical harvesting was being considered and whether the quality of starch produced are being taken into consideration in any of the research. It was reported that this has been considered to a certain extent and it was found that dry matter content and starch content of cassava

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roots are very closely related. The colour and taste of cassava products are not considered as priorities in the CIAT program at the present time.

3.4 Weed Control

Dr. Cock indicated that presently they have data on weed control experiments ready to turn over to the economists for evaluation. Close planting of cassava plants can reduce weeds. While this usually reduces crop yields, it could still give a higher economic yield by reducing the labour input in weeding. It was noted that these experiments are being done in order to be able to make recommendations for weed control in applied situations.

3.5 Propagation

The propagation program and experiments were presented by Mr. D. Wholey following the prepared report.

3.6 Breeding

The breeding program was presented by Dr. K. Kawano who had only been on the team for about 2½ months. There were some comments regarding the setting of priorities and choosing of the cultivars which would provide the principal genetic material for the breeding program. It was noted that breeding programs usually produce results quite slowly and that therefore, there should be a realistic time schedule incorporated as an important part of breeding work plans. CIAT indicated that the projected screening program of their germ plasm bank was not duplicating prior work since no systematic comprehensive screening of all the plant material in the bank had been undertaken previously. It was felt that a breeding program which involved selfing the entire collection at CIAT would be too much work and that a strategy of selecting low HCN cultivars in choosing the germ plasm to be used in the breeding program should be adopted. There was some question and discussion about the need to look for further genetic material in other species of manihot and doubt was expressed

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about the number of species existing. In this connection the taxonomy methods used by Rogers were questioned as regards their reliability. The feeling was that the breeding program should concentrate on *M. esculenta* so that efforts would not be dispersed too much and that a search outside the species should only be undertaken when inside characteristics had been exhausted. It was noted that the llanera variety of cassava which is CIAT's highest producing variety, seeds highly but has low stake fertility in terms of its reproduction. It was commented that this would suggest that the variety is closer to the original undomesticated plant material from which it originated.

3.7 Storage

Dr. R. Booth reported to the Committee on the progress of cassava root storage research. Referring to the potato clamp storage technique, it was noted that there might be two processes involved, one being curing and the other storage. Temperatures are quite high within the clamp but these conditions and how they affect the roots are not generally understood. Booth has been using rice straw around the stored roots, however, presently he is also experimenting with cane leaves and corn stalks. It was noted that there is not much difference in the behaviour of various cassava types within the storage clamps.

3.8 Drying

Mr. G. Roa reported that he had used solar heating in only two trials and found that air drying by wind movement through a vertical column of cassava chips was more effective. The development of farm models is anticipated and hopefully the principles on which the drying system is being developed will not be scale specific.

Before the Committee adjourned for the first day, Dr. Tossell indicated that he was impressed by the progress that had been made over the past year since he had last participated in an Advisory Committee Meeting. He also, on

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behalf of the University of Guelph, expressed a strong wish to co-operate in an integrated way with the CIAT cassava research work and requested that team members feel free to contact him in regard to any problems of co-ordination between research being done at Guelph and programs in CIAT should they arise.

Dr. Grant replied to these remarks emphasizing the fact that CIAT welcomed the participation of Canadian Institutions and scientists in a supporting role and noted that he regarded this as an important and integral part of CIAT's cassava program.

3.9 Cassava Agricultural Economics

Dr. P. Andersen presented a publication of data that had been prepared by CIAT on cassava production and use. He noted that there was a lack of good price data which made comparative studies of the value of production of cassava rather difficult. He further presented some tables showing world acreage and yield data as well as per capita consumption of cassava in relation to these. It was noted that most data on cassava production and consumption was questionable and not much more will be done with this general data at CIAT.

Tables were presented showing the estimated cost of producing cassava under three different conditions ranging from U.S. \$31.12 per ton in mountainous zones, to U.S. \$20.39 per ton on Colombian North Coast level land. Yields are higher in the latter case but the cost of production is still not competitive for entering the European market. Per hectare labour costs in producing cassava, including land preparation, weeding, fertilizer and insecticide application and harvesting accounted for 43.5% of the estimated cost of production. Seeds, fertilizers and insecticides represented 6.6% of production costs and transport, interest on land etc. represented 49.9% of production costs. These production costs were then

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compared with those of Thailand which is producing a large percentage of its cassava on small farms at a lower cost than the figures estimated.

Dr. Andersen noted two foci in the agricultural economics work related to cassava. First, efforts will be made to describe the production process and factors limiting production on farms in Latin America. The whole cassava team is to be involved in this process from which it is hoped to identify problems and their frequency in the field as well as the economic implications of these production problems. This work will take about a year since it involves following a select panel of farmers through their cropping year and observing their work methods and production systems. It is hoped that this field study will serve as a basis for delimiting research priorities. The second focus will entail demand studies for cassava in order to evaluate the economic implications of substituting cassava flour for wheat flour. While some data have been collected on this it has not yet been analysed.

Further questions to be studied related to determining at what price cassava can be used for swine feeds and how much the production cost of cassava has to be reduced in order to open up new markets. In addition, the economics program will also involve evaluation of experimental results in other aspects of the program.

In discussing the agricultural economics program, note was taken of the acute price sensitivity in world cassava markets for feed uses. The collection of prices on a world level was not likely to be feasible and CIAT felt that fairly reliable data could only be gained for Latin America.

The discussion shifted to questions of technology transfer and the interactions of subsistence versus cash crop systems. There was some diversity in the views expressed by the committee, some feeling that it was

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necessary to study these interactions in order to show how to develop markets, to transfer technology, and to understand how a subsistence farmer moves into the market economy and how he makes this decision. On the other side was a feeling that all this was not necessary and that if improved production systems could be demonstrated, people would automatically adopt them. Dr. Andersen stated that he hoped CIAT would be able to answer some of these questions especially those related to decision processes and priorities in programming. He noted that present studies were being done on adoption and diffusion processes in rice and maize. There was some question as to whether this was actually CIAT's role and if it should not be allowing some other research institution to do this work. It was suggested that another Centre for Socio-economic research might be set up but this was not presently forthcoming and therefore, it was probably necessary for CIAT to do this type of work on cassava.

It was suggested that in the future much of the world cassava production was likely to come from large farms and therefore the study of production systems on small farms was not likely to be applicable. CIAT had some reservations about this hypothesis and in the agricultural economics program they did not as yet want to make this distinction. Three criteria were suggested for orienting the economics program as follows: 1) the economic viability of cassava in general and not just in Colombia, 2) the identification of what is 'international' in scope in the program and 3) the identification of which of the 'international' aspects of the program should be studied at CIAT.

CIAT indicated that once some basis for evaluating production costs and production systems had been established, they hoped to provide technical advice to agricultural economists in national institutions since not nearly enough feedback from the realities of field situations gets injected into Latin American research programs. A further result of establishing some sort of collaborative basis should be the provision of information which

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could be used in training programs. It was agreed by the committee that the program should concentrate on production economics oriented to methodology, training and motivation as well as the identification of potentials. More esoteric kinds of model building should not be a CIAT agricultural economics priority at this time.

4. Field Visit

The Committee spent several hours visiting experiments at the CIAT field station. This field work included germination studies, self-pollination experiments, leaf fall and leaf angle characteristics of various plant varieties, plant density experiments in fans, a demonstration on ease of harvesting, a weed control experiment, storage of cassava roots in potato clamps and mist propagation. These experiments were viewed very favourably by the Committee and the cassava team was commended for its efforts.

5. Minutes of September 1972 Meeting.

The Minutes from the September meeting were unanimously approved with the exception of a spelling mistake in the name Villacorta on the first page of the report.

6. Cassava Mosaic

The Committee then heard reports of the mosaic workshop and the toxicity workshop, both held since the last Advisory Committee Meeting.

6.1 Mosaic Workshop

Dr. Steppler reported on the Mosaic workshop basing his comments on a report prepared by Drs. Nickel and Williams of IITA and by Dr. Steppler, and circulated to members of the Committee by Dr. Albrecht during the meeting. The program was described to the Committee and an opinion expressed that a good group had been brought together and a good workshop had resulted. As a result of the workshop, there were indications of interest in co-operation and collaboration in working on African mosaic diseases from 9 different institutions. Since the workshop lacked any

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information on the mosaic situation at Kerala in India, Frank Martin offered to investigate the situation and report on it to the Committee and the Cassava team, as he expects to visit the area this summer.

6.2 IITA Mosaic Work

Dr. Herb Albrecht, Director General of IITA presented the IITA Mosaic work of Singh and showed some slides of cassava plants and mosaic effects. He indicated to the committee the kind of work being done on cassava at IITA and noted that they will have to bring new material into Nigeria by seed and test it there for resistance to the African Mosaic disease. They hope to have 100,000 seedlings seeded in the spring season. Despite the problems reported in achieving germination in cassava seeds, they have experienced up to 80% germination due in part to the high moisture content of the soil and high ambient temperatures. By the end of the spring season, they may have as many as 125,000 seedlings screened for mosaic susceptibility. At the present time, they appear to have plant material which is resistant to mosaic.

6.3 Mosaic discussion

The discussion centred around plant resistance to white flies to avoid transmission of the disease and the possibility of finding a resistant plant. While it was noted that it is possible that the best plants may be able to live with the virus, it was felt that both resistance to the virus and to the vector transmitting the disease would be desirable. It was reported that variety 53-308 which Dr. Hahn has in his collection at IITA has some resistance to mosaic. A similar virus in sunflowers can be transmitted by several vectors so that even if a plant was found that had resistance to the white fly vector, it would still not necessarily mean that another vector might not be able to transfer mosaic. It was noted that the seeds for the plantings at IITA come from open pollinated plants and Dr. Albrecht indicated that he would be open to receiving large groups of open pollinated seeds from CIAT to test in IITA for mosaic resistance and for white fly screening.

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6.4 McGill Mosaic Proposal

Immediately following this discussion, a proposal for research on mosaic at McGill University was presented to the Committee. In presenting the proposal, Dr. Stepler noted that it arose directly from the mosaic workshop. The most important objective of the proposal was to identify and characterize the viruses and virus-like diseases infecting cassava in Africa. This objective was stressed as well in the letter from Dr. John Nickel of IITA evaluating the proposal. The chairman noted that this type of work was rated a very high priority at last September's meeting of the Advisory Committee and that a workshop was recommended to help sort out how and what work should be done in relation to the problem of African Mosaic.

A question was raised regarding the guidelines for evaluating Canadian University-Research Proposals and the chairman read the criteria that had been accepted by the Committee at its last meeting. In response to a query whether CIAT should be concerned with a virus that is only found in Africa, CIAT indicated that they must be involved in this kind of research. Even though African Mosaic had not arrived in Latin America, it must still be considered a threat and it is imperative to learn as much about it as possible since some day it may be a limiting factor in Latin America. A majority of the Committee felt that the project proposal warranted strong support and that some cooperation should be developed between CIAT and IITA in orienting the work. The Committee agreed to recommend support for the project and the Chairman invited CIAT to prepare comments and criticism of the proposal taking into consideration comments from IITA on the subject.

7. Toxicity Workshop report and Discussion

Dr. Nestel read a summary of the discussion issues at the Toxicity workshop held in London in January, 1973. He noted that there was enthusiastic response to the workshop and that the wide range of disciplines represented by the group assembled provided for a stimulating

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and fairly comprehensive interchange of ideas and experience relevant to the problem of Cyanide Toxicity in cassava. The conclusions of the conference had not been stated in clear cut terms but developing or discovering a zero HCN cultivar was given as a high priority in the cassava program. The processing of cassava was not felt to be an answer to toxicity problems. One committee member speculated that there was a possibility that a zero HCN cultivar might also be white fly free since some insects require or are attracted by cyanide containing plants. CIAT is now starting some experiments on insect-cyanide relationships.

A methodology argument arose at this point regarding the technique to be used in selection for a zero HCN cultivar. It was felt that mass selection techniques were most likely to be useful and to have a high possibility of success. A single cultivar with zero HCN, it was suggested would not be enough since a broad range of germ plasm was what was needed. Irradiation techniques were commented upon and it was noted that Dr. C.C. Moh at Turrialba in Costa Rica has started irradiation mutation work to develop HCN free cassava. Questions were raised regarding the epidemiology of toxicity and the importance of a high sugar content in cassava roots related to the toxicity problem. It was agreed by all that there was merit in rapidly getting rid of HCN in a number of cassava varieties and some support for giving this a high priority in cassava research.

8. CIAT Outreach Activities

8.1 Mosaic Outreach

Dr. Lozano talked briefly on collaborative contacts with work being done in Campinas, Brazil on mosaic. This program is still very much in the organizational stage and interchanges of information and substantive research work have not yet begun since the program is still being structured.

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8.2 Swine Outreach

Dr. Maner reported on Swine Program Outreach activities and a workshop conference held last September which was exceptionally well received. 84 people attended this seminar, many of whom had not met each other prior to this and often did not know of each others work, sometimes even in the same country. CIAT intends to follow this conference up with further seminars and workshops on specific topics in several countries. The second major swine outreach activity is the bringing of trainees and graduate students to CIAT to work with Dr. Maner on problems involving various aspects of swine management and nutrition. There are two trainees now at CIAT whose training is nearly completed. They will return to Costa Rica and Bolivia respectively to work in developing swine production systems in each of these countries. A third trainee who was to come from Nicaragua was delayed by recent events in that country.

9. Canadian Institution Research support.

The Committee then moved on to consider results and progress reports of the supporting research being done in Canadian Universities.

9.1 Chemotaxonomy (Dr. W.F. Grant, McGill)

Dr. H.A. Steppeler reported that they had further eliminated another 17 of the 55 spots reported as being significant in the last report leaving only 38 spots. Groupings in these spots as indicated by cluster analysis are beginning to appear on a geographical basis. A few varieties are not being grouped by the technique as for example, one variety appears only once in the clusters. There is still no agronomic data to correlate with the clusters as a cross check on the classification. At the present rate of work, 2400 - 2500 entries are likely to be grouped and classified by the end of this year and it appears that the total collection can be done. It is likely that they will probably do a few more runs of duplicates of 100 varieties or so in order to further calibrate and check their

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technique and methodology. It was also reported that they have offers of materials to classify from other geographical areas in Brazil and Africa.

There was some question as to the reliability of the technique and its ability to distinguish very rapidly. At the present stage the groupings did not seem very useful when comparing the results with field knowledge of the various varieties. It was indicated that some spots are probably more reliable than others and that further work must be done to refine the technique and interpretation of the results. It was also suggested that it might be better to work on refining the technique rather than to do a lot of samples so that the results that do come out are more reliable. Generally the Committee felt that the technique has promise and is still useful but that CIAT should not be asked to put in more information on plant varieties until the technique itself has been further refined.

9.2 Enrichment of Cassava with Single Cell Protein (Dr. K.F. Gregory, Guelph)

This project is on schedule and shows indications of progress. Techniques for the analysis of fermented cassava silage have been worked out and the program has also involved a graduate student from the engineering department with funds from another source to develop a fermenter. The engineering department has now scaled this fermenter up to a model factory size and this should be of use in further aspects of the project as well as for practical application. It was noted that there were two foreign students doing work in the project and that a third would be a welcome addition. The Committee recommended that the results should be introduced elsewhere in practical terms or studied in further research outside of Canada. It was suggested that with the discovery of a method of storing cassava roots, they may become cheaper to send to Canada for the project. In terms of a sequel to the project, the Guelph representative indicated that there was no hurry as existing funds were adequate for the next year of the project.

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9.3 Cassava Utilization and Markets (Dr. T. Phillips, Guelph)

This study was reported to be on schedule, and it is expected that Dr. Phillips will meet the April 30th finish date indicated by his contract. The report presented to the Committee was a short one pending presentation of the final report in about 6 weeks time. The Chairman indicated that a seminar was being organized for the presentation of the study by Dr. Phillips to a group of economists, CIDA people and others in Ottawa in June. It was suggested that the summary on page two of the short report presented to the Committee shows how important the project is and it would appear that CIDA and CIAT both seem justified in the importance they have put on the development of this crop.

It was noted that one of the biggest Dutch Feed Compounding companies has had problems of quality in the cassava pellets that are being imported from Thailand. This experience apparently discourages them from looking into the possibilities of importing cassava from Brazil from small farm production areas. Difficulties in the development of export markets and in increasing the production of cassava on small farms were related to traditional production systems and lack of infrastructural development. CIAT had been impressed with Phillips' seminar at CIAT in December last year and it was noted that he was in contact with the CIAT economist who was collaborating closely in the project. Generally, the Committee felt that the work was good, would be very useful, and they suggested it should be published as soon as possible after it was finished. It was pointed out that the Pie-diagram on page 3 shows cassava forming only 1.8% of principal food staple calorie supply in the world while at the London Toxicity seminar it was indicated that it formed 8 - 10% of world starch supply. A clarification of the table on page 5 was also requested and an indication of how these figures had been arrived at or how the projection was made. An uneasiness was also expressed in regard to the possible implications of surpluses in cassava especially in relation to subsistence agricultural areas.

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9.4 Nutrient Deficiencies (Dr. T.E. Bates, Guelph)

A 2 year project involving a graduate student who, during the first year, has been doing his course work. It was indicated that the student would shortly begin the actual physical research which will last over the summer and fall with a view to completion next winter. There was some criticism that the project was very slow to start and that there was very little indication in the report of what had been done, however, it was pointed out that this project was planned this way from the beginning.

It was suggested that the project director in Guelph make sure that they are using the right varieties of cassava and Ilanera CMC-9 and CMC-39 were suggested as appropriate varieties on which to do this work. Since cassava can grow under high aluminum levels, it was felt that aluminum toxicity effects should be studied. In order to get faster results, it was suggested that mist propagation of cassava plants would shorten the time needed in obtaining the plant material needed to carry out the analysis. Generally it was the Committee's feeling that this was a good project and an important one and that priority should be given to getting the results published as soon as possible after the termination of the work.

Several peripheral issues were discussed in relation to this project. One being that colour photography should be included in the analysis so that colour plates could be prepared for subsequent publication. It was noted that CIAT is hoping to produce a book on cassava disorders involving a number of colour plates and pictures of mineral deficiencies would be a logical inclusion in this publication.

Since cassava is likely to become a vitally important crop on lateritic soils and symptoms of various mineral deficiencies etc. are not the same in all regions, it was suggested that CIAT staff should be trying to identify people from various areas who could train at CIAT or elsewhere and that a scholarship program might be set up for this purpose. It was indicated

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by the Chairman that the University of Guelph had been talking to CIDA about setting up scholarship support for the Cassava/Swine program at CIAT which could be used in just such eventualities. It was suggested that a scholarship fund to take good people when they come as graduate students, and not just when a specific project or piece of research had been definitely identified, would strengthen graduate programs at Canadian Universities in support of CIAT activities and would benefit CIAT activities as well.

9.5 Cassava Growth Studies (Dr. L.A. Hunt, Guelph)

In this project growth chamber techniques for growing cassava have been developed. Considerable stocks of cassava have been grown and equipment and growth cabinets are now available. This aspect of the work was mainly a familiarization process. There was some feeling that this project had not been very successful and had not provided the sort of information and collaboration which had been hoped for. CIAT, however, announced that it was looking forward to Dr. Hunt coming to CIAT to work for a year on aspects of the growth physiology of manihot and that the successful completion of the future project was justification for this initial familiarization effort.

9.6 Cyanogenic glucosides (Dr. A. Zitnak and Dr. D.C. Hill, Guelph)

This project was again mainly a familiarization one involving preliminary preparation for the London Toxicity workshop in which the two scientists participated and made contributions including a bibliography. They had also produced interesting reviews of the subject matter involved in the project. It was suggested by one of the Committee members that no further work should be done on linamarin production but that it should be contracted out. An opposing view that this would be too expensive for the quantities needed for animal feeding experiments was also expressed. This issue was not resolved.

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9.7 Tissue Culture (Dr. O.L. Gamborg, Saskatoon)

This project is moving ahead very well despite the fact that initially there was some problem of material supplies. Dr. Cock of CIAT had conferred with Dr. Gamborg on the avoidance of duplication in cassava propagation efforts in the two institutions. The Committee was generally pleased with the work being done and indicated that it should continue.

9.8 Summary

The Chairman summarized the discussions relating to projects underway at Canadian Institutions by noting that two of the projects, microbiology and tissue culture, looked very good and will be continuing. The economics project has shown very promising results and will be completed in the near future. The chemotaxonomy study is encountering some problems in interpretation however, the output from the project is on schedule. The nutrient study in cassava is just starting and two of the studies were feasibility ones and would be further discussed regarding new proposals later in the meeting.

10 CIAT Revised Work Program Document

This document was commended as being the best which had yet been produced. The Committee was generally happy with it but some tightening up in the writing was suggested and committee members were asked to send comments to Dr. Cock in order to allow him to do this. The Committee then went through the document section by section making editorial and some project orientation suggestions. The first section was accepted as is except for the last paragraph on page 5 which was revised to read "the long term objectives of the program are to contribute to the increased production and improved utilization of cassava through research development and training."

In general, it was felt that the first part of the document should be a policy statement for CIAT which should be reviewed from time to time in light of new information and program developments. It was felt that the approach to any future changes in the document should be flexible but be made only in response to very definite indications. No definite time

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limit was placed on the document in view of the suggested periodical review. A concern was expressed about who the results of the research were for. If the work was to be oriented towards small farmers then the policy document should be somewhat different than for large farms. There seemed to be no general support for this view and CIAT staff seemed to think that in terms of research and the application of their findings, there was no incompatibility. Dr. Albrecht noted that in IITA, their mandate regarding what type of work they would do has changed from year to year depending on circumstances. He suggested that change should come only with a reason within an overall operating policy of flexibility with continuity.

In the discussion on the section regarding yield of cassava, a feeling was expressed that this may be too broad a concept within which to orient the program. This was not generally accepted, however, and it was felt that yields should be increased as much as possible to reduce fixed cost per unit of production. It was also noted that CIAT would hope to induce an integrated production processing system for cassava which could be part of a world wide system.

The section on storage, it was indicated, should be tightened up somewhat and that it should indicate implications of industrial application. This section was to be reworked by Dr.s Coursey, Cock and Booth.

Discussion on the section titled toxicity centred around the policy of whether the research team should go all out to find a zero HCN cultivar or whether it should take the approach that low levels of cyanide in a number of cultivars would be acceptable as a source of germplasm for the breeding program. This difference in views was not resolved. There was some feeling that zero HCN might be the ultimate goal but that levels of cyanide content in the plants less than 30 ppm would be acceptable. The Chairman noted that it was not correct to say that the symptoms of ataxic

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neuropathy have been reported in all areas where cassava consumption is high since the main areas where this condition is endemic are in West Africa.

In the section on low nutritional quality, it was suggested that the sentence on human use of cassava should be redrafted since CIAT's main efforts are going principally into the utilization of cassava for animal feeds. CIAT has taken note of the use of cassava for human food both in West Africa and through the use of fortified flours in Brazil but it does not intend to work on these aspects of cassava utilization.

It was suggested that the section entitled high production costs should be called "Economics of Production" and a number of editorial changes were suggested. The Committee suggested that the first two sentences in the section be removed and recognized that the question of production costs was intimately related with that of yields which may be based on such agronomic relationships as plant spacings, etc.

The section entitled "Uncertainty of Markets" was thought better to be entitled "Marketing" and it was suggested that throughout the document, references to collaborating institutions should be generalized rather than using specific names since the institutions collaborating could change as the development of new projects progressed. It was agreed that CIAT should only enter macro-economic studies when the work was necessary to their programs and when it was not being done or about to be done by another organization or institution such as a University. It was felt that CIAT should not deal to any great extent or manipulate secondary data which it did not collect itself. Dr. Martin offered to rewrite this section.

The title of the section called "General Lack of Knowledge of the Crop" was changed to simply "Information". It was suggested that it should be

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explicitly stated that CIAT is developing the world's principal Documentation Centre on cassava and that eventually it is likely to be plugged in as part of the AGRIS network.

The outreach section is not specific to cassava and therefore it was suggested must fit in more fully with CIAT's overall policy. There was some argument over how specific this section should be and the order of the points regarding CIAT's approach to the problem of outreach.

The Chairman requested that revisions of the various sections of the policy document should be in Dr. Cock's hands by April 22nd. These are to be editing suggestions and not major issue changes. The list of major projects attached to the policy document was not discussed in detail acceptance being recommended by the Chairman with the indication that written suggestions for changes from Committee members could be sent to the Cassava Program Leader. The Chairman noted that what use is now made of the program document is a matter of CIAT operational policy. Mention was made as well of a request for information to be published in the World Root Crops Journal regarding the cassava program at CIAT. It was suggested that this should be closely tied to the CIAT policy document but that the names of principal collaborators should, in this case, be mentioned.

11 CIAT 1974 Cassava/Swine Budget

The Chairman presented the budget and then noted that there was a 10% increase in the swine program budget over 1973. This increase, it was pointed out, was the result of Dr. G. Gómez, Assistant Nutritionist, being assigned to the project on a full-time basis and to the appointment of a Spanish-speaking secretary. Other personnel in the budget are 3 associate research fellows at the M.Sc. level, one research assistant and two lab technicians. In addition, 1/5 of a man year has been budgeted for

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agricultural economic inputs. Some comment was made about the overhead costs in the budget and how much support staff was needed for the professional staff. It was estimated that CIAT's professionals were costing somewhere around \$85-90,000 per man year. There was some indication that this was not out of line with costs of senior research personnel in other international institutions.

In the information and training part of the swine budget, there was a fairly large jump to \$17,000 in 1974 from \$10,000 in 1973. It was explained that the reason for this was more output such as the swine seminar organized by CIAT. The program put through 118 trainees last year and the cost of logistics was considerable and will increase as they put through more trainees. In summary, it was noted by the Chairman that the budget is being increased at a real rate of about 6% which could be considered-a hold-the-line budget after accounting for the fact that the second senior scientist would be full time in 1974.

The cassava budget, it was noted, accounted for approximately 40% of the plant sciences budget and composed some 6.4 man years of professional time. It was indicated that this 6.4 man years represented the basic team for the cassava project and that its growth in the future would depend on what is learned from present research activities and also how much research input comes from outside Institutions and professionals. There was a substantial increase in the budget for agricultural engineering in the 1974 budget over that for 1973 which CIAT indicated was for research on drying of cassava and, to a certain extent, for weed control. They felt that the full-time of a professional for half a year could make substantial advances in this aspect of their work. There was also some discussion on direct research cost differences between the swine and the cassava programs and on the cost per professional man year as indicated by the budget figures.

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The Committee expressed general approval for the cassava direct research budget with some queries regarding the agricultural engineering component which was not expressed as a priority in the program of work document. The expansion suggested in the budget, it was felt, is generally supported by the program of work document.

A substantial increase was noted in the training and communications budget especially for information services and conference support. Information services had been underestimated in the original proposals and they found that working in two languages in the production of bulletins and other publications had become more costly. The increase in soils special services is to be used for trials and tests of cassava varieties in the llanos. The Committee took note that of the total cost of the cassava program 38% was composed of indirect and overhead costs and it was felt that this distribution was acceptable. The Committee commended CIAT on the budget form and disbursement distribution and expressed its satisfaction that CIAT had attempted to incorporate many of the recommendations made by the Committee last year. The Committee recommended to IDRC that at CIAT's request they release the \$500,000 from CIDA for the 1973 budget year.

10.1 Financial Status of CIDA Funding for Cassava/Swine

The following tables show the status of commitments and expenditures of the CIDA funding for CIAT's cassava and swine programs and for Canadian Institutional supporting research.

	CIAT		Canadian Institutions	
	<u>Approved</u>	<u>Expended</u>	<u>Approved</u>	<u>Expended</u>
1971	150,000	150,000	3,000	3,000
1972	300,000	275,000	252,759	134,242
1973	<u>500,000</u>	<u>-</u>	<u>230,000*</u>	<u>-</u>
	<u>950,000</u>	<u>425,000</u>	<u>485,759</u>	<u>137,242</u>

*Based on approximate figures, subject to revision

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DATE APPROVED	INSTITUTION	PROJECT TITLE	APPROVED BUDGET	PAYMENTS TO DEC/72
Dec. 1971	McGill	Exploratory Studies in Cassava	\$ 3,000	\$ 3,000
Jan. 1972	Guelph	Exploratory Studies in Cassava	5,000	5,000
July 1972	P.R.L.	Plant Development - Tissue Culture	35,800	22,000
July 1972	McGill	Cassava Classification Feasibility Study	9,800	8,600
Aug. 1972	Guelph	Cyanogenic Glycosides in Cassava	7,682	7,682
		Micro-Nutrient Study	10,170	4,500
		Cassava Growth Response Studies	8,310	8,310
		Marketing Study	39,169	30,000
		Microbiology	82,114	30,000
Nov. 1972	CIAT	Canadian/CIAT Liaison Officer	10,000	8,000
Nov. 1972	McGill	Cassava Chemotaxonomic Classification	44,624	10,150
			<u>\$255,759</u>	<u>\$137,242</u>

Recently Recommended Projects *

Mar. 1973	McGill	Cassava Mosaic Diseases	89,000
Mar. 1973	Brace Inst (McGill)	Solar Drying	16,000
Mar. 1973	Guelph	Linamarin Distribution in the Cassava Plant	15,000
Mar. 1973	Guelph	Growth Physiology of Cassava	70,000
May 1973	Guelph	Cassava Markets (Continuation)	40,000
			<u>\$230,000</u>

*All subject to revision and final approval by IDRC

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11 New Canadian Research Proposals

11.1 Three projects on the Growth Physiology of Manihot (Dr. L.A. Hunt, Guelph)

Dr. Tossell suggested that a flexible approach be taken towards the evaluation of these projects and the work which needs to be done at CIAT since as new knowledge is gained the orientation and priorities of the research to be undertaken are likely to shift from time to time. He noted that this research would present the University of Guelph man the opportunity to gain experience with cassava at CIAT which he could then take back to Canada to aid in further research collaboration with CIAT and in preparing other Canadian Scientists for this kind of work. This approach was later supported by Dr. Grant who indicated that he wants a Canadian at CIAT working in the program including, if possible, some graduate students so that the Canadian input into the project will be more than just a monetary one and a close collaboration can be established. The Chairman requested the Committee to discuss and evaluate the content of the proposals and not to go into an evaluation of the budget as such since it was still preliminary and subject to later revisions in light of negotiations with CIAT.

Some concern was expressed about the growth chamber techniques indicated in the first two projects because of light and root restrictions in the more confined quarters, however, this reservation was expressed in an overall sense and the program leader indicated that he was broadly in favour of all the projects and would like to see them done. He suggested that the restrictions of growth chamber work didn't matter as much in the number 3 project and that, therefore, it should go ahead. The second project he rated as excellent if assurances could be made that proper photosynthetic comparisons were possible through the growth chamber work. While there were some serious reservations expressed regarding the relevance of this work, other committee members felt that

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this kind of work was promising enough to take the chance of it not being productive.

The most desirable part of this project was the environmental control possible in the growth chambers which could have important spin-off in other research endeavours. There was some question as to where the material for the number 3 project would be obtained, especially from other species of manihot. It was indicated that Hunt does already have some other species and had identified sources for more and it was hoped that the problem of obtaining this material could be solved. It was suggested that up to 10 different species might be needed in this research project. In response to a question regarding the involvement of graduate students in Cali as well as in Guelph, Dr. Tossell indicated that this was indeed possible eventually but that at the present time the program would need gearing up in order to incorporate this kind of input.

In summary, the Committee expressed reservations about certain parts of the proposal but at the same time, indicated that they felt that the risk was worth taking since projects 2 and 3 came relatively cheaply and that the first project involving Dr. Hunt coming to CIAT was providing them with a good investment in another physiologist unless there were hidden costs not readily apparent from the proposal. The proposal was then recommended on the basis of a flexible approach being taken so that the research program could be adapted to the needs of CIAT's program as more information is gained on the growth physiology of manihot.

11.2 Solar Dryers (Dr. M.S.A. Malik, Brace Research Institute, McGill)

The project was presented by Dr. Steppler, followed by an indication from CIAT that solar dryers were very definitely needed and considered a high priority by them. The Committee agreed that the development of dryers was a priority but some reservation was expressed about the nature of the

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present proposal and it was suggested that it was possibly too theoretical and a serious study of the work being done in Trinidad should be made first. It was also noted that while the subject merits attention the bibliography in the proposal shows that a lot of the theoretical work had already been done and that what the proposers would be doing was merely to apply known technology. It was questioned whether CIAT could not do the research and if it would welcome such an expansion. CIAT indicated that it was not capable of handling all the research since it doesn't have the personnel. It was also indicated that this is a highly technical field which an agricultural engineer such as the one at CIAT couldn't undertake properly and that the Brace Institute is a practically oriented organization working on small scale technology and therefore would try to avoid being too theoretical.

The Chairman stated that a processing and drying workshop is being planned by IDRC for the fall of this year and he would prefer to defer a decision on this project until then in order to get a broader picture of the kinds of work already done and the implications of this in further approaches to it. He indicated that Springer from Trinidad and one of the people from McGill might be invited to attend in order to work out some of these problems. He also questioned the practicality of application of the research results and equipment produced referred to in the bibliography. It was noted that there have been practical applications but these have not been publicised widely and it was suggested that CIAT's agricultural engineer could benefit from the influence of working with the team from the Brace Institute.

The general consensus of the Committee was that the project should go ahead with a modified plan B approach with the anticipation that some early results could be taken to the workshop in Thailand. The Chairman expressed concern as to what happens with the developed dryer and what link-in this would have with the outreach program of CIAT.

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11.3 Linamarin Distribution in the Cassava Root (Drs. A. Zitnak, D.C. Hill and J.C. Alexander, Guelph)

Dr. Tossell described the background leading up to this work and the first efforts which had been undertaken at the University of Guelph as preliminary feasibility studies last year. This had been done partially in preparation for the toxicity workshop held in London last January. He requested that the Committee decide in principal on goals which should be achieved in this work and then on that basis make decisions regarding the proposals. He considered the proposal being presented to the Committee as a preliminary one and requested their advice regarding which work should be followed, whether on the plant side or the animal side or both. It was suggested by Dr. Maner that even finding a zero HCN cultivar while providing the long-term answer to the problem of toxicity in cassava would not provide a short term answer since it would take a long time to diffuse to cassava growing areas around the world. Much more needs to be known about how linamarin affects the animal body and just what HCN does and how it behaves. It was suggested that the rat is a sensitive animal and could be used for initial studies. Should the project be done, it should be rewritten and focused on specific objectives such as how does thiocyanate cause goitre and/or how does sulphur fit into this picture in biochemical reactions. The research work was in this sense viewed as an insurance.

A question was raised regarding how much Canadian money should be involved in such basic research as this and it was suggested that this should be a policy issue to resolve. CIAT indicated that while the toxicity problem was not great in Latin America, it is still vital to the use of cassava in many other parts of the world and therefore of considerable importance. At the same time, the Director-General of CIAT indicated that he did not want his staff working on a basic research area. There was some concern that the project did not fit into the criteria set up for judging Canadian Institutional Research proposals and it was also suggested

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that the whole approach of the work would become of only academic interest when a zero HCN cultivar is found. This seemed to be the view of a minority of the Committee and most felt that the London Workshop had recommended that more be learned about cyanide toxicity, its side effects and its implications. Concern was also expressed about the source of supply for linamarin since the work can't be done without it and it was also suggested that the plant part of the proposal was rather weak. A suggestion that IDRC support the proposal with funds from another part of its program raised policy problems since IDRC is not set up to fund research in Canadian Universities directly without some direct relationship with a program in a developing country. In summary, limited acceptance of the proposal was given with a recommendation that the work be restricted to the animal component and that it be based on the availability of sufficient supplies of linamarin.

12. CIAT Outreach Proposals

12.1 Cassava Outreach

The cassava program presented a proposal which it was hoped would extend CIAT's program in a pilot outreach effort in order to extend the range of CIAT's cassava program. The project proposed would extend for two years at a cost of \$21,900 and includes some equipment. There was a question about whether the equipment in fact was needed, particularly the \$3,600 ovens and for what they would be used. Concern was also expressed over what seemed the ambitiousness of stated objectives and whether the Peruvian Government in fact was interested in taking it on. It was considered by the Committee that, if this in fact was the case, supporting the project would be good seed money. Support for the proposal, therefore, was recommended but on the condition that some tidying up be done and a positive assurance was required that the project had the full support of the Peruvian Government.

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12.2 Swine Outreach

The swine outreach programs are described in the progress report of the swine program. The leader of this program indicated that he is ready to sign agreements with both Costa Rica and Bolivia for collaborative efforts when the trainees from these countries finish their program at CIAT in the near future. The Nicaraguan trainee was not able to come because of the disruption caused by the recent earthquake experienced there and that part of the program has lapsed for the time being. There have also been administrative problems in identifying and bringing to CIAT the two Nigerian trainees recommended at the last Advisory Committee meeting but hopefully this problem will be solved before too long. A co-ordinator is also being sought for the swine outreach program subject to financial support from IDRC being forthcoming.

13. Cassava Documentation Activities

Dr. Monge reviewed the progress in the collection and abstracting of cassava related documents from various areas and indicated that of the estimated 4,000 documents relating to cassava, 3,200 - 3,300 had been identified and located. Of these, 1,200 - 1,300 had been received at CIAT and 450 were fully processed. An editor has been hired to key-word and abstract the articles and at the present time the daily output is about 12 documents. Dr. Monge estimated that they will meet the goal of having 2,000 articles fully processed and integrated into the preliminary bibliography which is to be produced for the Tropical Root Crops meeting in Nigeria in December 1973. Once the preliminary bibliography has been produced, CIAT will announce its periodical abstracting and copy service internationally. It was stressed that this will not be a free service and that a nominal fee will be charged for subscription to the abstracting service.

Other work being undertaken by CIAT in relation to documentation is a publication which is likely to come out next month concentrating on the questions of diseases and pests in cassava and containing a specialized

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bibliography relevant to this subject. A cassava citation index and an annual review of cassava research are also being planned. The question of what language should be used in the bibliography and abstracting services provided by CIAT came up and the Committee was informed that CIAT are now using English and Spanish although the latter is lagging behind because of the time needed for translation. CIAT indicated that the addition of French translations was feasible if funds could be made available.

Mr. D. Leatherdale reported on the provisional thesaurus he has developed on cassava and distributed preliminary copies for the Committee's perusal and commentary. He asked particularly for criticisms and corrections in the interpretations which had been made of various terms. A large part of this thesaurus consists of synonyms and its role is to provide key words for the bibliography CIAT is producing and eventually to fit cassava into the AGRIS documentary network as one of a number of specialized centres. He indicated that within a month, a thesaurus should be ready for use.

Dr. Monge was questioned on the sources of the documents he had identified and whether or not these were in fact reliable. He reported that he was using some 15-20 sources for the collection of cassava documents. Several other sources were suggested by the Committee which might prove useful, these being in Belgium, Portugal and Japan, (which latter had produced some publications on cassava during the second world war).

14 Future Function and Meetings of the Committee

The Chairman suggested that the next meeting of the Committee should be a program review of the Canadian Institutional projects with various members of the Committee each visiting a different Institution for one day. The second day of the meeting would be held in Ottawa and would be an open review of the total program involving representatives from CIDA, CDA,

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and other interested Canadian Institutions. The third day would be a closed session of the Committee to deal with whatever review or business items might be relevant at that time. It was felt that it would be best to let Committee members suggest the project they would like to visit and that the date of the meeting be set for the week of October 28 - Nov. 3.

The Chairman pointed out that this Advisory Committee was an ad hoc one and in no way permanent. He indicated that initially people had been invited to participate on the Committee who seemed to have the greatest possibility of making a good contribution in program planning and development. This function could still be served for the next meeting in Canada, however, at that time, a consideration might be given to broadening the Committee to bring in some more specific technical advice in support of the CIAT Cassava and Swine teams.

The CIAT staff thanked the Committee for the advice they had given and indicated that they had found it very helpful in developing the program but agreed with the Chairman that what was now needed was more of a specialist input. There was a general feeling that the project team was developing very rapidly and becoming the world experts on a wide range of research activity relating to cassava. It was suggested that following the next meeting of the Committee to evaluate the Canadian supporting program it might be allowed to lapse, and annual reviews might take the form of specific discipline reviews whose theme varied from year to year.

IDRC

CASSAVA/SWINE ADVISORY COMMITTEE

Report of the Fourth Meeting held at
IDRC Headquarters, Ottawa, November 8-9, 1973

Committee Members Present:

B.L. Nestel (Chairman)
H. Stepler
F.W. Martin
D.G. Coursey

E. Weber (Secretary)
W.E. Tossell
E. Alvarez

CIAT

J. Cock

Advisers and Observers:

University of Guelph

H. Binns
T.P. Phillips
K.F. Gregory
D.C. Hill
T.E. Bates
L.A. Hunt
S. Lowe
J. Mahon
A.E. Reade

Macdonald College

J.L. Peterson
W.E. Grant

Prairie Regional Laboratory, NRC

O.L. Gamborg
K. Kartha

Uniroyal

A.L. Miglietta

IDRC

J.H. Hulse
M. Brandreth

CIDA

W. B. Redekop

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1.0 Opening Remarks

The Chairman opened the meeting by welcoming the committee members, participating scientists in the Cassava Development Program and observers to the meeting. He pointed out that it was now 18 months since the initial research projects at Canadian Institutions had been approved at the first Cassava/Swine Advisory Committee Meeting and while the CIAT program had been reviewed semi-annually on a fairly intensive basis, this was the first time that all the scientists participating in the Canadian based aspects of Cassava research had been brought together. Following introduction of the participants to the meeting and some announcements, the meeting moved directly into the technical presentations and discussion. Copies of the reports to which the program participants were speaking had been circulated by mail at an earlier date.

2.0 Canadian Research Project Reports

2.1 Potential Utilization and Markets for Cassava by T.R. Phillips.

Dr. Phillips reported that a final report had been submitted to IDRC entitled "Cassava: A Study of Utilization and Potential Markets" by the 23rd of May 1973. As a result of an IDRC sponsored workshop, in June 1973, to discuss the report recommendations were made that the project be expanded to include an analysis of the effects of a global increase in the price of high protein feeds on the European Economic Community demand for cassava. The additional analysis has been completed and a revised final report being published by IDRC is scheduled to be available by early 1974. The study looked at three distinct markets for cassava: 1) the human food market which can be expected to increase by 45% to 1980 (production in the range of 82-86 million tons) since by that time an estimated 500 million people in the tropics would depend on cassava for half their calorie requirements; 2) the industrial starch market dominated by the United States, Japan and Canada in that order which showed variable demand characteristics because of the substitutability of various starch sources and price fluctuations with the result that the projection to 1980 indicated a 20-50% increase in demand depending on the assumptions used; and, 3) the animal feed market which has shown the greatest increase in the use of cassava and this past growth should continue

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at least to the end of this decade. Dr. Phillips indicated that cassava stands up well in competition with grain feed crops in terms of price as well as with other starchy roots although these were not considered directly in the model. Export price increases are likely to be very small but total returns to the farmer could increase through increased yields.

The principle recommendation made was for applied research into cassava breeding, cultivation, processing, marketing and integrated systems since demand for cassava seems to be growing at a faster rate than supply and the greatest immediate returns are likely to be derived from research which directly increases the supply of cassava and cassava products.

2.2 Plant Development of Cassava From Somatic Cells by Tissue Culture Techniques by Dr. O.L. Gamborg.

Dr. Gamborg reported that cassava plants had been produced in his laboratory from cultured cells. These cells taken from the meristem of the plants are believed to be virus free, therefore the plants produced should also be virus free. These procedures are now being extended to design a method for producing virus free plants for use in plant breeding and for propagation purposes. Comparisons are being made between the cultured plants and plants produced from stakes for evidence of cassava mosaic disease. The next step in this research is to develop methods for producing plants from single cells and in studies on inter-species cell hybridization. Cell hybridization depends on the ability to culture protoplasts and, in preliminary experiments, Dr. Gamborg has been able to produce callus and root formation. Some of the callus showed intense greening, indicative of chlorophyll containing cells, but no evidence of shoot formation was observed. It was suggested that plantlets from the successful meristem culture experiments should now be planted in the field in order to grow them through the full life cycle of the cassava plant and to test for their genetic stability. One of the problems to be overcome here is that of acceptance of the plantlets as being disease free and the necessity of an isolated field station.

2.3 Cassava Chemo-Taxonomic Classification Study by W.F. Grant

The objectives of this project are to classify the CIAT germplasm collection into groups of similar types as a means of identifying the material and to facilitate comparisons of material from different geographic areas where quarantine restrictions prevent free movement. 55 chemical attributes, which appear as spots on prepared glass plates, have been identified to date and these are grouped by a cluster analysis technique into groups of more or less homogeneous characteristics. The number of groups defined depends on the level at which the clustering process is terminated in the computer program. The number of groups and their specificity can therefore be varied according to special characteristics or groupings thereof. Dr. Grant informed the committee that the findings of his work correspond fairly closely to that reported by Rogers. Chemical identification of spots has been started, however, considerable work is still needed in this respect if comparisons are to be made between American, African and Asian material. Nevertheless, this identification is worked on only when there is time available from the objectives of classifying cultivars, noting effects of seasonal change on the spot pattern and associating morphological with chromatographic data. To the end of August, 1208 accessions had been analyzed, most of them from the Americas. Ten accessions were received from Nigeria and leaf samples of six cultivars have been received from Malaysia. It was reported that there is some variability in chromatographic patterns due to environmental and seasonal changes.

2.4 Enrichment of Cassava with Single Cell Protein by Dr. K.F. Gregory.

Dr. Gregory indicated that the biomass production studies seem to be very encouraging and there is reason to assume that a viable process will be ready for testing with swine feeding at the pilot plant scale by about September 1974. Three fungal cultures are currently under intensive study and in preliminary feeding trials with rats one of these appears to be superior to soya bean protein and almost as good as casein. The other cultures produced good weight gains but were not as efficient. The advantages and disadvantages of present known "best" cultures were discussed but reservations were expressed about possible long term effects of the use of this in a feeding situation. Preliminary estimates of yields of final biomass product which might be expected indicated a

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a content of 15% protein. A scale up of the initial 2 litre model of the fermentor has been successfully completed at an intermediate scale and work is likely to proceed on developing a full scale commercial model shortly.

2.5 Dietary Significance of Linamarin and Animal Nutrition by Dr. D.C. Hill

This was the final report related to preliminary investigations on cyanogenic glucosides in cassava and a new contract has now been developed as a follow up. Dr. Hill reported on preliminary feeding experiments with rats to test the toxicity of cyanide and the development of an experimental diet for studies on cyanide and linamarin metabolism. He also noted some findings of the toxicity of KCN for rats fed a purified diet based on casein. Part of the original project was undertaken by Dr. A. Zitnak who worked on a methodology of linamarin assay and linamarase concentrate preparation in order to obtain these substances in pure form for experimental purposes. Dr. Hill reported some difficulty in obtaining supplies of linamarin to use in his test diets and the problem of supply had not yet been solved.

2.6 Mosaic Disease in Cassava by Dr. J.F. Peterson

This project began in July 1973 and therefore is still very much in the initial stages. The objectives of the work are: the identification and characterization of the viruses or virus-like agents infecting cassava in Africa; an investigation of possible methods of handling these agents and assaying for their presence; and, an assessment of possible practical control measures. Initially time was spent learning how to grow cassava in growth chambers, studies on transmission of cassava mosaic, and preliminary characterization studies.

2.7 Nutrient Deficiencies in Cassava by Dr. T.E. Bates

Symptoms caused by typical deficiencies of important macro and micro nutrients in cassava as recorded in this project were illustrated and explained using colour slides.

2.8 Growth Physiology of Manihot by Dr. L.A. Hunt

Dr. Hunt reported that efforts in this project to date have involved preparations for growing cassava in growth chambers at the University

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of Guelph and experimenting with equipment for measuring photosynthesis. He illustrated the facilities available as they had been altered to accommodate the full growth of cassava. Dr. Hunt will be leaving for a 12 month period at CIAT in January 1974.

2.9 Summary and General Comments

Dr. Nestel briefly summarized the main points presented and expressed pleasure at the progress which has been made over the past 18 months. Dr. Alvarez thanked the scientists on behalf of CIAT for their valuable contribution to the development of the cassava program at CIAT and expressed CIAT's feeling that this kind of cooperation and collaborative effort was essential. Mr. Miglietta of Uniroyal Plantations Research Division thanked IDRC for the invitation to participate in the meeting and spoke briefly of his company's production and research activities principally with rubber but into which they hope to introduce Cassava as an associated crop.

3.0 Cassava Literature Indexing

Mr. Mike Brandreth of IDRC reported on the "Indexing and abstracting of cassava literature" project at CIAT and the information retrieval system which has been set up. It was noted that the growth of the literature related to cassava is now at something like 50 items per year. He showed computer printouts of title search results and retrieval of abstracts. He also reported on the status of the cassava Bibliography.

4.0 Recent Development in CIAT Cassava Program

Dr. James Cock gave a rapid overview of the current status of work being done at CIAT. He reported very briefly on work in bacteriology, physiology, entomology, growth studies, cyanide content, propagation, breeding, agronomy, drying, and economics.

5.0 Report of March 1973 Meeting

The Chairman presented the report of the last meeting of the Cassava/Swine Advisory Committee meeting as the first item on the agenda of the second day of the meeting which included only members of the Advisory Committee.

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The report of the meeting was unanimously approved and attention was drawn to the fact that, since the committee would probably not be meeting for another two years, it would form a good and useful record of the ideas and opinions discussed.

6.0 Discussion of the Status of Canadian Cassava Project Budget

The status of the current funding for Canadian Institutional Research on Cassava was presented to the committee and a copy is included in this report. Each project was reviewed individually and possible continuations of some of the projects were proposed. Two projects at Guelph, one at McGill and one in Saskatoon seem likely to continue on to a second phase. Including the total amount already approved of \$445,000, an estimated proposed amount of \$155,000 for continuing projects would bring the total commitment to \$600,000. This leaves \$150,000 yet to be allocated before termination of the funding in 1975. It was felt that this was an adequate amount to cover foreseeable supporting research needs. Keeping in mind, however, that there are three full years remaining and several of the studies could possibly be further extended, this would not provide a great deal of leeway for any new project which may come up.

7.0 Discussion on Project Progress Reports

7.1 Potential Utilization and Markets for Cassava

Since Dr. Phillips had completed his initial contract and submitted an acceptable final report, most of the discussion revolved around a proposal for continuing with other related aspects of economic research. Essentially what Phillips was proposing was a cooperative study involving CIAT, IITA, Cruz das Almas, Thammasat University in Thailand and possibly several others still to be identified. It was suggested that the proposal was too broadly defined at present and one member of the committee felt that it involved too much money. There was general consensus that the proposal should be more precisely oriented, however, there was also a suggestion that in fact it could cost more money than that proposed. It was pointed out that there is little knowledge of the structure of production costs in growing cassava and that this type of study could provide useful and needed information as an input into CIAT's program. It was felt that the proposal as is is too broad and needs more specific focusing on particular

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objectives. The committee did not fully agree on what those objectives should be, but the consensus was that some form of continued economic study of cassava production would be continued with IDRC and CIAT personnel working out the objectives of the work in a more precise manner. It was suggested that this could be done with Dr. Phillips at the Tropical Root Crop Society meeting in Ibadan, Nigeria.

A point that was woven through the discussion on further economic studies, particularly pertaining to the physical side of production, was the nature of the linkage between this project and existing programs. It was suggested that this work should be done by the agricultural economists at the institutions named and that the proposed undertaking was getting to be too large a program. There was mention of establishing a network and it was suggested that giving trainee programs a high priority would fulfill this need. It was pointed out, however, that a network involves more than training people in a particular methodology and sending them back to their countries and that the work proposed would involve economists, agronomists and others from the centres named providing information in a standardized way so that it could be compared across countries and regions and used as a help in identifying research priorities.

7.2 Chemo-Taxonomic Classification

The Chairman noted that a one year extension has been requested for this project and the committee seem to be in agreement that the request should be granted. It was suggested that attempts be made to expand the program geographically to include material from Madagascar, Southern India, and Southeast Asia. CIAT indicated that it would like to see the project defining the broader categories of germplasm differentiation and leave aside the fine classification which is more difficult and less feasible. The project would be most useful to CIAT by continuing as a means of identifying further germplasm for them to include in their breeding programs. Additional suggestions were that it is still necessary to get more agronomic and morphological information to Dr. Grant so he can make the proper correlations and tidy up certain aspects of the classification. This is to be given early priority as well as a visit by Dr. Grant

STATUS OF CANADIAN CASSAVA BUDGET

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	<u>APPROVED</u>	<u>PROPOSED</u>	<u>TOTAL</u>	<u>TERMINATION</u>	
				1974	1975
Phillips	39,000	65,000	104,000		Dec.
Grant	55,000	25,000	80,000	Dec.	
Gamborg	36,000	20,000	56,000	Dec.	
Gregory	82,000	45,000	127,000		June
Hill	23,000	--	23,000	Dec.	
Peterson	94,000	--	94,000	Dec.	
Bates	10,000	--	10,000	June	
Hunt	91,000	--	91,000		June
CIAT	10,000	--	10,000	--	--
Malik	5,000	--	5,000	--	--
	<u>445,000</u>	<u>155,000</u>	<u>600,000</u>		

to CIAT to make contacts, see more of the crop in the field, and gather other information he may need. A second level priority in the research would be to look at regional differences in cassava as well as between other species of *Manihot*. Dr. Cock suggested that a visit should be made in about eight months since at present CIAT doesn't have the agronomic data necessary.

During the discussion two problems were noted that had affected the work: 1) the slowness of CIAT in sending materials; and, 2) the lack of contact Canadian scientists have with scientists in tropical countries. In the first case, CIAT had been a bit slow in supplying the needs of Canadian scientists for cassava plant material even after funding had been provided to hire a man specifically for this purpose. In relation to the second point and a question about the difficulty Canadian programmes are having in getting material a number of points were made. First of all, there are physical problems which often slow shipments of Plant materials down considerably. In addition, Canadian workers don't have that many contacts in the world of tropical agriculture and, when it was pointed out that they should take more initiative in this sense, comments were made to the effect that funds were not available in the projects for staff to travel and gather their own material. In many of the countries where it was suggested materials should be sought, collections are not maintained or available. Dr. Coursey was asked to make some contacts for Dr. Grant at the Tropical Root Crop Society meeting in Nigeria, and it was suggested that Dr. Grant should prepare a list of the material he needs in order to get this information into the Society Newsletter which is circulated to many of the people who might be able to provide material not presently available. In addition, CIAT was asked to provide the committee with a list of characteristics of cassava on which they have data available.

7.3 Tissue Culture Project

This project is presently funded to the Spring of 1974 and Dr. Gamborg has requested an extension of this funding in order to look at some of the protoplast fusion aspects of the work in which he is presently involved. The committee felt that the results of the work to date have been very good and

that the plants which have been grown from meristem cell cultures should be grown through a full growth cycle in order to note their behaviour and to test for their genetic stability. It was noted that this can't really be done in the tropics, where cassava diseases are endemic and still produce disease free plants, which means that the work would have to be done in Canada in growth chambers. Dr. Steppler here raised the point that this problem goes way beyond cassava and is applicable to similar techniques in other crops. He suggested that a temperate zone service station for international centres to produce disease free material could very soon be a necessity and that this should be pointed out to TAC and the Advisory group for their consideration since the scope of the funding and program involved is beyond the capacity of a single institution. In general there was agreement that the tissue culture project should continue giving attention first of all to proving the genetic stability of plants produced, to continued work with callus cells and to growing plants from cells. Protoplast work and cell fusion hybridization was considered of much lower priority at the present time.

7.4 Microbiology Project

The committee was impressed with the progress made in this project and despite the fact that Dr. Gregory is still somewhat concerned about toxic effects in his present product, it was felt that they should start getting the results out for testing and feeding trials. It will probably be September of 1974 before feeding trials in CIAT can get underway but work should be started on construction of a full scale fermentor by at least next April or March. Feeding trials should also be done on criollo pigs as well to see how they respond to this type of diet. The silage aspects of the project have made very little progress and therefore, it was suggested that this work be dropped. Suggestions were made to the effect that the present organisms they are using should be fully characterized but the group should proceed with further screenings in order to identify other possible organisms as an insurance policy. They should also look at modifying their organisms to improve their characteristics. Dr. Nestel noted that once the CIAT testing phase is somewhat advanced, the whole procedure should be ready to try out in another region, possibly in Malaysia.

7.5 Animal Nutrition Project

A continuation of the initial funding of this work is just starting, however, there had been problems in obtaining supplies of linamarin for preparation of special diets for the experimental animals. Without linamarin, the project is meaningless and therefore, considerable discussion revolved around the acquisition of adequate supplies of this substance and where it could be found. There has been some correspondence on this matter and further efforts will be made to locate and obtain supplies if possible. Dr. Cock noted as well that CIAT should have a supply of linamarase for use in screening for linamarin and cyanide. It was suggested that if supplies are not located fairly shortly discussions with the Horticultural Department at the University of Guelph should be reopened pertaining to the possibility of their producing supplies of linamarin. It was stressed, however, that this should not be done unless there was a positive intention of going through with such a project.

7.6 Mosaic Disease in Cassava

There was a strong feeling amongst the committee that this project is one of high priority and despite the fact that it is just getting off the ground it does look good. A much closer working relationship with Dr. Gamborg and the tissue culture project was recommended so that certain aspects of the work are not duplicated.

7.7 Nutrient Deficiencies in Cassava

This project will not be continued since CIAT now has a part-time soils man who is doing some of the cassava work and therefore, the Canadian support is no longer needed. There is no longer any need as well to look at aluminum as recommended at the last Advisory Committee meeting. There is still some money in the grant and with this they are doing work on more elements and definition of the deficiency symptoms of these elements. Some of the money will also be needed for the colour photography publication of cassava symptoms which is to be produced.

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7.8 Growth Physiology of Manihot

Some strong reservations were expressed about this project, however, the rather long familiarization period was defended by several people indicating that cassava stakes had not been available on time to start the project right away. It was stressed that the applicability of the results should be evaluated carefully. The CIAT representative, however, pointed out that Dr. Hunt will be working in Cali for a year and therefore, the photosynthetic systems will not be different. CIAT can also check out the results obtained in growth chambers with their data obtained in the field.

7.9 Solar Drying

This project was a small exploratory one and no report had been provided for the meeting. Mr. Hulse informed the committee that a report was to be forthcoming from Dr. Malik in the near future on the basis of which it would be decided whether further work along this line would be supported or not. Dr. Stepler criticized IDRC for dragging its feet on this project.

8.0 CIAT Outreach

8.1 Latin America and Brazil

Cassava is produced principally in three countries in Latin America: Brazil, Paraguay and Peru. CIAT representatives have visited all three of these countries in an attempt to develop a training and extension network in the region. In Brazil, a lack of trained personnel to do research with cassava was noted and representatives of EMBRAPA would like CIAT to train 15 to 20 Brazilians in research methodology for cassava in July 1974. In Paraguay there has been little interest shown to date, however, further attempts will be made in the future to make contacts and set up some kind of outreach program there. Colombia is already linked into CIAT's research and training program through close links with ICA and the Coffee Producers Association. Peru has no real cassava program at the moment, however, the Ministry of Agriculture is interested in developing some work on cassava and a relatively small input with a trained person could result in a program there. At present there is an excellent Peruvian trainee at CIAT who will be returning to Peru before long, and a two year program of support for him was presented to start a varietal testing and basic agronomy program in Peru.

Support was expressed by the committee for the Brazilian proposal and possibly the Peruvian one and it was suggested as well that some form of economic evaluation and analysis should be introduced into the training program of the Brazilians in order to link in with the Phillips proposal. It was noted that this was seed money to encourage the spread of CIAT findings as well as develop human resources and that the committee should underwrite the policy and idea of this kind of outreach. A word of caution was interjected to the effect that the committee can't commit CIAT board or IDRC to any specific action and therefore, further official consideration was needed in this, however, in principle, the idea and philosophy is valid and useful.

8.2 Southeast Asian Sub-Centre

Dr. Cock proposed that the technology for crops can progress most rapidly away from its center of origin where less plagues are liable to affect it. Cassava mosaic, for instance, is not found east of southern India and it was proposed that a small subcentre be set up somewhere in Southeast Asia, possibly Malaysia, with the objectives of making available different varieties of cassava, experimenting on adaptation of varieties, the development of production systems for Asia, and a training program for local technicians and scientists who are likely to work with the crop. If possible this should be a very small effort, possibly with one man and some field help in an existing Southeast Asian Institution. There was some opposition to this idea in the committee from the point of view that it is too early for this sort of thing and in several years it might be more necessary. There were also reservations that a separate unit would be set up and that CIAT should not be operating that far from its home base. India was suggested as a possible location for this subcenter, even though mosaic is found there, and it was suggested that the arrival of the disease was quite recent while another viewpoint cited evidence that there were resistant varieties in India which suggested mosaic has been there for a long time.

In general it was agreed that due to the start up time for this kind of project and the availability of a good man, it would be a good idea to go ahead now even though the program at CIAT may not yet be quite ready to reach out that far. Essentially, the suggestion was for one person to be put in Asia to act as a catalyst and communication link between an institution or institutions there and CIAT. The Chairman summarized by taking account of the various reservations expressed, and indicated that the Brazil project would receive support and the Asian proposal further attention.

8.3 Visiting Scientist in Biochemistry

CIAT had received a request from an Asian biochemist to spend a sabbatical year at CIAT. While it was not altogether clear how he could best be used or what he would be interested in doing, a number of suggestions were made by the committee which could tie in with CIAT's program. One suggestion was that he could be useful in testing for linamarin, linamarinase and cyanide and developing procedures for this. It was also suggested that he could look at the nutritive value of cassava leaves since it is possible to produce up to six tons per hectare of dried green matter in three months and the leaves of this cassava contain as much as 21% true protein. Another suggestion was screening for HCN in leaves of cassava. There was some discussion on these various suggestions and all of them received some criticism in one way or another until eventually it was pointed out that looking for a problem for a particular man was not good scientific procedure. In the end it was decided that it was worth taking the risk of bringing him to CIAT and it was agreed that Dr. Cock should communicate with him to find out if he were interested in a particular problem which CIAT was also interested in and if so, Dr. Cock should then contact Dr. Nestel.

8.4 Training Funds

It was pointed out by CIAT that they have only five man years of support for graduate fellows to participate in aspects of their programs at CIAT. Students from Canada would be welcome to do research at CIAT if funds were provided for their support and it was suggested that possibly two MSc or PhD students, one each from Guelph and McGill Universities would be a good place

to start. This was a suggestion that IDRC provide the support in question and it brought up some policy difficulties in that IDRC cannot support a student as such except as part of a research project. On the other hand, the Universities need funds to support the student during his course work as well as his thesis research and it was queried whether IDRC could not support a small research project which would include this. This issue was not resolved, however, the idea of Canadian students participating in the CIAT program was encouraged in principle with stress put on the fact that adequate supervision of the research work done by research fellows from both the Universities and CIAT is important. It was noted that the Universities and the CIAT program are both now ready for this and that some arrangement for letting Canadian students know what kinds of research CIAT needed done should be developed along with provision of funding. This is necessary in order to move quickly when suitable candidates are identified and CIAT agreed to make suggestions to Guelph and McGill which they can present to their students.

9.0 IDRC Supported Projects

9.1 Drying and Processing Workshop

This workshop which is to be held in Asia has now been pushed back six months in order to give more time for organization and planning and it was indicated that possibly three consultants would be engaged to provide specialist papers. Mr. Hulse explained that the object of the workshop was to examine current drying and chipping practices in Asia, discuss the technical feasibility of various kinds of improvement of drying and chipping, and problems and means of storing and processing cassava. It was questioned whether Dr. Malik from McGill University would have an input into this workshop and in reply it was noted that IDRC is to receive a report from him shortly and a decision would be made on the basis of the content of his report. The object of the workshop is to help define research priorities in the drying and processing of cassava.

9.2 Small Agronomy Workshop

It was suggested that IDRC would be interested in supporting a small workshop on agronomic aspects of cassava production possibly sometime around the end of 1974 at CIAT.

10.0 Future Direction of the Cassava Program

Dr. Cock indicated that he felt CIAT was only beginning to scratch the surface in their cassava production efforts and that a variety of other aspects of the crop could be looked at in much more depth as well. As an example he cited the CIAT-TPI cassava root storage program and indicated that one of the principle benefits of this program to date was the increase in shelf-life time they had been able to attain in cassava roots. Other suggestions were made as to future foci for research efforts which included work on cassava foods and human consumption of cassava products. It was noted that there is a lack of studies on the utilization of root crop flours and that some work could be done along this line. Reservations were expressed about this, however, since food technology products generally have to be developed and tested on site where they are used. The whole range of modifying traditional foods or developing new ones is a very large one and will be likely to involve a large number of people and institutions. Dr. Cock noted that CIAT's resources were limited and that it could not deal with all parts of the cassava production marketing and consumption system without spreading itself entirely too thin. On the other hand, he agreed with the idea of substitution for wheat flour by root crop flours. It was further pointed out that a distinction should be made between the CIAT cassava program and what could be called, in a much broader sense, a world cassava improvement program which includes research of many kinds and many places around the world. In closing this part of the discussion, the Chairman noted that it was significant that the CIAT team was looking to future objectives and thinking about where the program is headed in the long run.

11.0 Future Role of the Advisory Committee

This subject had been discussed at the end of the last Cassava/Swine Advisory Committee meeting and a lapse of two years had been suggested before the full committee would be called together again to review the overall program. It was questioned whether, since CIAT is to review all its programs just before its board meeting each Spring in order to avoid a string of individual reviews, this committee or part of it might not play a part and have an input there. CIAT did not feel that this was necessary for the next year at

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least, and the CIAT Annual Report would be sufficient to provide a comprehensive idea of program progress. If in fact, some disagreement or problem arose, it would be possible to bring some portion of the committee together to discuss it or, as an alternative, to deal with the problem by correspondence. The question of the committee's advice on CIDA's money for each year's program and on new Canadian research projects was discussed and it was felt that this could also be done by correspondence. It was agreed that a two year lapse would be in order, but that it would be valuable to the committee to be kept up to date on activity and developments in the overall program. Another meeting will not be held, therefore, until close to the end of the present CIDA funding in 1975. However, a comprehensive review of both Canadian and CIAT research at that time was viewed as being an important activity in recommending to CIDA whether or not they should continue support after 1976.

It was questioned whether, since this was a Cassava/Swine Advisory Committee the committee should not have been reviewing the swine program as well. The Chairman indicated that IDRC was making arrangements for an in depth review in the Spring of 1974, using experts in various aspects of animal production and research. This would form part of the CIAT Annual Review.

12.0 Should IDRC Look at the Yam?

The Chairman asked Dr. Martin to give a brief rundown on production and utilization of the yam. This he did, dealing with a number of points which covered production systems, botany, breeding, agronomy, weed control, harvesting, uses and utilization, limitations, taxonomy, processing, economics, and physiology. Dr. Coursey added that yam research has faltered because of the idea that yam production was declining, being displaced by cassava. While this is true in an overall sense, the yam is still a crop people eat as a preferred staple in many ethnic groups and is being displaced by cassava only because they can no longer afford yams. It must be looked at from the point of view of a horticultural crop and at specific geographic locations in order to appreciate its importance. In terms of nutrient content, it is better than cassava.

IDRC was urged to consider funding a workshop on yam research priorities and to review the status of current research. IITA has expressed interest in doing work on yams in West Africa, however, they will not work on Asian ones and this would be necessary.

13.0 Publications .

Questions arose as to who clears research reports for publications and what procedure should be followed in this respect. Dr. Tossell noted that his scientists have been asked to acknowledge both CIAT and IDRC in any publications they may produce and to send copies of the documents to both IDRC and CIAT. Mr. Hulse stated IDRC's policy that, since IDRC does not want in any way to control the content of scientific papers, scientific publications should go out under the name of the scientist doing the work. On the other hand, if policy or commitment statements are to be made, they must be cleared with IDRC. Dr. Cock felt that since much of the research in Canada is related to CIAT's program as well, the kinds of publications put out could have implications for CIAT and its program. It was agreed that the whole issue was based on a gentlemen's agreement of providing acknowledgement for collaboration from other individuals and institutions on the part of the individual scientist as well as a certain amount of goodwill.

14.0 Closing Remarks

Dr. Cock reported that the cassava team at CIAT had asked him to express thanks for the support and direction that the committee had provided for their endeavors over the past year and a half. Mr. Hulse in turn thanked the committee for their time, effort, advice and interest in what has been a very helpful and useful influence in the development of the whole cassava program. In particular he mentioned Dr. Steppler, who recommended Canadian support for cassava research in the first instance, and commended him for his foresight. The Chairman noted that IDRC had received good value from the meetings of the committee and that their input had been much appreciated by him personally. With this remark the meeting was adjourned.

TRITICALE: PROCEEDINGS OF
AN INTERNATIONAL SYMPOSIUM

El Batan, Mexico, 1-3 October 1973

List of Titles and Authors of Papers Presented

Forward	W. David Hopper
Historical Review of the Development of Triticales	Arne Muntzing
The Development of Triticales in Western Europe	E. Sanchez-Monge
The Development of Triticales in Eastern Europe	A. Kiss
Research Work with 4x-Triticale in Germany (Berlin)	K.-D. Krolow
The Triticale Program in the United Kingdom	R.S. Gregory
Progress in the Development of Triticale in Canada	E.N. Larter
The Triticale Program in the United States	R.J. Metzger
The Triticale Program at CIMMYT	F.J. Zillinsky
Prospects of Triticale as a Commercial Crop in India	J.P. Srivastava
Triticale Breeding Experiments in India	N.S. Sisodia
Triticale Research Program in Iran	M.A. Vahabian
Triticale Research Program in Ethiopia	F. Pinto
Triticale Research Program in Algeria	Herb Floyd
Triticale Program and Potential in Kenya	B.A. Nganyi Wabwoto
Triticale Breeding Experiments in Chile	P.C. Parodi
Expanding the Outreach Programs	R.G. Anderson
Meiotic, Gametophytic, and Early Endosperm Development in Triticale	Michael D. Bennett
Improving Seed Formation in Triticales	F.J. Zillinsky
Univalency in Triticale	P.J. Kaltsikes
Cytogenetics of Hexaploid Triticale	Anulf Merker
The Use of Chromosome Analysis to Detect Favourable Combinations From Octoploid x Hexaploid crosses	M.H. de Sosa

Preliminary Report on the Cytogenetics of Tetraploid x Diploid Wheat Crosses	R.J. Metzger and B.A. Silbaugh
Diseases of Triticale	M.J. Richardson and J.N. Waller
Agronomy and Physiology of Triticales	Anthony R. Fischer
Early Steps on Triticale Breeding at CIMMYT	M.A. Quinones
Introduction of New Forms and Types from Wheat to Triticale	R. Rodriquez
Need for Wide Adaptation and Sources of New Genetic Variability in Triticale	M.M. Kohli
Production of Triticale Germ Plasm	J.P. Gustafson
Broadening of the Triticale Germ Plasm Base by Primary Hexaploid Triticale Production	A. Campos V.
Nutritional Investigations on Triticales for Poultry	James McGinnis
Comparison of the Vole, Rat, and Mouse as Assay Animals in the Evaluation of Protein Quality	B.E. McDonald and E.N. Larter
Industry and Utilization	Charles Briggs
Future Role of Triticales in Agriculture	L.H. Shebeski

AMERICAN ASSOCIATION OF CEREAL CHEMISTS

58th Annual Meeting, St. Louis Missouri, November 4-8, 1973

SYMPOSIUM: BIOCHEMISTRY, NUTRITION, AND UTILIZATION OF TRITICALE 1

- Hulse J.H..... Triticale and Developing Countries
- Zillinsky F.J..... Highlights of Recent Triticale Development
- Jenkins B.C..... Hexaploid Triticale: Past, Present and Future
- Strand R.D..... Triticale Standards in the Marketplace
- Dronzek B., Orth B.,
Bushuk W..... Scanning Electron Microscopy Studies of Triticale and Its
Parental Species
- Bushuk W..... Chemical and Physical Characteristics of Triticale Proteins
- McDonald C.E.,
Ahmed S.R..... Protein Quality of Triticale
- Villegas E.M., Bauer R. Protein and Lysine Content of Improved Triticale
- Madl R.L., Tsen C.C.... A Study of the Proteolytic Enzyme System of Triticale
- Madl R.L., Tsen C.C.... Trypsin and Chymotrypsin Inhibitors of Triticale
- D'Appolonia B.L..... A Review on the Starch of Triticale
- Elliott F..... Bioassay Analysis of Triticale with Meadow Voles
- Kies C..... Triticale and Human Nutrition
- Farrell E., Tsen C.C... Milling Characteristics of Triticale
- Tsen C.C..... Bakery Products from Triticale Flour
- Lorenz K, Welsh J..... Food Product Utilization of Colorado-Grown Triticales
- Allee G.L..... Triticale as a Feed
- Saunders R.M.,
Betschart A.A.,
Connor M.A.,
Edwards R.H.,
Kohler G.O..... Preparation and Properties of Triticale Protein Concentrates
Prepared by Wet-Processing of Triticale Bran