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BRA/69/535

CNPTRIGO - EMBRAPA
PASSO FUNDO, RS, BRASIL

INCREASE AND DEVELOPMENT OF WHEAT PRODUCTION

Phase I (1971-March 1980)

DRAFT INTERIM REPORT

T. Mc KNIGHT, Project Manager (1969 - 1973)
W. F. KUGLER, Project Manager (1974 - 1978)
B.R. BOUGLÉ, Acting Project Manager (1979-1980)

Summary

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Part I - Introduction

1.1 Background of the Project

As early as 1967, the Government of Brazil submitted a request to UNDP for international assistance, aimed at strengthening national institutions of agronomic research in Brazil, especially on wheat production.

In the past, the Brazilian agronomic research has been negatively affected by two main trends. On that hand, due to the relative abundance of land and handworkers, there was low pressure on agronomic research for developing technologies aimed at to husband these factors. On the other hand, individualistic standards in research work (imported from developed countries) were prevailing at that time. In the beginning of the decade 1970-80, new trends developed under the pressure of increasing demand for food and fibers, as well as under the necessity to reach the new economical goals. A new concentrated model of research was studied for better use of research people and available resources in a limited number of agricultural products. On 7 December 1972, the Congress approved founding of EMBRAPA (Empresa Brasileira de Pesquisa Agropecuária), as public enterprise for coordinating and operating, at federal level, research activities on agriculture and stock-farming. This rapid evolution of the Brazilian system in agronomic research reflects the governmental care for ensuring adequate structure able to implement, through concentrated human and financial resources on some limited agricultural products, the economical objectives fixed by the Government, among which national self-sufficiency in wheat production was of major priority.

The policy of the Government of Brazil to achieve self-sufficiency in wheat was institutionalized in 1967. As a consequence of a price subsidy programme associated with a credit policy for promoting wheat cropping, a steady increase in wheat acreage occurred:

	Wheat acreage (1000 ha)	National Production (1000 t)	Productivity
1967	562	365	648 kg/ha
1970	1,861	1,735	932 kg/ha

The apparent increase in productivity is in reality within the range of the great variations over the years which characterize the average productivity of wheat in Brazil: for example, 989 kg/ha in 1962 and 324 kg/ha the following year 1963.

Unstability and low level in wheat productivity are the main features of the national Brazilian production.

In spite of a great increase of the acreage cropped with wheat, the national wheat production remained very short in comparison with the national consumption (about 3,680,000 tons in 1970), which showed at this time an increase of 7.4% per year, due to synergical effects of demographic increase and qualitative food habits favouring bread consumption. The same year 1970, Brazil imported some 1,937,000 metric tons of wheat, so burdening the national balance of payment of about 130 millions US$. After oil importations, wheat is the second major imported item in Brazil.

That is why development of wheat production is considered to be of highest priority by the Government of Brazil with a view to reducing import needs and eventually reaching a level of self-sufficiency, but the major constraint to this broad objective are the high incidence of wheat diseases and the soil fertility problems. In that scope, the Government of Brazil sought assistance from the United Nations Development Programme, with FAO as Executing Agency, to institute a coordinated research programme aimed at the solution or amelioration of the problem, through the Project UNDP/SF.381 (FAO/BRA/69/535), headed "Increase and Development of Wheat Production".

1.2 Objectives of the Project

1.2.1 The purpose of the Project was to assist the Government of Brazil in increasing and developing the wheat production through a

co-ordinated research programme in the major wheat growing areas in the States of Rio Grande do Sul, Santa Catarina and Paraná.

The Project's Headquarters was located at Passo Fundo in the State of Rio Grande do Sul, harboured by the Wheat Experiment Station of IPEAS (Instituto de Pesquisas e Experimentação Agropecuárias do Sul) until October 1974, from which date that station was transformed into "National Wheat Research Center" (CNPT) of EMBRAPA.

1.2.2 The main objective of the Project was to raise wheat yields from an average of 800 kg/ha (with top yields of 2000 kg/ha under the best conditions) up to an average of 1,200 kg/ha (with top yields of about 3,000 kg/ha).

1.2.3 The specific actions included:

a) Plant Breeding

- introduction of genetic material from CIMMYT programmes in Mexico, Argentina, Colombia and from other wheat improvement centres, in the hope of an immediate breakthrough.
- conventional breeding programme under existing or improved soil conditions.
- extensive testing of selected varieties coordinated with fertility and ecological characteristics of the major wheat-growing areas.
- reducing the time needed for breeding new varieties by systematic cropping of two generations throughout the year.
- laboratory studies on wheat quality.
- basic seed production and multiplication of high yielding selected varieties.
- release to the farmers of the suitable highest yielding varieties.

b) Plant Pathology

- reviewing the existing plant pathological work.

- helping the Breeding programme through creation of epiphytotics aimed at selection of resistant varieties, and recording disease data when necessary.
- testing advanced lines in the field and the greenhouse against prevalent diseases.
- information on physiological races of prevalent diseases.

c) Soil Fertility

- extending and increasing the scope of regional experiments on fertilizers and liming, assessing the influence of lime in association with major and micro nutrients on yields.

d) Cultural practices, weed control, crop rotations

- improvement in soil management techniques, weed control and cultural practices.
- studies on other crops in rotation with wheat.

It was later agreed (1974) with the Director of the Counterpart Agency (EMBRAPA) that work on soil fertility should be carried out by the counterpart staff, allowing a Farm Management Economist to be added to the FAO team for the following activity:

e) Farm Management

- development of farm management economics and production systems research, in order to promote wheat production through the rational use of farming enterprise resources.

In that scope, the FAO Agronomist (Field Trials) was asked for initiating technical studies on Production Systems for providing physical data to the Economist and to work with him in close collaboration in that field of research.

In its activities, the Project received full support, assistance and facilities of IPEAS from the beginning and, further on, of EMBRAPA's CNPT. It has been premised that complete integration of FAO staff and Brazilian counterpart staff was the dominant rule in the research work performed in the CNPT of Passo Fundo as well as elsewhere in the different

research stations of Rio Grande do Sul, Santa Catarina, Paraná and Mato Grosso States.

1.3 Implementation of the Project

1.3.1 For the purpose of increase and development of wheat production in Brazil, the Food and Agriculture Organization of the United Nations was designated as Executing Agency for the Special Fund, acting in co-operation with the Government of Brazil. The Plan of Operation of the Project UNDP/SF.381 (FAO/BRA/69/535) was written as provided for in Article I, paragraph 2, of the Agreement signed on 16 September 1960 by the Government of Brazil and the UN Special Fund. The Plan of Operation was approved and signed by the Parties in December 1970 (UNDP: 4/12/70; Ministry of Agriculture: 6/12/70; FAO: 16/12/70; Government of Brazil: 28/12/70), for a duration of four years (starting 1/1/1971, terminating 31/12/1974), under the following financial basis:

	in US$:
. Special Fund Allocation:	1,063,800.--
Consisting of: - Special Fund Contribution:	970,200.--
- Government Contribution towards local operating costs:	93,600.--
- Government Contribution in cash:	N.A.
. Government Counterpart Contribution in kind:	1,065,077.--

(details in Annexes No. 1 and 2)

The Project Manager arrived at the Project's site in Passo Fundo in October 1969, a little over a year before approval of the Plan of Operation. The Project started functioning from 1st January 1971. The lists of FAO Personnel and Counterpart

Personnel are given in Annexes 3 and 4, respectively. FAO staff evolution is summarized in Annex 5.

1.3.2 A mid-term evaluation of the Project was made in October 1973 by a joint UNDP/FAO Mission, which recommended extension of the Project for a period of two years beyond 31 December 1974. The Project Revision "E", approved and signed by the Parties on 27 November 1974, provided supplementary assistance until 31 December 1976, according to revised work plan and revised project budget (see Annex No. 6).

1.3.3 A second mid-term UNDP/FAO Review Mission visited the Project site in October 1975. Considering the enormous problems facing wheat cultivation, which require long time for achieving their solution, the Mission recommended new extension of the Project for a period of at least two years for strengthening research on new or less developed areas.

The Project Revision "M", approved and signed by the Parties on 30 June 1978, provided supplementary assistance for a period of three years terminating on 31 December 1979, according to revised work plan and revised project budget (Annex No. 7).

1.3.4 Lists of fellowships awarded by the Project, of major items of equipment provided by UNDP and Total UNDP Contribution as adjusted on 5 June 1979 may be found in Annexes No. 8, 9 and 10, respectively.

1.3.5 In December 1978, a Tripartite Review Mission (UNDP/FAO/Government Agency EMBRAPA), held at the CNPT in Passo Fundo, assessed the work performed by the Project in close collaboration with Brazilian staff. The Head of CNPT described the UNDP/FAO contribution as decisive in setting up the Centre and in training personnel, but today the need to modify the approach and concentrate on systems is recognized.

The investments of CNPT for implementing research work increased

dramatically from 11.7 million Cr$ in 1975 up to 84.6 million Cr$ for 1979. Extension of the Centre's area is forecasted for an additional 150 hectares (+ 50%).

In 1979, the personnel of the CNPT reached 203 total staff, among which 40 researchers. Nearly all researchers are at least at Masters Level and several at Ph.D. level. In Brazil at present there are estimated to be approximately 100 researchers in the area of wheat.

In its final conclusions, the Tripartite Review Mission, strongly recommended that a draft project document be prepared for a project Phase II beginning in 1980 for three years in a view to developing and supporting the four research areas considered now of utmost importance within a comprehensive approach of wheat production extended to the national wheat growing area:

- Genetic improvement, with special reference to "horizontal resistance";
- Production systems research;
- Wheat root system research;
- Integrated control of wheat aphids.

The Project Document was approved and signed by the Parties on March 27th 1980 extending the ongoing Project by three years (ending 31/12/1982), with main activities as above-described. Since the beginning of 1980, the CNPT has been namely designated as coordinator of the National Wheat Programme, supervising and implementing at national scale all activities in wheat research developed within the EMBRAPA's system or by other Brazilian institutions. This fact gives an effective national dimension to the CNPT of Passo Fundo, the activities of which being extended to the national wheat growing area.

1.3.6 Project reporting was organized as follows:

- Periodic 6-months Project Progress Reports submitted by the P.M. to FAO and UNDP Resident Representative, giving summary of project implementation, general description of activities and achievements

in research areas related to FAO staff's work, project inputs and statement on Project and Government Personnel. These reports are referred to the Government through UNDP Resident Representative.

- Periodic Quarterly Progress Reports, written by each FAO staff member on his specific work, submitted through P.M. to the Division of Operations (Latin America Service, AGOL) and relevant Technical Divisions at FAO Headquarters in Rome, as well as to FAO Representative in Brazil and FAO Regional Office for Latin America in Santiago (Chile).

- Technical Final Reports, written by each FAO expert (or consultant) upon termination of assignment, finalized and validated by the relevant Technical Divisions at FAO Headquarters, and transmitted formally to the Brazilian Government. These reports are constituting the essential outputs of the Project on technical and scientific assistance provided by the Project staff. They are listed in Annex No. 11. It is pointed out that these reports give the list of all publications or papers presented in meetings, congresses or seminars attended by the FAO expert, at national or international level, and related to the work he developed during his assignment in the Project.

1.3.7 Before presenting the results of the agricultural studies carried out during the Project, which are of very substantial value, particular successes must be emphasized, giving additional light for measuring the achievements of the Project:

. A major contribution of the Project has been the establishment in the field of a multi-disciplinary, professionally agressive and respected team of researchers in which international FAO staff fully integrated.

. The rapid development by the Government, through EMBRAPA institution, in the heart of the wheat area, of a perfectly equipped National Wheat Research Centre (CNPT) should be noted. The complex research campus of the CNPT in Passo Fundo is now

probably one of the best wheat research centre in Latin America, and the Government's determination to continue to develop the CNPT is of greatest significance for reaching the national objectives in wheat production.

- The enthusiasm, the skills and the attitudes of the counterpart staff must be referred to, and at this stage it must be stated that there is no question of their ability to continue with the Project activities and later to develop new lines of investigation, in so far as analytical research is concerned. However, the profound change occurred during the most recent years into the scientific approach of wheat research at the CNPT (see General Recommendations) implies further training of counterpart research team in comprehensive and synthetical approach of national wheat research.

Therefore, it is appropriate to refer to these aspects in this report.

Part II - Results and Conclusions

1. Plant Breeding

1.1 Wheat Breeding

Breeding better varieties suited to Brazilian conditions was one of the main activities of the Project, with the support of phytopathology, soil fertility and agronomy experts.

Almost all the efforts were devoted to achieve a higher yield potential in new cultivars, resistant or tolerant to main diseases and pests as well as adapted to the soils of the main wheat growing region of Rio Grande do Sul, known by their Al toxicity.

Since the Project started in 1970, 22 varieties were released by IPEAS and the Passo Fundo Wheat Experimental Station (1970-1974) and afterwards, up to now, by the National Wheat Research Centre (CNPT).

Actually, 21 counterpart staff members are fully or partially engaged in wheat breeding, most of them with M.S. degree.

Three counterpart staff members took post graduate courses in plant breeding in different countries and universities.

The FAO Expert (Plant Breeder), who assisted breeding since 1971, finished his assignment at the end of 1976. Actually, the breeding programme is taken over by the national counterpart.

1.1.1 The breeding programme has developed according to the local requirements. A very large collection consisting of material from all over the world has been screened to select material for use in the crossing programme. Up to two thousand crosses are made every year. Due emphasis is given to multiple crosses for combining desirable characteristics. Newly developed material both in segregating populations and advanced generations is being used for better adaptation. Large populations are grown in segregating generations for effective selection. The field selections are carried out as

and when diseases appear. Final seed selection is made in the laboratory. 2886 new lines were bulked for yield testing from 1972 to 1976. Multilocation testing of superior lines is carried out in collaboration with other institutes connected with wheat improvement (see: 6. Institute Building). Since 1972, 15 varieties have been released for farmers use, showing noteworthy yield increments. Moreover, lines with similar yield potential but possessing desired combination of disease resistance are also released to maintain diversity.

Excellent facilities for growing an off-season crop in Brasília have been developed. Limited number of crosses are also attempted during off-season in Passo Fundo where small off-season nursery is grown every year with irrigation arrangements and this activity is going to be developed by implementing a new screenhouse especially suited for this purpose.

Field selections were carried out under natural epiphytotic conditions. Under natural conditions material remains free from selection pressure against those diseases which are not prevalent. Stem rust has started to develop only in the years 1974 and 1975 and lot of material was observed to be susceptible. With artificial inoculations, selection work has improved.

Work on Cytogenetics has been taken up by the counterpart staff and work in the development of monosomic lines in the local material has been initiated.

1.1.2 Wheat area in the northern part of Paraná, São Paulo and southern Mato Grosso expanded rapidly since 1973. Unfortunately there have been heavy losses to wheat crop in this region in the last years due to climatic adversities like frost and untimely dry season or excessive rains. In 1976, heavy attack of stem rust has also damaged the crop. Based on the experience it can be concluded that this region also does not provide easy conditions for wheat cultivation. The expansion of area under wheat in these regions requires extensive regional research efforts to find out appropriate

sowing time and other cultural practices, and also breeding of new varieties. The introduction of varieties susceptible to stem rust can cause serious problems not only for this region but for the crop in the south as well. In 1976, stem rust appeared 40 days earlier in the south as a result of inoculum build up in the north. Since crop matures earlier in the northern region it is necessary to take special care in choosing the sources of resistance in the breeding programme in the north. Using the same genes in both the regions would be undesirable. Adequate research facilities were developed in the region for successful cultivation of wheat, through satellite research stations of EMBRAPA in Mato Grosso and Paraná States.

1.1.3 The wheat yields in Brazil are not only low but highly unstable because of high fluctuations in weather conditions. The stability in yield can be achieved if commercial varieties are genetically diverse and do not suffer equally from a serious epidemic of any disease. To achieve this objective, a serie of new improved cultivars is now available for the main wheat growing areas in Brazil. Since 9 years are needed from the initial cross to seed release for farmers use, the first wheat cultivars fully created by EMBRAPA-CNPT's breeders will be available in 1984. This is why the improved cultivars actually commercialized come from the breeding work previously started and developed by the State Secretariat of Agriculture of Rio Grande do Sul (IPEAS, Pelotas and Passo Fundo), with the assistance of the Project as soon as it begun. Additional information on the material bred by the CNPT with the assistance of the Project is given in Annexes No. 12 and 13, where information is given on recommended cultivars for southern wheat growing regions. Though it is difficult to appreciate through average yields the progress achieved in wheat breeding, some examples given below would help in this evaluation:

- In a very bad year, 1977, the farmers following the technical recommendations of the CNPT harvested up to 2,500 kg/ha of good

quality grain, whilst 400 kg/ha of shrivelled grain were obtained under traditional wheat cropping.

- In a very good year, 1978, the same farmers yielded up to 4,200 kg/ha, compared with 1,200 kg/ha in traditional production.

The most important conclusions arising from these examples are:

a) when adopting a newly improved wheat cultivar, the farmer must also adopt an improved technology in wheat cultivation; if no, he is loosing the benefit coming from the potentially increased productivity of the new cultivar.

b) since the average wheat yield in Rio Grande do Sul was 400 kg/ha in 1977, and 1,200 kg/ha in 1978, the comparison with the yields obtained by farmers following the CNPT's recommendations gives some measurement of the gap still existing between research and extension.

1.1.4 The impact of the breeding work realized by CNPT with the Project's assistance is considerable. In fact, the use of a "recommended wheat variety" is a compulsory condition for the farmer to obtain bank credit for financing necessary inputs (seeds, fertilizers, etc.). Yearly, the South Brazilian Commission for Wheat Research elaborates a list of recommendations for wheat production, amongst which "recommended cultivars". That is to say, the totality of the wheat acreage financed by the Bank of Brazil is planted with improved wheat varieties which are direct or indirect outputs of the breeding work developed by CNPT with the assistance of the Project. This acreage was, in 1979, 4,100,000 hectares.

1.1.5 Wheat breeding alone cannot overcome all problems in the Brazilian wheat production. The use of improved wheat varieties is an important component in the research for better productivity and stability in wheat production, and also is, indeed, the cheapest investment for the producer. However, the production system and the technological package (seedrate, soil preparation, fertilization, etc.) with which wheat is produced, are essential factors determining the practical

effectiveness of wheat breeding at farmers level. Although crop protection by treatments with chemicals was developed early (1974, 1975), it was only in 1977 that the fundamental importance of crop rotation was recognized by the Brazilian counterpart.

1.1.6 New openings are in sight in wheat breeding techniques, through applied utilization of fundamental findings in Plant Physiology recently achieved. If a wheat segregating line could be reproduced in such a way that an haploid descend is obtained (i.e. a plant with "n" chromosomes, instead of "2n" chromosomes as usual in a common plant), it should be possible after duplication of the chromosomic number by appropriate treatment (colchicine) to obtain, in only one step, fully homozygous and fertile plants (i.e. genetically "fixed" cultivars). This work was performed at the CNPT by a FAO Consultant (E.J-M. PICARD, France) in October-December 1979, who plated 42,000 wheat anthers into a special culture medium. These cultures gave 32 embryos, amongst which 4 haploid plantlets emerged. These 4 wheat haploid plantlets are the first ever produced in South America. They have been cloned (vegetative multiplication) and already gave 40 plantlets, which will be "duplicated" by colchicine treatment as soon as possible, with a view of obtaining "diplohaploidized", fully homozygous and genetically "fixed" wheat cultivars. This means, in practice, a drastically reduced time for obtaining a new wheat cultivar ready for multiplication and further release: theoretically, one year only, instead of some 8-9 years according to classical selection methods. This new method only requires handiness and no sophisticated material but an air-sterile desk. It is now developed, for the moment, in the CNPT's Cytogenetics Laboratory and followed-up with the greatest interest by the team of breeders. This is another outstanding achievement of the Project to have introduced this "revolutionary" technique in plant breeding, aimed at to speed up the obtention of new improved wheat cultivars.

1.2 Wheat Breeding for Horizontal Resistance

1.2.1 In November 1975, the international programme on horizontal resistance was initiated in Passo Fundo to stabilize and increase wheat yields, while the use of fungicides and insecticides should be reduced to a minimum. Plant protection indeed is one of the most serious problems of wheat production in Brazil. Every year large crop losses occur due to diseases, sucking pests and virus.

The programme has been set-up by Mr. R.A. Robinson, having still a very important contribution to the programme as FAO Consultant, providing most of the theoretical background and giving stimulating new ideas for further development. Excellent support and coordination was given by the Technical Division at FAO's Headquarters. In Zambia and Morocco are two other I.P.H.R. programmes on horizontal resistance of wheat underway and there exists a close collaboration with these programmes in the form of interchange of experience, combined experiments on male gametocides and multiplication for each other.

Breeding for horizontal resistance in wheat is a new approach with great advantages over the traditionally applied techniques. Large scale (± 1/2 ha per population) random polycrosses with a male gametocide are made, accumulating horizontal resistance in a sequence of generations, exerting an adequate artificial selection pressure in the field with all the local important pests and diseases together.

The horizontal resistance programme distinguishes itself by the possibility of selection for resistance against all the diseases and pests together (including those of the roots) as well as for agronomic type, root system, quality etc. etc.

Since the selection is made within the esodemic, it means that the resistance accumulated in this programme is stable and will not break down.

1.2.2 Today the most advanced population called "Generation 5" is the best material to evaluate the first results of the horizontal resistance programme.

In Passo Fundo, in 1978, has been performed a crop loss appraisal experiment to evaluate the first results accrueing from the new horizontal resistance screening method (Annex No. 14).

A measurement of accrueing horizontal resistance is given by the comparison between original mixture and Generation 5, without any plant protection:

	No plant protection		
Generation 5	2939	(115)	A
Original mixture	2545	(100)	B
Jacuí	2511	(99)	B
Nobre	2070	(81)	C

(Tukey 5% = 320 kg/ha)

The varieties Nobre and Jacuí are the current major wheat varieties representing 80% of the wheat area of Rio Grande do Sul.

"Generation 5" is the most advanced material in the H.R. Programme. About 50,000 wheat plants have been hand-selected after artificial inoculation in the field with stem rust, leaf rust, Septoria nodorum, Septoria tritici, powdery mildew, scab and Helminthosporium sativum.

The 3rd generation of a second original mixture, started in Passo Fundo in 1977 to enlarge the base of the programme, looks very promising and a selection of ± 20,000 individual plants has been done.

1.2.3 The polycrosses with Brazilian and Dutch spring wheat varieties have been partly successful, but had an interesting unexpected aspect. Only one Dutch variety coincided with its growth cycle and has been open cross pollinated. However Dutch wheat seems to produce a significant better root system and tillering capacity than the Brazilian varieties. Therate of infection with Helminthosporium was the same and the varieties were growing side by side. In that scope, root problems can be approached through horizontal resistance programme.

1.2.4 Each year from 1977 onwards about 10,000 of the best individuals of the population were and will be selected, going into a "Single Seed Descent" trial for seven generations of self-pollination in order to obtain in a minimum period 10,000 homozygous plants out of which future varieties can be selected.

Landrace observations and selection have been carried out. Selections look very promising for making stable stop-gap varieties until the random polycross populations are producing cultivars.

1.3 Triticale Breeding

In 1976, one counterpart staff member holding Ph.D. was put full time in charge of the triticale breeding programme, which was already in progress started with material introduced from CIMMYT and INTA (Argentina). Accompanied by another national counterpart, he went to CIMMYT, during February-May 1976, to get in closer contact with the breeding programme there.

2,500 entries of triticale selected at CIMMYT were planted at Passo Fundo, besides 650 F_2 and 400 F_6.

During 1978 season, 710 cultivars and 650 F_2, brought from CIMMYT were planted at Passo Fundo.

The very bad season of 1977, offered a good opportunity for selecting triticales in breeding nurseries.

The best selections have been increased for commercial production. Five new cultivars, selected for Brazilian conditions, have been included in a regional yield trial.

Triticale looks very promising, yielding up to 4,000 kg/ha. On an average, triticales produce 30% higher yields than wheat.

Triticales behave very well under Brazilian conditions, and are adapted to Al toxicity soils. Triticale looks as a new promising crop for Brazil, and breeding for quality improvement aimed at bread making (blended with wheat flour), is continued.

1.4 Malting Barley Programme

On the light of the very good results obtained through crop rotation trials executed in 1975 by the FAO Agronomist (Production Systems), illustrating the high potential productivity of barley in southern Brazil (4-5,000 kg/ha with low protein content), the Brazilian Government decided to expand barley production starting 1975 in order to achieve by 1984, self-sufficiency in malt. Actually 90% has to be imported demanding more than US$ 60 millions in currency.

Malt consumption for 1976 has been estimated around 239,000 t. By 1984 the demand for malt, for the brewery industry, would surpass 320,000 t. In order to supply all the malt needed, barley production would have to be increased from 23,000 t (1975) to 530,000 t by 1984.

In order to achieve such a goal, special actions have been taken, in different fields and aspects.

Research on barley production was promoted in many specific fields, covering at the same time, different regions of Brazil.

Under the chairmanship of the CNPT Director, a special committee in which the Project Manager integrated, outlined some guidelines, for the CNPT, indicating main research areas, giving also estimates on the budget needed for carrying out the work.

The malting barley programme of the CNPT was approved in 1976, and started the activities in 1977. The FAO Project assisted the barley programme through introduction of collections (92 entries from Beltsville, U.S.A., 1972; 5,000 entries from USDA World Collection, 1977; 2,000 entries from CIMMYT, INTA Argentina, and Columbia, 1978).

Self-sufficiency in malt is forecasted for 1984, depending on the industrial capacity, which is rapidly increasing. This achievement, representing potential savings of more than $ 60 millions (in 1979), must be considered as an indirect output of the Project.

1.5 Other Crops

Attention was paid, as early as 1975, to other crops to be introduced

into a more diversified cropping pattern, especially in the South of Brazil, aimed at better control of wheat soil-borne diseases like "take-all" (Ophiobolus graminis).

The Project assisted in the introduction of collections of oats (2,300 entries from USDA) and lineseed (from Argentina). A special breeding programme for oats started in 1976 at the CNPT, taken over by the counterpart. Similarly, a cooperative lineseed breeding programme developed between Brazil and Argentina.

More recently, the Project also assisted in introducing some cultivars of rapeseed and lupines, to be tested under local conditions.

Actually, oats, rapeseed, lineseed and lupines are included as winter crops, alternated to wheat, in the new diversified crop rotation experiments now underway at the CNPT of Passo Fundo.

2. Plant Pathology

As many diseases attacking the wheat plant are present in Brazil, and many of them are very severe, phytopathology research demanded a very strong support, in close collaboration with the wheat breeding activities. Since this collaboration was, as early as the beginning of the Project, perfectly established, the outputs and conclusions as described in sub-chapter 1. (Plant Breeding) are in fact common achievements of both areas, especially for disease resistant cultivars. This intense collaboration was one important aspect of the assistance provided by the Project.

The other essential part of this assistance was devoted to identification of the main pathological factors affecting the wheat plant, assessment of their importance, and attempts for overcoming the problems.

The FAO Expert (Plant Pathology) begun his activity in 1971, having been very helpful in organizing the laboratory and greenhouse facilities, as well as all pathological activities in support of the breeding programme.

One counterpart staff member took his Ph.D. degree with a FAO fellowship at Washington State University, Pullman. Actually, eight phytopathologists

are working at the CNPT, most of them having M.Sc. degree.

2.1 As early as 1971 and 1972, field experiments were carried out, in order to obtain a first appraisal of losses caused by wheat parasites. The global aim was to share the part of each group of parasites in the yield losses in relation to fully protected plants, i.e. plants growing in desinfected soil (VAPAM), under insect-proof cages, with fungicides applied once a week during the whole plant life cycle. From these experiments, it was estimated that:

- when total plant protection is applied (check), wheat yields were as high as 9.6 $t.ha^{-1}$ (1971) and 5.4 $t.ha^{-1}$ (1972), so demonstrating that Brazilian wheat cultivars are genetically suited for high yields;
- foliar diseases reduced the yield by 69%*;
- soil borne pathological factors reduced the yield by 50%*;
- wheat aphids reduced the yield by 49%*.

(*: in relation to the check with full protection)

These data, although giving a rough approximation of the damages, gave for the first time a clear picture of the situation faced by the Brazilian wheat growers, and also gave a basis for determining research priorities.

2.2 Since 69% and 49% of the damages were caused by foliar diseases and wheat aphids, top priority was given to the use of phytosanitary treatments in order to overcome these problems, having always present in mind that, at any rate, controlling wheat diseases with chemicals should not be looked as an alternative to breeding disease resistant wheats. However, an immediate solution was needed. The main diseases attacking the aerial part of the wheat plant were found to be: powdery mildew (Erysiphe graminis f.sp. tritici), leaf rust (Puccinia recondita), stem rust (Puccinia graminis f.sp. tritici), leaf blotch (Septoria tritici), glume blotch (Septoria nodorum) and helminthosporium (Helminthosporium sativum). Pioneer works

on the use of chemicals, at field scale, started in 1973 at the CNPT with the assistance of the Project, aimed at to determine recommendations for farmers use. These recommendations became officially recognized on and after 1976 in Rio Grande do Sul State, including bank credit. Therefore, the acreage receiving phytosanitary treatments expanded rapidly: from 500 ha treated in 1973 (experiment fields), to more than 1.5 million ha, approximately, in 1977 (southern zone). In order to recommend the best treatment schemes with fungicides (and insecticides, cf. 3. Entomology), experimental network continues to be carried out yearly for determining, beyond the best products available, the rate, specificity, time and number of applications, in order to secure the best economical returns from this practice.

2.3 Although fungicide effectiveness has been experimentally proved, some impediments are still hampering full adoption of phytosanitary treatments in wheat production, amongst which, by example, the lack of informative and demonstrative media linking research and farmers. Success or failure in fungicides use much depends on the disease(s) occurring, the wheat cultivar grown and, overall, on correct application. There is no ready-made pattern in plant protection through chemicals, and each wheat field is a particular case. Therefore, better skilled and more numerous extensionists are needed, for training, informing and assisting the farmer on the matter. The practical effectiveness of the recommended phytosanitary treatments is highly variable, depending on the local situation and the year. However, it is very common to observe a yield increase of about 20% in treated fields in comparison with untreated ones.

2.4 The researches on what has been called "the wheat roots problem" really started in 1975, with the first field data putting into evidence a low number of spikes per plant, hence a low population of spikes per unit area in spite of rather good plant population (see 4. Agronomy). Plant growth being governed by photosynthesis in the green aerial parts and by uptake of

nutrients and moisture by roots, there is an evident interaction between the two processes. Therefore, if roots are damaged by any pathological factor, they absorb only small amounts of nutrients and moisture, so impairing shoot growth even when aerial conditions are favourable. Additionally, the 1972's experiment stated that 50% of the yield losses came from soil borne problems. Therefore, it is somewhat surprising that the "wheat roots problem" has been kept in the background by the CNPT during about 5 years. Priority should have been given to it as soon as put into evidence (1972).

2.5 Effective work started in 1977 with the assistance of a FAO Consultant (J.W. HENDRIX). Studying roots growth in a "mist-chamber", he stated that root growth was conditioned by soil borne factors, at germination stage, still unexplained. Later on, two decisive FAO consultancies (P.J. SHIPTON and A.D. ROVIRA, 1979) clearly identified two fungi (Gaeumannomyces graminis, var. tritici, "take-all" disease; and Helminthosporium sativum) as being the major root diseases on wheat in Rio Grande do Sul. There was no evidence of nematode damage to roots in any sample observed. The FAO Consultants also stated the widespreadness and economical importance of these soil-borne diseases. A field survey was undertaken to assess root diseases in 31 fields chosen at random on a 1,200 km route in western and northern Rio Grande do Sul. All the fields (100%) were found infected with Helminthosporium, and about one third (32.2%) with "take-all". The value of overall yield losses to Rio Grande do Sul has been estimated to excess US$ 76 million for 1979. The solution of this problem of root diseases can be solved only by adopting a "cropping system" approach (diversified crop rotations) or "whole farm" approach involving several disciplines.

2.6 Essential contribution of the Project was to put into evidence that a continuation of the present system of wheat-soybean-wheat or wheat-soybean-fallow will ultimately destroy the wheat producing capacity of most of the wheat growing areas of Brazil (especially in the south), through the combination of root diseases with other detrimental factors as soil erosion.

3. Entomology

3.1 Importance of Wheat Aphids in Brazil

Since 1970, especially in the southern wheat growing area, increasing attacks of aphids were registered, previously unknown, determining a fast escalation in the use of insecticides. This was probably caused by the fast increase of the wheat acreage within a simplistic system of wheat-soybean double-cropping, allowing a fast multiplication of aphids. It was estimated that, in 1977, almost the total area grown with wheat (about 3 million ha) was treated three times with insecticides, representing about 5% of the direct production costs. The potential losses due to aphids having been estimated to be about 49% of the yield (see 2. Pathology, 2.1 experiment 1972), the national overall losses for 1977 would have been about 1.5 million tons of wheat, i.e. US$ 300 million, if no treatment was applied. However, the total cost of the insecticide treatments was estimated to be, the same year, about US$ 20 million , so heavily burdening farmers inputs.

3.2 Necessity of Biological Control of Wheat Aphids in Brazil

In almost all wheat growing areas in Brazil, wheat integrates into a very generalized production system with soybeans. Natural enemies of soybeans pests, such as caterpillars, play an outstanding role in saving, generally, many chemical sprays. That means that the protection measures used for cereals have consequence on the natural enemies of soybean pests as well, and reciprocally. Soybeans, very often, are also insecticide treated two or three times. Undiscriminated use of insecticide in both crops would lead to the disruption of the natural pest controlling system, and this is especially true for the northern and central zone where the wheat-soybean system was introduced in recently incorporated land. Additionally, a strong pollution by insecticides would occur, as already reported by several newspapers as soon as 1976. Therefore, the biological control of wheat aphids, aimed at to reduce to a minimum the use of

insecticides, appeared to be the unique rational and universal approach within the context of an integrated programme for controlling wheat pests and diseases.

3.3 Creation and Implementation of the Biological Control of Aphids

Upon request of the Project Manager, in full agreement with the national counterpart, the assistance of the University of California (Berkeley, USA) was asked for outlining a research programme on biological control of aphids at the CNPT of Passo Fundo. During December 1977, an assistant of the Head of the Department of Biological Control, University of California, visited the CNPT and outlined a programme, which was further approved by EMBRAPA's Headquarters and put into practice as early as the beginning of 1978, using funds available from the Project. Two entomologists were specially recruited by EMBRAPA for effective work in that new research area. Later on, four FAO Consultancies (June-July 78, July-August 78, September 78 and November 79) were devoted to develop the new activity.

With the aim of strengthening and speeding up the work on IBC, propositions for a Technical Cooperation Programme (TCP) were submitted to FAO Headquarters in April 1978, upon request of the national counterpart Agency EMBRAPA. This TCP was approved in June 1979, under No. TCP/BRA/8908 (M) "Integrated Control of Wheat Aphids", starting on August 1st, 1979, ending December 1st, 1980 with a total budget of US$ 70,000. The TCP's objectives are given in Annex No. 15.

3.4 Activities on IBC under TCP BRA/8908 (M)

At the time of writing this Interim Report, most of the work forecasted in the Phase I is already terminated, and Phase II is underway. All technical information is given in a Technical Report (in Portuguese) covering the period 1978-1979, submitted to FAO Technical Division on November 23rd, 1979.

As early as September 1978, the first remittance of various parasites

arrived from France and four additional ones later on, dispatched by the European Parasite Laboratory (USDA) of Sèvres (France). Other parasites were also received from Europe and Near East, owing to the efficient collaboration of various institutions and entomologists. A total of 15 natural enemies of wheat aphids have been introduced. The quarantine operations developed satisfactorily and mass rearing started rapidly and efficiently, so that during three months of parasite mass production in 1978, around 200,000 parasites of aphids were released in Rio Grande do Sul, Santa Catarina and Paraná States. Two shipments were also made from Passo Fundo to INIA (Chile) of most promising parasite species received from France.

In 1979, about 350,000 parasites were released in Rio Grande do Sul and Santa Catarina. Though it is very soon to report any definite achievement, field observations carried out in 1979 showed that several species colonized or established:

	Species
Colonized:	Aphidius colemani *
	" ervi *
	" pascuorum
	" rhopalosiphi *
	" uzbekistanicus *
	Ephedrus plagiator
Established:	Praon volucre

(*: naturally widespread species)

Since 12 species have been released from 1978 and 7 of them recovered, it means a good success in that work.

3.5 IBC Programme also works on soybeans pests

As early as the beginning of IBC Programme, special attention was also paid to soybeans pests, since most of the wheat was grown in sequence with soybeans. Steps were taken for asking parasites of Nezara viridula to be sent from Australia by CSIRO. Biological control of this soybean pest is developed by the EMBRAPA's National Soybean Research Centre of Londrina

(Paraná State), with which close collaboration is now established, aimed at an "integrated" biological control for both crops wheat and soybean. A special FAO Consultancy in February 1980 was devoted to this matter.

The Brazilian counterpart team of entomologists, young and enthusiastic, deserves special acknowledgement for its dedication, and the efficient works it developed in this difficult research area. It must also be pointed out that remarkable FAO consultancies helped in the achievements above described.

3.6 Workshops, Meetings and Seminars; International Cooperation

Relevant information is given under Chapter 6 (Institution Building).

4. Agronomy

With the discontinuation of the previous Agronomist (Soil Fertility) post, the activities concerning soil fertility have been continued by the Brazilian scientists, now duly trained in the matter, most of them being M.Sc. in Soil Science. Then, the Brazilian team working on soil fertility received only advises and guidance from the FAO Expert (Agronomist, Field Trials), who joined the Project on 15 October 1974. His terms of reference were extended in 1976 (Agronomist, Production Systems), according to the recommendations of the Review Mission of October 1975.

Most of the experiments carried out by the expert led to interesting results giving some light on the various problems linked with wheat production and, moreover, enlightened one of the main "bottle-neck" for wheat yield increase: root problems and crop diversification aiming at reduction of diseases inoculum. Some of these results are now applied on a large scale, officially recommended in the "Wheat Cropping Technological Package", or even included as condition into bank financing terms for wheat cropping. The Brazilian "National Malting Barley Programme" for self-sufficiency now underway may be considered as direct application of the crop rotation trials 1975 and 1976, which put into evidence the great potential of southern Brazil

for barley production.

4.1 Soil Fertility

4.1.1 Liming, acidity and Al^{+++} toxicity

Liming has been proved, within the double-cropping system "wheat-soybeans", very efficient for soybeans but rather dangerous for wheat, especially when mismanaged. The "SMP" method to determine the need for liming (developed by Shoemaker, McLean and Pratt in Southern Brazil) arrives to figures much higher than the reality, because extracting not only exchangeable Al^{+++} and H^{+} but also the not exchangeable H^{+} mainly coming from the organic matter. The need being first overestimated, the situation is worsened by irregular distribution in the field (overlapping) and poor incorporation in the soil (shallow discking, sometimes "duck-foot" only).

Overliming has been found to be responsible for the occurrence of wheat "take-all" disease (Gaeumannomyces graminis) and the multiplication of a soil-borne fungus (Polymyxa sp.) vector of the Wheat Mosaic Virus. However, the crop rotation trials underway from 1975 and recent FAO Consultancies (1979) have demonstrated that the continuous cropping of wheat every winter was in reality the main factor responsible for "take-all" occurrence, and that liming only exacerbated disease intensity and damages.

Experimental results obtained from the "Production System" trial carried out in the CNPT of Passo Fundo since 1975 obviously show that only one half of the need for liming, as calculated through SMP-method, is sufficient to reduce aluminium toxicity for wheat (i.e. about 3-4 t/ha for 3-4 years). On the other hand, the same trial shows the positive synergical effect between moderate liming and direct drilling in delaying the natural acidification of the soil and the increase of Al^{+++} toxicity along the time:

"Liming x Soil Preparation" interaction on soil exchangeable Al^{+++} content (in meq/100 g) in 1977, in relation to Al^{+++} initial content 1975 (1.40 meq/100 g)

	No lime	Limed (3.75 t/ha limestone in 1975)
Conventional preparation	1.86 (+33%)a	1.53 (+ 9%) ab
Direct drilling	1.83 (+31%)ab	1.21 (- 14%) c

(limestone was uniformly incorporated by ploughing in 1975)
(Tukey 5% = 0.24 meq/100 g)

The synergical interaction between liming and direct drilling is calculated to be 0.145 meq/100 g, i.e. 10.4% of the initial Al^{+++} content. Beyond the effectiveness of direct drilling in protecting the soil against erosion, direct drilling helps in delaying soil acidification.

4.1.2 N-Fertilization

Through the "Production System" experiment, it has been found that nitrogen efficiency is low in wheat production, around 4 kg of wheat grain per kg of applied N. Exceptionally, 10 kg grain per kg N were reached in 1976, when ammonium nitrate was used instead of urea for the second top-dressing, leaving to think about a better effectiveness of this fertilizer.

Effectiveness of N-fertilizers on wheat production:

	Cultivars	"Optimum" N level (for V/C = 1)	Wheat yield at N opt. (kg/ha^{-1})	Average productivity of N (kg grain/kg N added)
1970 - 72	(several)	(linear)	2,219	3.71
1970 - 72	IAS.59	(linear)	2,472	4.73
1975	IAS.59	64 N/ha	1,845	3.17
1976	IAS.59	92 N/ha	2,640	10.53
1977	CNT.10	70 N/ha	1,049	4.49
1978	CNT.10	77 N/ha	2,285	4.73

Averaged on four years (1975-78), the wheat yields are adjusted to the following regression equation:

$$\hat{y}\ (kg.ha^{-1}) = 1305.3 + 10.495\ x - 0.04883\ x^2 \qquad (x = kg\ N.ha^{-1})$$

This equation gives a N optimum = 83 kg $N.ha^{-1}$, calculated in constant cost since 1975 and with a ratio V/C = 1. The average productivity of nitrogen is only 5.7 kg grain per kg N added, demonstrating how low is nitrogen productivity on wheat under the wheat-soybeans double-cropping system, and how narrow is the edge for profit through nitrogen use. This problem is certainly linked with the "wheat roots problem".

Most of 238 wheat cultivars tested against 4 nitrogen levels (0-30-60-120 kg N/ha) show an abnormal response curve to nitrogen. In comparison, fairly good results have been obtained with malting barley, in crop rotation experiments, reaching yields as high as 4 t/ha with 70 kg N/ha, with low protein content. This comparison led to think about a "specific biological factor", probably soil borne, attacking the wheat root system and strongly reducing the plant uptake mechanism. This factor was identified in 1979 to be Helminthosporium sativum (common root-rot).

4.1.3 P and K - Fertilization

National Brazilian phosphates were tested against other imported P-sources (superphosphates and natural rock phosphates), and their effectiveness calculated in relation to Triple Superphosphate:

	Relative effectiveness % TSP
Triple Superphosphate (TSP)	100
Simple Superphosphate	112
Patos de Minas phosphate	14
Araxá phosphate	2

However, long term experiments are needed to determine the economic value of these Brazilian phosphates, especially in the "Campos Cerrados" central zone where the use of these phosphates could be cheap and profitable. In terms of phosphate fertilization, what is called "long term" experiment means about 10 years when natural rock phosphates having very low solubility are used.

Most of the soil analysis records from numerous field experi-

ments gave clear evidence that there is a marked trend for steep decrease in K content of the soil after 3 or 4 years of continuous wheat-soybean double cropping:

	K^+ content
Initial	170 ppm
After 1 year double-cropping	100 ppm
After 2 years double-cropping	70 ppm
After 3 years double-cropping	55 ppm

The official recommendations for potash fertilization were therefore revised accordingly.

4.1.4 On the light of recent findings leading to the identification of the factors hampering normal growth and nutrient uptake of the wheat roots (see 4.4 Wheat roots problem), there is now an obvious need for fundamental revision of the official recommendations for wheat fertilization elaborated by the CNPT prior to 1979. This will be an important task to be carried out by the counterpart team of soil scientists.

4.2 Cultural Practices

4.2.1 Soil Management

Numerous advantages of "no-tillage" or direct drilling practice have been enlightened, owing to the "Production System" trial. By Comparison with the conventionally prepared plots (ploughing + discking), soil analysis realized after three years of continuous experiment display 24% more available phosphorus, 14% more exchangeable potash, 2% more organic matter and 10% less toxic aluminium in the direct-drilled plots. Wheat and soybeans yields progressively increased, in the "no-tillage" plots.

Average yield increases obtained through direct drilling in comparison to conventional soil preparation (ploughing + discking):

Years	Wheat	Soybeans
1975	-	+ 1%(n.s.)
1976	+14% *	+12% *
1977	+29% *	+ 8% *
1978	- 3%(n.s.)	+15% *

(*: significant increase at $P \leq 0.01$)

Besides, direct drilling has been found to save 75% of diesel oil consumption, and acknowledged the best way and means to reduce or prevent soil erosion, of tremendous importance in Brazil. These highly favourable features of direct drilling for both wheat and soybeans have been grasped very early by many farmers, and actually more than 200,000 ha are direct drilled. The ICI-Brazil Company took an active part in this extension work, sponsored by the FAO Project in its initial stage (1972). The rapid development of direct drilling system, now officially recommended in the Wheat Technological Package, giving more stable and higher wheat yields, must be considered as a noteworthy achievement of the FAO Project BRA/69/535.

Other medium-term experiments on "soil management x fertilization" are still in progress.

It is concluded that outstanding progresses in wheat yields could be reached at this very moment, only by improved soil management and rational cultural practices.

4.2.2 Seedrates and plant population problems

Some light has been given on the conflicting results previously obtained in numerous wheat seedrate trials. In 1977, an experiment in which rowspacing and seedrates were factorialized variables obviously demonstrated a detrimental on-the-line competition between wheat plants. Low seedrate and narrow spacing gave the higher number of spikes per plant, the higher number of grains per head, the highest specific weight, therefore the highest grain yield. This trend was furtherly confirmed in 1978, and could deeply modify the concepts actually in force on the yield components (mainly on the optimum number of spikes per m^2), unless contradicted by solution

of the "root system problem" outlined further on.

4.2.3 Weed control

With the development of direct drilling, new weed control problem arose mainly for narrow leaves into soybean direct-drilled crops. The generalized use of phytohormones (2,4-D and MCPA) in the wheat crops induced a natural selection of weeds, the wild buckwheat (Polygonum convolvulus) being more worrying. These problems have been cleared up by the use of specific and persistent products (type "Lexone", "Sencor", "Lasso"...) for soybeans, and the use of dicamba (type "Banvel") against Polygonum in wheat crops.

4.2.4 Phytosanitary treatments

Officially recommended and financed for wheat production, the phytosanitary treatments using aphicides and fungicides are now widespread in the southern wheat growing area of Brazil. In 1977, it has been evaluated that the wheat acreage receiving these treatments was 555,000 ha, among which 352,000 in the Paraná State (25% of its wheat acreage) and 200,000 in the Rio Grande do Sul State (13% of its wheat acreage). Many chemicals and combinations of chemicals are yearly tested in the CNPT of Passo Fundo for improving the effectiveness of the treatments, as well as spraying dates and rates.

As recommended by the expert from 1974, a network of medium-scale "demonstration-fields" was carried out in 1977 in order to test the recommended technology all over Rio Grande do Sul wheat growing area. At this juncture, it was found evident that such a sophisticated technology is now always properly applied (or even understood) by the farmers or the bailiffs; then appears a problem of extension, manpower training and transfer of technology.

4.3 Crop Rotations

Several crop rotation trials have been established in the CNPT of Passo Fundo since 1975. At this time, a very narrow concept in cropping systems prevailed amongst Brazilian scientist and it was only possible to settle rotation sequences restricted to two winter crops (wheat or barley, wheat or winter fallow) associated with three summer crops (soybeans, corn, sorghum) in double-cropping sequences. One of these trials occasionally enlightened the high potential productivity of malting barley, and led to draw up the National Malting Barley Programme (see 1.4). This outgrowth of the crop rotation experiments, extremely important in terms of currency, must be credited to the Project.

Following trends have been detected through statistical analysis of the 4-year serie of crop rotation experiments:

- When cropped every two years (wheat/fallow sequence), wheat gives only a slight increase in yield: + 6% in average.

Sequences	Wheat yields (index)	
Wheat/Wheat	100	
Wheat/Fallow	106	(P = 0.15)

- Whatever is the summer crop, wheat yields are better when barley alternates with wheat as winter crop (+ 14%):

Wheat/Wheat	100	
Wheat/Barley	114	(P = 0.11)

- Similar reciprocal trend occurs with barley:

Barley/Barley	100	(barley yields)
Barley/Wheat	110 **	($P \leq 0.01$)

- Corn is the best summer crop to be associated with wheat, as far as "double monocultivation" is concerned:

Continuous Wheat/Corn	117 *	($0.05 > P > 0.01$)
Continuous Wheat/Soybeans	100	
Continuous Wheat/Sorghum	91	

- Finally, the average wheat yields obtained through "diversified" double-cropping sequences were significantly better than continuous wheat-soybeans ones, especially when barley and corn are used as alternative crops:

Sequences	Wheat yields (index)
Wheat-Corn/Barley-Sorghum	122 a
Wheat-Corn/Barley-Corn	121 a
Wheat-Corn/Barley-Soybeans	118 a
Wheat-Corn/Wheat-Corn	117 a
Wheat-Soybeans/Wheat-Soybeans	100 b (check)

Moreover, systematical sampling of whole plants including roots, was made during the 1978 wheat season, aimed at to quantify the severity of root/crown injury:

Rotation schemes	Infection index*:
Continuous Wheat-Soybeans	over 50%
Continuous Wheat-Sorghum	over 50%
Continuous Wheat-Corn	25-50%
Wheat-Soybeans/Barley-Soybeans	over 50%
Wheat-Sorghum/Barley-Sorghum	over 50%
Wheat-Corn/Barley-Corn	25-50%

(Infection index: 0 = without lesion; 1-25% = slight; 25-50% = moderate; over 50% = severe infection)

Helminthosporium sativum was the organism most frequently encountered in association with root/crown necrosis. Whenever corn is associated with wheat in a double-cropping sequence, the severity of the infection was significantly lower. These outstanding results are consistent with the corresponding wheat yields.

These crop rotation trials, though very short in duration, have been essential in giving to the Brazilian counterpart scientists full consciousness of the dangers of wheat monocultivation, as well as in giving the first experimental data supporting a drastic change in wheat production approach. Consequently, the Wheat Research Commission for Southern Brazil, during a meeting held in Porto Alegre in 1978 resolved that special terms for bank financing will be given only to farmers observing a crop rotation in which wheat must be grown only every third year (no wheat, nor barley, during the preceding two years). Therefore, the greatest problem faced now by the farmers is crop diversification, especially for winter time

(see: Recommendations). As early as 1979, a special programme titled "Diversified Crop Rotations" was settled at the CNPT, now underway. However, special studies on green manure (or cover crops for protecting the soil against erosion), urgently needed, are still pending.

Conclusively, it may be stated that a continuation of the simplistic wheat-soybeans annual sequence, as previously widespread, has been proved to progressively destroy land productivity through combined effects of wheat roots diseases and soil erosion.

4.4 Wheat Roots Problem

Systematic countings realized in all experiments realized by the expert, in the CNPT as well as elsewhere in the wheat growing areas in Brazil, have enlightened an abnormally low wheat plant fertility: less than one spike per plant (0.75 in average) at harvesting time. Many experiments lead to think about a detrimental "biological factor" hindering a good root system development of the wheat. An experiment realized in 1977 by a FAO Consultant showed that further development of the wheat could be conditioned by short exposure (one week, during seed germination) to various soils having different cultivation history. Malting barley having a right development and rooting in the same conditions, the so-called "biological factor" could be specific to wheat, unless experiments on environmental wheat physiology (temperatures, daylength) would give inconsistent results. In 1978, a pot experiment confirmed this assumption. Two FAO Consultants (A.D. ROVIRA and P.J. SHIPTON), in September-October 1979, definitively identified Gaeumannomyces graminis and Helminthosporium sativum as being the main pathogens attacking wheat roots. Full details on these important findings are given in section Pathology (2.5 - 2.6).

4.5 Soil Conservation

The potential soil productivity has to be maintained and improved through more rational cropping systems and appropriate soil management

and conservation techniques. The Project had necessarily to deal with this complex problem although it was not in its terms of reference. In fact soil conservation and related activities have become an important item of the work programme.

In the Project area and in other parts of Brazil, soil erosion is serious and characterized by three dimensions:

- Productive soils are lost by water and wind erosion and other forms of degradation to an alarming extent.
- A major part of the soil is transported from the agricultural area to a number of important water reservoirs, thereby considerably deteriorating the hydroelectrical potential of the country.
- Part of the washed down soils reach the big rivers and increasingly affect fluvial navigation and transport (45 000 km).

In this way soil erosion affects not only agriculture but also other important sectors of the country's economy.

The following examples are given:

- The sediments accumulated since the dam of Passo Real (Ibirubá County) was finished in 1972, up to now, according to a very recent appraisal, by the Project up to 18% of the height of the water table, estimated at 15.5 m.
- In less than 30 years, the hydroelectric power plant of Passo Real, which covers more than 50% of the electric energy required by the State of Rio Grande do Sul, would be almost useless. In 1967 geologists Porto and Oliveira estimated the lifespan at 9000 years.
- One of the successful agricultural measures in reducing soil erosion, the "no till" system, has been tried out at the Passo Fundo Experimental Station in 1973 and later on transferred to practical agriculture. In 1978 "no till" planting was applied in more than 200 000 ha.

A single storm at the National Wheat Research Centre, caused a loss, on unprotected soil, of 34 tons per ha, whereas the loss on a direct drilled plot only amounted to 0.2 ton/ha. Direct drilling saved also around 71% of fuel, which is of considerable importance in terms of energy savings.

The Project initiated the quantification and measurement of the direct and indirect effects of soil erosion on the economy. However, a more comprehensive survey of this type is needed as a basis for motivation of public opinion and for more comprehensive soil conservation action.

The county of Ibirubá was chosen in 1975 as pilot area to establish a watershed management project, in a joint effort with other international, national, state and county agencies. The programme was named "Operation Umbrella" (Operação Guarda-Chuva), and is now underway.

A special document on "Background Information on Soil Conservation Performed with Project BRA/69/535 Assistance" was produced.

4.6 Special Programme for Southern Mato Grosso

Initiated in 1975, the research programme on airplane wheat overseeding into standing soybeans gave satisfactory results. In 1977, about 3,000 ha of wheat were airplane overseeded in Southern Mato Grosso and North-Western Paraná (Maringá). The experimental programme has been extended for 1978 to Minas Gerais State (PADAP Programme Area) and South-Western São Paulo State (in collaboration with the Agronomic Institute of Campinas). Wheat overseeding in Southern Mato Grosso has been provisionally approved as officially recommended practice for bank financing in 1976. It has to be noted that airplane overseeding was found to save 82% of fuel consuming by comparison with conventional wheat sowing.

Overseeding technique is now expanding in São Paulo and Minas Gerais States. It is becoming a common practice, but only helps in saving time and conserving residual soil moisture. It does not resolve the drought problem (scattered and scarce rainfalls during the wheat growing season) in Central Brazil, unless linked with an efficient weather forecasting service.

4.7 Study Tours and International Contacts

(See Chapter 6. "Institute Building").

4.8 No-tillage Machinery

Before the year 1975, the research work on direct-drilling (no-tillage) was carried out with a commercial machine of long standing in Brazil. Another machine was imported to CNPT through FAO available funds for equipment. Two Brazilian companies further developed "no-tillage sowing drills". In 1978 was carried out by the CNPT an evaluation of the merits and limitations of present commercial (or near commercial) machines which are available for direct drilling of wheat.

A variety of sites were selected to take in the major representative soil types, and five machines were selected, according to their availability and the comparison which they made possible with their different systems:

	Systems				
	A	B	C	D	E
Fertilizer placing:					
. Band placing, incorporated :	+	+	+		
. Combine-drilled with the seed :				+	+
Seed placing:					
. into a rearward thrown curtain of soil ("rotavator") :	+		+		
. double disc unit :		+		+	+

The triple disc system had the most significant influence on plant growth under direct-drilling conditions. Seed placement appeared to have some effect, as the machine B achieved improvement over A, whilst fertilizer placement would also appear to have some effect.

When considering the differences obtained in work rate, seed placement, seed cover, undulation following properties, and economy of energy, then the introduction of the triple disc system understandably generated considerable interest in direct-drilling wheat. Subsequently, a private company in Passo Fundo developed the first Brazilian-made triple disc prototype, which is now being tested before local commercialization.

5. Farm Management Economics

The activities of the Project in Farm Management Economics started in September 1975. During the first phase (September 1975-September 1976), the work was devoted to economical assessment of the experimental results, and to settlement of a small accountancy network. The second ongoing phase pays major attention to studies on the economical feasibility of new production systems.

5.1 An economical assessment of the experimental results was realized by using the methodology of differential budgets. The conclusions achieved must be considered as preliminary ones, for lack of information obtained at farmers' level. At least, they may be read as first approximation of the problem.

- First, it must be pointed out the weak improvement of the average gross profit per hectare of wheat crop when the improved technological package recommended by the CNPT is applied, by comparison with the overspread wheat package actually used by the farmers. The recommended package is especially recommending the use of phytosanitary treatments (fungicides and insecticides).
- Moreover, the high variability of the wheat yields over the years, even when using phytosanitary treatments, brings a ground of dubiousness to which the farmers are very sensitive, especially those of lesser available means. This remains true in spite of an insurance system (PROAGRO). Introducing the notion of "bankrupt risk" into the economical assessment of the new production techniques shows that the utilization of a more sophisticated technological package for wheat cropping always implies a major probability for insolvency, though slightly improving average profitability. The small or medium-sized farms, however responsible of one half of the total wheat supply in southern states, are especially reluctant to take up such sophisticated technology for these very reasons.
- Direct-drilling for soybean planting was also analysed showing 79% time-saving and 76% fuel-saving by comparison with conventional

soil preparation and planting, although an extra cost of US$ 10 per hectare is recorded, due to the high cost of the herbicides. The direct-drilling machines now available on the local market are not well-suited for small or medium-sized farms, for which fixed costs become too high. However, the increasing cost of fossil energy will be determinant in the future of direct-drilling.

5.2 Just beginning studies on production systems on 1977, the first care was to gather maximum technical and economical information on the wheat producing farms. A test-survey was carried out in the region of Ijuí, in collaboration with the COTRIJUÍ-Cooperative, with the following statements:

- the surveyed "family farms" form the most stable part in terms of wheat acreage, when considering the concurrent fluctuations of total wheat supply; these family farms represent about one half of the total wheat production in Rio Grande do Sul State;
- the prevailing production systems are based on soybeans and wheat, with self-consumption activities (milk, poultry, etc...);
- Soybean production represents in average 72% of the cash-flow, so strongly binding the farm economy to the technical and economical fluctuations of that crop, in a highly risky farming system.

The methodology developed for this purpose was efficient for better knowledge of the wheat-producing farms in their technical and economical aspects. Statistical analysis of collected information allowed to state that more diversified production systems, in relation to the simplistic wheat-soybean double-cropping, showed economical advantages under the actual circumstances. This conclusion was consistent with results obtained from other institutions (cooperatives).

5.3 The first step aimed at to adjust computer programmes from ENSA of Grignon (France), actually ingrafted into the EMBRAPA's Computing Centre (Brasília), as a tool for economical studies on new production systems. These programmes are especially suited for orientating the producers' decisions, directly

or through their cooperatives. The second step, now underway, aims at elaborating a linear programming model for more detailed study of production systems. This work is already in advanced stage.

5.4 Considering the gravity of the technical and economical problems generated by the extremely specialized farming systems (wheat/soybeans) used all over the wheat-growing areas in Brazil, studies on new production systems based on cropping diversification are of utmost importance. The computerized methodology for reckoning economics, elaborated by the Project, constitute a powerful and useful tool in helping the producers for taking decision on the new orientations to be given to their farms. As well, these computer programmes, of easy approach, will fit for use by extension services. By these means, it will be possible to test technical recommendations through estimated economical reckoning, as well as to train extension people in farming management and agricultural administration.

6. Institution Building

This paragraph reports the relationship of the Project with other national or international institutions.

6.1 Cooperative Programme on Wheat Research in the Southern Cone Countries (Argentina, Bolivia, Brazil, Chile, Paraguay and Uruguay)

6.1.1 First Latin American Wheat Conference

Sponsored by the Brazilian institutions EMBRAPA, FECOTRIGO and Secretariat of Agriculture of Rio Grande do Sul and by the United States Agency for International Development (AID) in collaboration with the University of Nebraska, the First Latin American Wheat Conference was organized, under the joint coordination of the

Project, in Porto Alegre (Brazil) during 21-28 October, 1974. It was attended by 151 wheat researchers from Brazil, Uruguay, Argentina, Paraguay, Bolivia, Chile, Ecuador, Peru, Mexico, Colombia, and USA.

Although the Conference was a real success as a scientific meeting, its main achievement was the opportunity it gave to researchers of different countries to meet and to discuss the advantages of solving common problems in a cooperative manner, as it was decided during the Closing Session of the Conference. This Conference broke the isolationism, which for many years kept apart researchers from different countries working with common problems, by bringing them together and by giving them a chance to interchange experiences and to spontaneously arrange the exchange of materials.

6.1.2 Regional Wheat Seminar for the Programming of Cooperative Research Activities on Wheat in the Southern Cone Countries - Passo Fundo (17-22 March 1975)

Following the First Latin American Wheat Conference, need was evident to get together the scientists of neighbouring countries which face very similar problems limiting their wheat production.

A joint effort would, therefore, be very helpful in order to achieve higher efficiency in their own scientific activity. As a first approach in that direction, the organization of a cooperative seminar was decided in agreement with the counterpart to analyse possibilities for an action programme on specific subjects. EMBRAPA, UNDP Representative and FAO Headquarters agreed accordingly, authorizing the use of funds of the Project. Only the southern cone countries were invited, each one represented by two delegates, and IICA "Zona Sur" (Dr. Hernan CABALLERO, Montevideo) sponsored the travel of foreigners. The seminar was held at Passo Fundo from the 17th to the 22nd of March 1975.

Regional yield trials were carried out as planned by this Wheat Seminar. The best varieties and selections of each country were included. Trials were sown at 1 locality in Argentina, 2 in Bolivia, 3 in Brazil, 2 in Chile, 1 in Paraguay, and 1 in Mexico. A duplicate

of this trial was also sown in Mexico, by CIMMYT.

Diseases nurseries, for testing resistance against: leaf, stem and stripe rust; Septoria tritici, S. nodorum, and Gibberella zeae, were distributed among the above-cited countries, including CIMMYT (Mexico).

6.1.3 Wheat Rust Meeting at the Centro Nacional de Investigaciones Agrícolas (INTA) Castelar, Argentina - 7-12th November 1976

Promoted by the CNPT and UNDP/FAO Project BRA/69/535, and under the sponsorship of INTA and IICA (Zona Sur), a special meeting was held at Castelar, attended by phytopathologists from Argentina and Brazil, to analyze changes in rust epidemiology, mainly of stem rust. The FAO Pathologist of the Project also participated.

During the meeting, all aspects concerning stem and leaf rusts specialization were discussed and very soon it was found that both rusts, practically, have the same physiologic specialization in Brazil and Argentina.

Several decisions were made during the meeting aiming at: (i) the establishment of a strong cooperation between researchers of the two countries in exchanging wheat and information on the evolution of these rust fungi; (ii) the use of different sources of resistance by breeders of the two countries; (iii) the start, or intensification, of epidemiological work in both countries, in order to obtain information on the appearance of new races and on the spread of epidemics in each country; (iv) carry studies on the perpetuation of these rust fungi on cultivated or volunteer wheat and grasses; (v) exchange of information on rusts control by means of fungicides, and (vi) strength the cooperation in testing special wheat collections for rust studies (green traps).

6.1.4 Workshop of Wheat Breeders and Phytopathologists of the Southern Cone Countries at La Estanzuela Experimental Station - Colonia, Uruguay (25-29 April 1977)

The meeting was organized by the Centro de Investigaciones Agrí-

colas "Alberto Boerger", with the sponsorship of IICA (Zona Sur) and UNDP/FAO Project BRA/69/535.

The report of the workshop is going to be published by IICA (Zona Sur), actually in press.

6.2 Cooperative Breeding Programme (EMBRAPA-UNDP/FAO-CIMMYT) 1976-1979

The 28th of October 1974, the day the National Wheat Research Centre was officially inaugurated by President Ernesto Geisel, an informal meeting was held by the Project Manager with Directors of EMBRAPA and Dr. Norman Borlaug, Director of CIMMYT's wheat programme, for discussing possibilities of expanding the local wheat breeding programme in a joint effort with CIMMYT. Travel expenses and perdiem of counterpart staff members would be on behalf of the FAO Project.

During April 1975 the Deputy Director of the CNPT and the Project Manager were able to visit CIMMYT at El Batan and the experimental fields at CIANO (Ciudad Obregon). Programmes of reciprocal visits and stages were outlined for 1976.

The FAO Expert (Plant Breeding) and two Brazilian counterparts made the first planting of CNPT breeding material during 1976, in order to advance one generation, and for crossing with Mexican and foreign germplasm. During 1977, 1978 and 1979, five other counterparts travelled to Mexico to continue the programme.

From CIMMYT, since the programme started, came to Passo Fundo Dr. Norman Borlaug and several other technicians, some of them several times. The Director General of CIMMYT also visited Passo Fundo, during 1974. This cooperative breeding activity offered good opportunities for taking advantage of available germplasm at CIMMYT from all over the world with very positive consequences not only for the Brazilian programme but for CIMMYT as well.

Brazilian germplasm has been introduced into CIMMYT's breeding stock up to a proportion of 25-30%.

Brazilian germplasm revealed very positive characteristics, for sub-tropical soils and ecological conditions in other regions of the world;

therefore the wide interest in Brazilian germplasm, as it has been emphasized at the Second Meeting of the IBPGR Advisory Committee on Wheat Genetic Resources, held at Rome during 25-27 September 1978.

6.3 Integrated Biological Control of Wheat Aphids in the Southern Cone Countries

6.3.1 During the "Regional Wheat Seminar for the Programming of Cooperative Research Activities in the Southern Cone Countries" (see 6.1.2), an "ad hoc" meeting of entomologists was recommended, due to the seriousness of the damages.

Sponsored by INTA from Argentina, IICA, UNDP, FAO, this first meeting was held at the Pergamino Experimental Station (21-24 October 1975).

There was a general agreement about the regional characteristics of the plague and its severity, specially in Brazil, where its incidence increases from year to year.

After considering the situation of the aphid problem in each of the countries, the spreading of the virus diseases, their natural enemies, future biological, chemical, genetic and integrated control, a joint action programme was discussed.

A copy of the final report was forwarded to the Integrated Pest Control Expert of FAO (Rome).

6.3.2 A Workshop on Crop Losses Appraisal and Horizontal Resistance, sponsored by EMBRAPA, UNDP, FAO and IICA (Zona Sur), held at the CNPT in Passo Fundo (12-18 September 1976), with delegates from the Southern Cone Countries. The FAO (Integrated Pest Control) Specialist suggested that, at the 2nd Workshop on Wheat Aphids, programmed to be held at Santiago (Chile), each participating country should apply for technical assistance financed by FAO or UNDP/FAO looking forward to implement a regional project devoted specifically to the control of wheat aphids. The Scientific Adviser of IICA (Zona Sur) anticipated that IICA was willing to assist in the organization of a future meeting on this subject.

6.3.3 The 2nd Workshop on Wheat Aphids was held at the Experimental Station La Platina - Santiago (Chile), sponsored by INIA (Instituto Nacional de Investigaciones Agropecuarias), UNDP, FAO, and IICA (November 22-26 1976).

One delegate from Argentina, Bolivia, Brazil, Paraguay and Uruguay, as well as many scientists from INIA and the Central, Catholic and Austral Universities participated.

A report has been edited by INIA and IICA, including papers presented by each one of the delegates. The FAO (Integrated Pest Control) Specialist, as well as the Project Manager, also participated.

6.3.4 The Chairman of the Division of Biological Control of the University of California was invited by the Project UNDP/FAO 381 BRA/69/535 to give a course on Integrated Pest Control, at Passo Fundo during 8-12 August 1977, co-sponsored by EMBRAPA, USAID and IICA.

Brazilian scientists as well as delegates from the Southern Cone Countries attended to this relevant course. After finishing the programme, an additional day (13th August) was devoted for discussions about the biological control of wheat aphids on a regional scale. An action programme was outlined (See Part III. Recommendations).

6.4 Study Mission of Expert FAO Agronomist (Production Systems) to France and England (July 1977)

During his home leave, the FAO Agronomist was authorized by Headquarters to visit some research organization and institutes in France and England engaged primarily on root growth research.

A detailed report was presented about these visits, with comments and observations in relation to Brazilian wheat cropping problems.

Part III - Recommendations

1. Specific Recommendations for Research Areas

1.1 Plant Breeding

1.1.1 The wheat breeding programme developed by CNPT, aimed at to create new high yielding and disease resistant cultivars, better adapted to environmental conditions, must be obviously continued. This has to be considered as a continuous task making full use of available germplasm, through bilateral and multilateral cooperation with CIMMYT and other countries from Southern Cone region, as well as with Canada or wherever useful germplasm is available.

The search for new sources of resistance has to continue on a regular basis, as a lot of new material is generated every year and everywhere. Since 1975, the wheat breeding programme has been taken over by the national counterpart and the CNPT's team of breeders has full ability and skills for developing this activity. This is proved by the responsibility given recently to one CNPT's breeder for coordinating the wheat activity in the Regional Project of IICA for southern cone. This activity should lead to an increased cooperation, at regional scale, between wheat breeders in South America and could be strengthened again more through a regional TCDC cooperative programme.

The expansion of the wheat growing area in Brazil, mainly northwards, is leading to new problems owing to the agroecological diversity of the land recently opened for agriculture. Special care should be paid to epidemiology of the main wheat diseases, for better adaptation and orientation of the breeding programme. Disease resistance being the main goal of the breeding work in Brazil, the breeding programme must therefore be considered as a joint activity of breeders and plant pathologists to be developed in a common task.

Only some details in breeding work need to be improved:
- systematical mechanization of the field works;
- incorporation of frost resistance as desirable characteristic;
- it is highly desirable that performance of new lines having merit for release are also tested on large plots in farmers' fields, giving so better information on the comportment of promising lines under natural cropping conditions. This large scale testing should complete and improve the results of the multilocation "small plot" testing system actually used, and could give better information on some agronomical characteristics (optimum seedrate, reaction to nitrogen, etc...) which are essential to be known before release of a new cultivar.

1.1.2 Very promising results already achieved in breeding for horizontal resistance, though needing further confirmation, recommend full support from the counterpart for speeding up, strengthening and broadening the H.R. programme. The recent incorporation of the H.R. programme within the CNPT's breeding programme is a noteworthy progress, which should be materialized by one national counterpart staff working full-time with FAO Expert (H.R.) and by increased facilities (manpower, greenhouse) attributed to this programme. Classical wheat breeding and breeding for horizontal resistance are parallel ways aimed at to produce improved wheat varieties having accrued resistance in the field under the heavy pressure of diseases prevailing in Brazil, and not antagonistic ways. The CNPT of Passo Fundo having now a national-wide responsibility in coordinating all breeding works in the country, the new concept of Horizontal Resistance (still somewhat ignored or misunderstood) should be popularized and supported, especially to other institutions dealing with wheat breeding.

1.1.3 A real breakthrough in plant breeding is the production of dihaploid-ized plants by <u>in vitro</u> anther culture technique. This method, very simple, only requires some handiness, no sophisticated material, and

can be rapidly implemented as routine work. One might regret that CNPT's wheat breeders have not welcomed this new method as they should have to do it, only remembering its low productivity rate (which can be easily improved in a next future) and disregarding the new fascinating openings which should give new dimensions to breeding work. CNPT Laboratory of Cytogenetics has been the first in Latin America in producing haploid wheat plantlets which are going to give 100% homozygous dihaploidized wheat plants, in only one step requiring only 6 months. The leadership acquired by CNPT in this area should be considered only as the first step for a resolutely innovating programme for wheat breeding, which could be furtherly extended to the South American wheat growing countries through TCDC programmes.

On the other hand, in vitro culture techniques should be applied in Brazil to all other food crops breeding programmes, especially to those dealing with plants having a vegetative reproduction or multiplication (banana tree, oil palm-tree, etc...), as well as to germplasm national bank.

1.1.4 The above recommendations are also valid for breeding works related to triticales and malting barley, as well as to other crops recently incorporated into diversified crop rotation schemes aimed at to build up a rational and comprehensive agricultural policy securing the farmer with more stable income and respecting the national soil patrimony.

1.2 Plant Pathology

1.2.1 Closely linked with plant breeding, a sound pathological research work should remain of great importance and of high priority in the researches carried out by the CNPT. It has to be repeated that disease resistance is the common goal for breeders and pathologists. Therefore, an important collaboration should be given by pathologists to plant

breeders (and vice-versa), especially on:

- identification of the prevalent wheat diseases and their physiological races, in all existing or potential wheat growing regions of the country;
- better knowledge of the epidemiology of the diseases, at regional and national scale;
- assessment of the crop losses due to aerial diseases, in relation to weather conditions of the year, in different wheat growing regions.

As a result of international meetings organized in Brazil, were created the foundations for neighbouring countries to cooperatively conduct researches on common problems. Undertaking an epidemiological work in such a cooperative way should be considered as of great urgency. It is most desirable that this type of work is supported and stimulated by multilateral international agreements leading to regional projects. This means a typical TCDC approach.

1.2.2 The second essential work to be intensified in Plant Pathology is, inquestionably, to identify the practical means to be used for overcoming the "wheat roots problem" which has been recognized as one of the most important strangling point in wheat production (see Part II, Pathology, 2.5). Before undertaking any extensive work on biology or control of G. graminis and H. sativum, it is first required to determine the extent of distribution in crops throughout the principal wheat-growing areas. Since the soybean (normally considered to be resistant to these wheat pathogens) integrates with wheat into the annual double-cropping system still predominant throughout the arable areas of Brazil, the behaviour of the soil borne pathogens in a closely integrated cycle of alternate parasitic-pathogenic and saprophytic activity is of the utmost importance. This is why attention should be given to the study of these pathogens during the duration of the soybean crop, to an extent comparable to that given to wheat.

Detailed and sound research programmes on G. graminis and H. sativum have been written by two FAO Consultants, world-known

specialists on the matter. These programmes were fully endorsed by the ongoing Project and by the Brazilian counterpart CNPT. Therefore, it would be rather useless to go on in detail. However, some essential recommendations may be given in this research area:

- Research into root diseases is one of the most difficult areas of agricultural research requiring a great deal of laborious sampling and processing of roots, so that adequate technical resources must be provided;
- The multiple interactions between the pathogens and the soil, the host and non-hosts, and seasonal conditions make a team approach essential for the ultimate success of the programme;
- Since the unique way of controlling these soil borne diseases is the use of non-susceptible "break" crops, to be integrated into the wheat/soybeans system, it is therefore considered as essential that a comprehensive study be made jointly with the agronomists and the agro-economists of the CNPT, assisted by the FAO Project staff members.

Indeed, the value of introducing "break" crops can be three-fold: for their cash-value itself, for the benefit to the yield of the succeding crop (wheat or soybean) from improved fertility or soil structure, and for the effect on pathogen survival and subsequent infectivity. These considerations fully justify a multidisciplinary approach of the problem, as strongly recommended above, under a more comprehensive "Production Systems" approach.

1.3 Entomology

1.3.1 The research programme on biological control of wheat aphids developed by the CNPT with the assistance of the Project is a very positive experience and a real success. In only two years (1978-79), the CNPT team of entomologists performed an excellent work and acquired a noteworthy experience of the difficult problems brought by biological

control. It is therefore recommended to strengthen this activity, especially through:

- . better screening of parasitoids and predators suppressing wheat aphids populations;
- . improvement of the techniques of breeding and mass rearing, overcoming the problem of male/female balance during multiplication in insectarium;
- . systematical screening of insecticides, aimed at better knowledge of selectivity vis-à-vis of aphids and their natural enemies;
- . systematical search for new alien species of aphid parasites, able to be imported for multiplication and release for colonization under Brazilian conditions;
- . improvement of the techniques of field release and colonization assessment;
- . determination of the economic thresholds for selective insecticides use. In this matter, a close collaboration and linkage with extension services is especially recommended, for better training of extensionists in IBC techniques.

1.3.2 The CNPT's activities in IBC should be considered as part and parcel of a comprehensive research programme titled "Integrated Control of Wheat Pests and Diseases", in which Entomology, Plant Pathology and Plant Breeding integrate. Once more, a multidisciplinary approach is obviously needed. This is fully justified more especially as new "break" crops are going to be introduced into the cropping systems (see Part III, 1.2.2). Therefore, an essential activity in Entomology should be to study the influence of these new crops on the comportment of the wheat aphids and their predators and parasites. In that scope, a close collaboration with extension services is again strongly recommended.

1.3.3 Moreover, the control of wheat aphids undoubtedly must be considered as a regional or international problem. As already emphasized, the

aphid-virus complex is a serious menace to more than 10 million hectares, yearly cropped to wheat, in the southern cone countries. During 1978, the Project Manager was invited to the FAO Regional Office in Santiago (Chile) to discuss the subject, and the draft of a regional project titled "Integrated Control of Wheat Pests and Diseases in the Southern Cone Countries" was jointly prepared, and further submitted to FAO HQ's, to UNDP HQ's and to each of the southern cone countries. On this time, this regional project was wisely considered as somewhat unrealistic. On the light of the experience gained on the matter by Chile and Brazil, this project deserves to be reconsidered now on a new basis. It should certainly be profitable for Brazil and Chile to closely cooperate under a TCDC Programme on integrated control of wheat aphids, with limited and pin-pointed assistance of UNDP in specific matter (for example, world-known specialists called for consultancies).

1.4 Agronomy

1.4.1 Soil Fertility

. All experiments made prior 1978 on soil fertility have been developed into the very narrow scope of wheat-soybean annual double-cropping. Therefore, all conclusions derived from these experiments only apply to this system. Since the simplistic wheat-soybean double-cropping has been recognized as detrimental for wheat production, and that new winter crops are going to be introduced into a more diversified crop rotation, all conclusions and, therefore, all official recommendations for limestone and fertilizers use must be reconsidered.

. During a lot of years, liming was erroneously considered as unique responsible for the occurrence of wheat "take-all" disease. In reality, the continuous wheat cropping, every year in the same field, is the fundamental cause of "take-all", the part of lime being only to exacerbate disease occurrence. Therefore, the correction of

soil acidity and Aluminium toxicity by liming must be reconsidered within the new scope of diversified crop rotation.

. The same recommendation is made for N-P-K fertilization, which obviously need to be reconsidered within the "new deal" brought by diversified cropping systems. All previous experiments were distorted by the complex syndrome called "wheat roots problem", partially explaining the poor response of wheat to nitrogen. Therefore, systematic experimentation on wheat fertilization in fields "cleaned" from "take-all" and H. sativum is needed for renewing the recommendations to farmers.

. There is an urgent necessity for better knowledge of the organic matter in Brazilian soils, in direct relation to nitrogenous fertilization of wheat. Most of the soils where wheat is grown have a surprisingly high content in total organic matter, but this content should be more accurately characterized by determination of the "easily mineralisable" amount of organic matter, giving so a rough estimation of the potential nitrogen supply from the soil. This is of utmost importance as far as N-fertilizers are concerned. Quantitative and qualitative estimation of the microbial life in the soil deserves also special attention. Nutrient losses by leaching should also be estimated through simple studies with lysimeters under controlled conditions of rainfalls.

. Medium- or long-term experiments should be continued or settled, aimed at better knowledge of the effectiveness and possible utilization of national rock phosphates, as well as on potash content decline of the soils under intensive double-cropping every year.

. Taking advantage of the crop rotation experiments underway, the national team working on soil fertility should draw a "nutrient balance" for each rotation followed, aiming at to estimate the total needs in N.P.K. fertilizers for a given rotation - These data are fundamental in production systems studies.

. It is recommended that the Laboratory of Soils in the CNPT be discharged of the routine work on soil analysis. This routine work heavily burdens the laboratory, and turns it away from its intended

purpose which is research. Specialized other laboratories (i.e. neighbouring Faculty of Agronomy) could be entrusted with this routine work.

1.4.2 Cultural Practices

. Since most of the Brazilian soils have good properties in terms of structure and facility in working with farm machinery, it is quite surprising to find out that very heavy disc implements and powerful tractors are still in use. Lighter tine implements should be used instead of heavy discs, for many reasons: reduced weight and broader width for the same traction power (saving fuel consumption), easier servicing and repairing, cheaper cost, etc... Certainly, tine cultivation could play an important part as well as direct drilling for better crops through reduced work. This is another new research area in which Brazil needs further development.

. Special effort should be devoted by extension services for cultural practices improvement at the farmer's level. Substantial increases of wheat yields undoubtedly would be achieved through very simple improvements and more carefulness in common agricultural work.

1.4.3 The wheat roots problem

. Regression of the tillers and of the root system soonafter the beginning of stem elongation, leading to an abnormally low plant fertility (less than one spike per plant, in average), is now recognized as one of the most important bottle-neck hindering any breakthrough in wheat production in Brazil. To overcome this problem must be considered of overwhelming importance and top-priority in wheat research. Broadly overspread in all wheat growing regions, the syndrome does affect not only national wheat production, but also the practical results and the very effectiveness of important research areas as plant breeding and soil fertility. The best breeding programme carried out during a lot of years with the best germplasm available and the highest care, may be useless if the newly improved cultivars are grown in such conditions that the expression of accrued yield

potential or disease resistance is hindered by abnormal root development. All experiments realized up to this date on wheat response to N-P-K fertilizers only reflect the reaction of plants growing under abnormal conditions of nutrient uptake because of deficient root system (see above 1.4.1).

. Though two fungi have been identified as the main pathogens attacking the wheat root system (see Part III, Pathology, 2.4), it is recommended to continue investigations on non-pathogenic factors (Al^{+++} and Mn^{++} toxicities, micronutrient deficiencies, physiological disturbances, etc...) dealing with root development and growth, because these factors may interact with soil borne pathogens.

. Root system studies, as already pointed out (Part II, 2.5), require a multidisciplinary approach, because of their complexity, and will demand devoted and common efforts from plant pathologists, physiologists, soil scientists, agronomist and plant breeders. It is strongly recommended to promote and to foster any attempt for developing a multidisciplinary team dealing with root system.

1.4.4 Crop Rotations

The simplistic wheat-soybean double-crop system actually prevailing in Brazil means really a "double monocultivation". This system leads to a natural accumulation of soil borne organisms, some of them being pathogens.

Crop diversification is now recognized as the unique way for controlling soil borne diseases of wheat and soybeans. It has to be remembered that Rhizoctonia is becoming a very important problem in several soybean growing areas. That is why crop rotation experiments need to be extended to medium-term rotation models involving different species for cash-cropping, fodder or green manuring, grown in succession in order to break the reproductive cycle of pathogenic soil borne organisms. Although recognizing the leading part played by soybeans in the Brazilian national economy, the wheat research cannot be limited within a narrow "loophole" between two successive soybeans crops. This constraint must be overcome, because of several reasons:

- crop diversification is needed for better control of soil borne pathogens for both wheat and soybeans;
- crop diversification is a necessity as far as integrated biological control of pests and diseases is concerned;
- crop diversification is essential to any comprehensive farming system where soil erosion would be thoroughly controlled;
- crop diversification should help the farmers, especially the small ones, in obtaining more stable and safer profits.

Conclusively, special emphasis should be given to studies on diversified crop rotation patterns in which wheat plays a leading part. These patterns should be evaluated and optimized by agro-economical studies, and adapted to the different socio-economical features of the different wheat growing regions in Brazil, so leading to comprehensive wheat production systems.

1.4.5 Soil Erosion Control

It has been an essential contribution of the Project to have brought consciousness to the Brazilian authorities of the hugeness and emergency of soil erosion problems.

Soil conservation practices must be an essential part of the comprehensive "diversified agricultural production scheme" as it was spoken above.

Thus it could lead to a comprehensive national planning for land use, into which integrated pest control plays another essential part. Soil erosion goes beyond the agricultural framework: energy, transport and human life are also affected. The National Congress approved (14/7/75) the law 6225 authorizing the Ministry of Agriculture for compulsory soil protection and erosion control programmes in most affected areas of the country. The National Programme of Soil Conservation (NPSC) was established by the Ministry of Agriculture (decree 76470), outlining three major activities:

- technical assistance to farmers through any extension organization;

- research focused on pilot conservation areas throughout EMBRAPA and other research entities;
- credit facilities to farmers affected by implementation of the law 6225/75.

Such a programme demands a big number of well-trained technicians. A Technical Cooperation Programme for "Assistance for the Implementation of a National Programme of Soil Conservation" has been drafted by the Ministry of Agriculture with the assistanship of a FAO Consultant, and forwarded in November 1978 to relevant authorities, in order to be handed over to FAO Representative in Brasília. The objective of FAO assistanship would be to fulfill the immediate aims of the NPSC. Obviously, it is strongly recommended that the NPSC be implemented in the best conditions, with full support of FAO and UNDP.

However, the soil erosion problem deserves a broader approach. As far as hydroelectric plants, navigation and devastating floods are concerned, a regional approach should be recommended. Developing and harnessing the huge waterway of Paraná basin are common concern for all neighbouring countries (Argentina, Brazil, Paraguay, Uruguay), and international agreements have already been signed for hydroelectric equipment. However, a common policy on soil erosion control is a necessary complement to keep the lifespan of hydroelectric power plants. This should be a unique opportunity for developing a TCDC Programme on soil erosion control.

1.5 Farm Management Economics

1.5.1 According to the technical considerations and conclusions issued from the study carried out in the region of Ijuí, it is clear that thorough studies should be made on new production systems allowing better average wheat yields with improved farm income, so joining the national objectives with the common good of the farmers.

1.5.2 Studies on new production systems must be preceded by better knowledge of the production systems prevailing now, aimed at a more realistic evaluation of the feasibility and implications of the modifications to be introduced. It is then essential to gain the most accurate diagnosis on the technical, economical and financial state of various farming patterns in different wheat growing regions. Such a diagnosis should be carried out by an interdisciplinary team gathering agronomists, agro-economists and extensionists, but final statement should be made jointly by the CNPT and the wheat cooperatives. As a matter of fact, these cooperatives play an essential part in the economical and social development of the wheat growing regions.

1.5.3 The selection of the best adapted production systems should be evidently made through profitability tests. For that purpose, it is advisable to use simulation models with the help of a computer. It is then recommended that the CNPT be equipped with a mini-computer which could be used in farm management studies as well as in other research areas, especially in Entomology (aphids populations modeling).

1.5.4 It is considered as essential to realize an exhaustive enquiry on the actual state and foreseeable trends of the agricultural policy, at national and states levels, about the problem of production systems diversification. A complete compilation should be made on the market conditions of the main agricultural products able to be introduced into new production systems. It is so advisable to develop close links between CNPT and all professional or official bodies related to agricultural planning and marketing at national and states levels. In the same way, it is also necessary to make the research programmes more consistent with the main guidelines of the national agricultural policy, through better connection of EMBRAPA's CNPT with decision-making national institutions (SUPLAN, CEPA, etc...).

1.5.5 Last but not least, special emphasis must be paid on the fact that economical studies on the profitability of wheat production will

become more and more essential as the wheat growing area is expanding to regions where agroecological conditions are less and less favourable to wheat production.

2. General Recommendations

The following recommendations concern the general framework within which CNPT's activities are performed. They must be considered as guidelines aiming at to increase the efficiency of the research work carried out in the Centre, and to speed up the realization of the Government's objectives:

2.1 The CNPT of Passo Fundo has been initially created in order to develop agronomical researches on wheat. Summarizing the works realized in the period 1970-79 with the assistance of the Project BRA/69/535, it can be assumed that most of the wheat research work performed by the CNPT has been conducted with a very specific approach, the only associated crop being soybeans. Over the years the essential need became evident for integrated study of the wheat crop in its biological, technical and economical aspects, and its relationship to other activities of the agricultural enterprise. Now the CNPT was given a national-wide responsibility, and it has to embrace the problems which wheat cropping faces in all existing and potential wheat-growing regions in different parts of Brazil. This means a new dimension given to its activities, but also means a new approach to a more general problem dealing with regional development. The so-called "miracle" wheat-soybeans double-cropping is dead and gone (especially in the South), new diversified production systems are urgently needed, and the CNPT's Management is perfectly aware of it. It is therefore desirable that more flexible guidelines be given to CNPT (though keeping it as responsible for wheat research at national scale) in order to allow it to pay more attention to other crops than wheat (rapeseed, lupins, etc...) in so far as they interfere with wheat production into new diversified production systems.

Having always in mind the conservation of national soil resources and the protection of environment, future wheat research should be developed within to concurrent concepts:

- an agroecological context, aimed at to optimize the wheat crop ecosystem: integrated biological control of wheat pests and diseases (horizontal resistance, IBC programme for wheat aphids, root system problems);
- an agroeconomical context aimed at to secure the farmers with better income through more rational use of the land and farm resources, including higher and more stable wheat yields, in a general scope of regional development: diversified production systems.

2.2 This new approach, to which the Project devoted much effort in recent years, means interdisciplinary research work. Because of their formation and maybe of inherited individualistic standards in research work, CNPT's researchers are not yet accustomed to work in really multidisciplinary teams. Considering the complexity of the problems dealing with wheat production increase, it is essential that a given research topic be carried out by a team, and not by a single specialized researcher. It is then strongly recommended that CNPT develop an "interdisciplinary spirit" in the scientific team working at the Centre.

2.3 Since a comprehensive approach to wheat production is considered, priority should be given, from a practical point of view, to carefully selected research programmes. The selection of priorities should be detected and decided by the Management of EMBRAPA/CNPT, taking in account the Government's objectives, the structure of crop production and the farmers' needs. When determined, these "top-priority lines" should be translated in practical terms by the Deputy Technical Chief of the CNPT (with the help of some specialists of the Centre, something like an "Operations Group"), so building up well-defined "Research Projects". Each research project would be

executed by an interdisciplinary team headed by the scientist whose specialization area is the most concerned. It is clear that when the selection of priorities is decided, all available resources in equipment and manpower should be given to the corresponding research projects, even if resources must be reduced to a minimum for other research areas. Obviously, no specialized research area should be dominant in the activities of the CNPT, in so far as comprehensive approach of wheat production increase is concerned.

2.4 Linkage between research and extension is of utmost importance. It is therefore recommended to institutionalize and implement a better and efficient coordination between EMBRAPA and EMBRATER. It is imperative that research be in touch with the practical problems of the farmer, and that the false image given by the scientist working alone in his "ivory tower" be definitely broken down. Closer links with extension are strongly recommended. In order to make easier the contacts between research people, extensionists and farmers, establishing of "Centres for Agricultural Technical Studies" is particularly desirable. In Brazil, a number of CITEs (Clubes de Integração e Troca de Experiências) already exist, based on the same principles as defined in France by Bernard Poullain (1945, founder of the first French CETA), as well as in Argentina and Uruguay where they are called "CREAs". Most of the Brazilian CITEs existing now in Rio Grande do Sul are oriented toward stock breeding. Establishing CITEs of wheat producers, first near Passo Fundo and more widely in the main wheat growing areas of Brazil would be of utmost interest. Since a CITE is a focusing point where producers, extensionists and researchers gather informally, this seems to be one of the best means for creating and further strengthening of the links between research and extension. Additionally, some large scale experiments at farmer's level could be realized easily through a CITE, since they are not entertained within the administrative and practical framework of the CNPT.

2.5 As already pointed out (Part I, 1.3.7) the national counterpart staff at the CNPT has full ability to perform analytical research, but needs to be trained

and temporary helped for a new comprehensive approach of wheat problems, mainly in "Production Systems" and "Integrated Control of Wheat Pests and Diseases" research areas. As well, breeding for horizontal resistance is a new activity requiring further assistance. Therefore, it is appropriate to strongly recommend that CNPT's research team receive further international assistance through UNDP/FAO. A draft Project Document titled "Increase and Development of Wheat Production in Brazil, Phase II", has been prepared according to the recommendations of the Tripartite Review Mission held at the CNPT (December 1978), and sent to relevant authorities (Government of Brazil, UNDP and FAO) on 22/08/1979 for examination.

2.6 As already pointed out in relevant paragraphs, many CNPT's scientists have gained a noteworthy experience in several research areas, through their personal work and technical training they received from FAO's experts or fellowships. In the same manner, other developing countries (in South America or elsewhere) also gained experience in several fields of interest for Brazil. It is therefore strongly recommended to explore new opportunities for developing TCDC programmes (Technical Cooperation among Developing Countries), in which Brazil would play an eminent part. Reversely, Brazil could receive assistance in some fields where necessary.

Along this report, several fields especially suited for TCDC programmes have been outlined, among them:

- Wheat breeding in southern cone countries;
- Application of in vitro culture techniques in breeding programmes for food crops and germplasm banks;
- Epidemiology of wheat diseases in South America;
- Integrated biological control of wheat aphids (in cooperation with Chile);
- Soil erosion control in the countries neighbouring the Paraná basin;
- etc...

There is particular advantage in using developing country capacities in fields where these countries have accumulated valuable and sometimes unique experience through their own development efforts.

Annexes

No. 1 - Plan of Expenditure - Special Fund Allocation (1970-1973)

No. 2 - Plan of Expenditure - Government Counterpart Contribution (1970-1973)

No. 3 - List of International Staff

No. 4 - List of Government Personnel

No. 5 - International Staff Movement

No. 6 - Project Revision "E" (23 November 1974)

No. 7 - Project Revision "M" (30 June 1978)

No. 8 - List of Fellowships awarded

No. 9 - List of Major Items of Equipment provided by UNDP

No. 10 - Total UNDP Contribution as adjusted on 5 June 1979 (Revision "O")

No. 11 - List of the Technical Reports presented by the FAO Experts

No. 12 - List and pedigree of wheat cultivars recommended in 1979 by CNPT

No. 13 - Characteristics of wheat cultivars recommended in 1979 by CNPT

No. 14 - Crop Loss Appraisal Experiment

No. 15 - Technical Cooperation Programme TCP-BRA/8908 (M) "Integrated Control of Wheat Aphids.

ANNEX No 1

Increase and Development of
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PLAN OF EXPENDITURE - SPECIAL FUND ALLOCATION (1970-1973).(Estimated Costs)

	Total m/m	Total Project Costs (US$)
Experts:		
i) - Project Manager	48	107,600.-
- Plant Breeder	40	89,700.-
- Agronomist (Soil Fertility)	40	89,700.-
- Agronomist (Field Trials)	48	107,600.-
- Plant Pathologist	48	107,600.-
ii) - Consultants	36	80,700.-
iii) - Administrative Officer	24	40,800.-
Sub-total :	284	623,700.-
Fellowships:		
Sub-total :	120	58,000.-
Equipment:		
Sub-total :	-	220,000.-
Sub-contracts:		
Sub-total :	-	10,000.-
Miscellaneous local operating costs :		
Sub-total :	-	37,400.-
TOTAL GROSS PROJECT COSTS:		949,100.-
Participating and Executing Agency Overhead Costs :		106,700.-
Special Fund Direct Costs :		8,000.-
SPECIAL FUND ALLOCATION		1,063,800.-

Increase and Development of
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ANNEX No 2.

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PLAN OF EXPENDITURE - GOVERNMENT COUNTERPART CONTRIBUTION (1970-1973)

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	Total m/m	Total Project Costs (Cruzeiros)
Personal Services :		
-Professional Staff :		
- Co-Manager	48	167,040.-
- Plant Breeders (4)	192	330,976.-
- Plant Pathologists (3)	144	248,232.-
- Farm Management	48	82,744.-
- Agronomists, Soil Fertility (2)	96	165,488.-
- Agronomists, Field Trials (3)	144	248,232.-
- Biometrician	48	82,744.-
Sub-total:	720	1,325,456.-
- Non-professional Staff:		
Sub-total:	2,016	669,900.-
- Travelling Expenses :	-	591,600.-
Sub-total for all Personal Services:	2,736 m/m	2,586,956.-
Land and Buildings :		2,175,000.-
Equipment and Supplies :		
- Field Equipment and Machinery		1,305,000.-
- Soil Laboratory		87,000.-
- Phytopathology Laboratory		43,500.-
- Operation and Maintenance, other Facilities		893,925.-
Sub-total:		2,329,425.-
Miscellaneous :		237,075.-
Local Transport and Handling (Equipment) :		87,000.-
Total Counterpart Contribution in Kind.....		7,415,456.- Cruzeiros
(i.e., in US $ equivalent*).....		1,605,077.- US$
Contribution Towards Local Operating Costs.....		93,600.- US$
TOTAL GOVERNMENT CONTRIBUTION.....		1,698,677.- US$

(*): prevailing United Nations operating rate of exchange of one US Dollar = 4.62 Cruzeiros

ANNEX Nº 3.

Increase and Development of
Wheat Production in Brazil
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LIST OF INTERNATIONAL STAFF

Post Description	Name, nationality	Arrived	Department
Project Manager	McKNIGHT, T., Australia	Oct. 69	Dec. 73
Project Manager	KUGLER, W.F., Argentine	Apr. 74	Dec. 78
Plant Breeder	GILL, B.S., India	Sept. 71	Dec. 76
Plant Pathologist	GUTHRIE, E.J., U. Kingdom	Mar. 70	Aug. 70
Plant Pathologist	SANTIAGO, J.C., Portugal	Aug. 71	Dec. 76
Agronomist (Field Trials)	PAN, C.L., China	Feb. 70	Dec. 73
Agronomist (Soil Fertility)	MARTINI, J.A., Panama	Sept. 70	May 74
*Agronomist (Production Systems)	BOUGLÉ, B.R., France	Oct. 74	Dec. 79 (exp.)
Farm Management	PERETTI, M.A., Argentine	Sept. 75	Sept. 76
Farm Management	DE GRANDI, J.C., Argentine	Nov. 77	Dec. 79 (exp.)
Horizontal Resistance	BEEK, M.A., Netherlands	Nov. 78	Dec. 79 (exp.)
Administrative Officer	KOSTENBAUM, J., Belgium	Oct. 70	Oct. 72
Associate Expert I.P.H.R.	BEEK, M.A., Netherlands	Nov. 75	Nov. 78 (incorp.
Consultants:			
Plant Pathology	HENDRIX, J.W., U.S.A.	Sept. 75	Nov. 75
Plant Pathology	HENDRIX, J.W., U.S.A.	Nov. 77	Dec. 77
Plant Pathology	ASHWORTH, Jr., L.J., U.S.A.	Sept. 75	Oct. 75
Soil Conservation	MOLINA, J.S., Argentine	Sept. 75	Oct. 75
Soil Conservation	GRANADOS, A.H., Spain	Mar. 78	Sept. 78
Biological Control Aphids	GUTTIERREZ,A.P., U.S.A.	Dec. 77	Dec. 77
Biological Control Aphids	GUTTIERREZ,A.P., U.S.A.	Sept. 78	Oct. 78
Biological Control Aphids	BAUMGAERTNER, J., Switzerland	Jun. 78	Aug. 78
Biological Control Aphids	ZÚÑIGA, E., Chile	Jul. 78	Aug. 78
Wheat Root Disease	SHIPTON, P.J., U. Kingdom	Aug. 79	Sept. 79
Wheat Root Disease	ROVIRA, A., Australia	Sept. 79	Sept. 79
Anther Culture	**PICARD, E., France	Oct. 79	Nov. 79
Biological Control Aphids	**GONZALES, R., Chile	Nov. 79	Nov. 79

(*) : Acting Project Manager from 01.02.1979.
(**): Consultants under recruitment at the moment of Terminal Report drafting.

ANNEX Nº 4.

Increase and Development of
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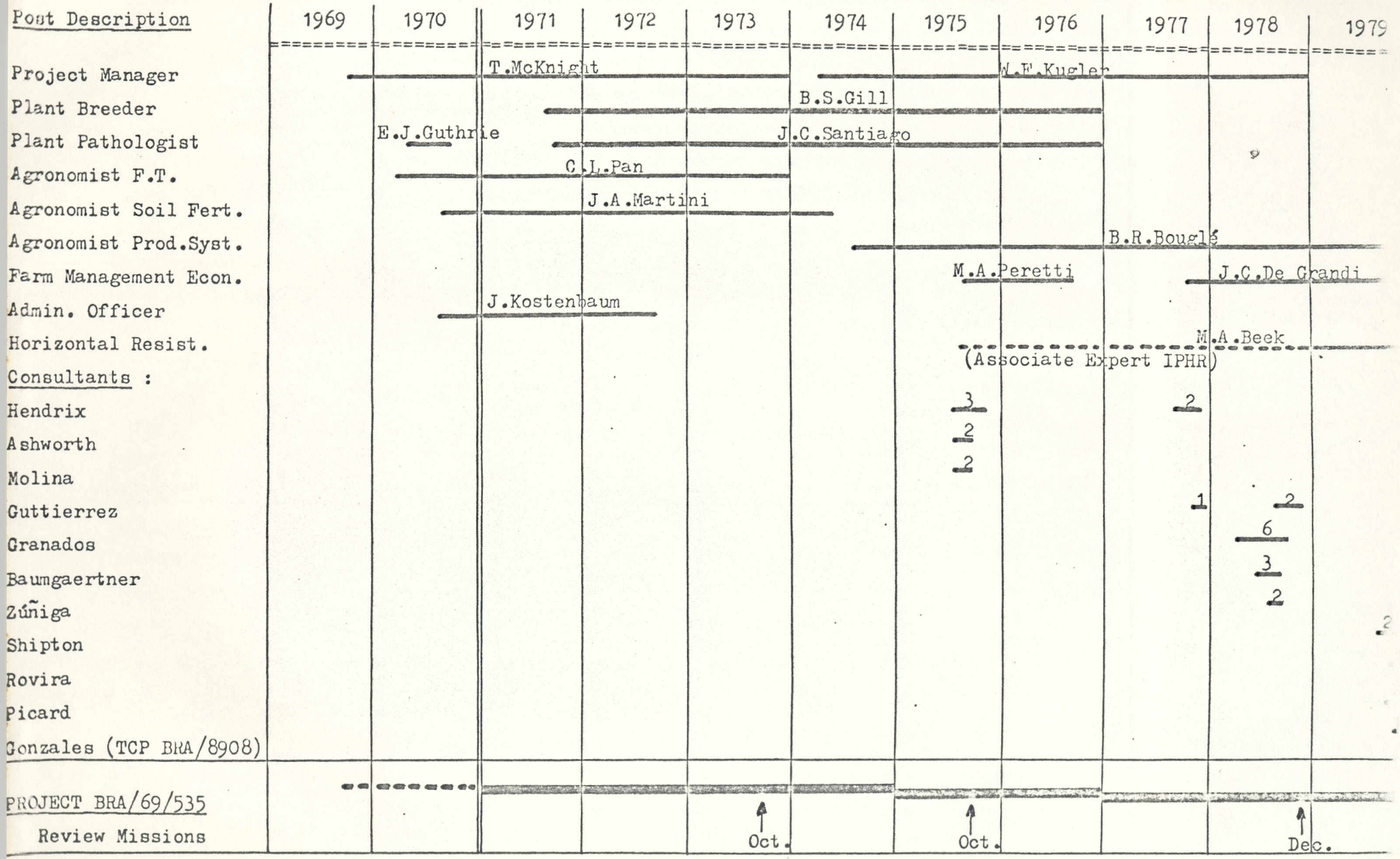
LIST OF GOVERNMENT PERSONNEL

Post Description	Name of incumbent	Assumed duty**
Co-Manager - Chief NWRC	Edar Peixoto Gomes* (1)	June 73
Deputy Chief NWRC	Francisco Antonio Langer*	Mar. 77
Deputy Chief NWRC	Firmiano Idyllio Ferreira	May 75
Plant Breeding	Augusto Carlos Baier	Sept. 74
Cytogenetics	Maria Irene Baggio de M. Fernandes	Aug. 75
Virology	Vanderlei da Rosa Caetano	June 75
Plant Pathology	Amarilis Labes Barcellos	Feb. 75
Soil Fertility	Ana Cândida Pacheco de Aguirre	Nov. 77
Seed Technology	Aroldo Gallon Linhares	Oct. 68
Plant Breeding	Cantídio N.A. de Sousa*	Nov. 71
Plant Breeding	Edson Jair Iorczeski*	Jan. 73
Plant Pathology	Elisa Thomas Coelho	Feb. 75
Entomology	Franco Lucchini	Jan. 78
Plant Physiology	João Batista Teixeira	Aug. 78
Plant Breeding (triticale)	João Carlos Arruda Dias	June 78
Statistics	João Carlos Ignaczak*	Jan. 73
Plant Breeding	João Carlos Soares Moreira*	Nov. 71
Plant Pathology	José Artur Diehl	Mar. 72
Soil Conservation	José Eloir Denardin	Apr. 77
Soil Fertility	José Renato Ben	July 77
Production Systems	Julio Cesar Barreneche Lhamby	Jan. 78
Plant Pathology	Leonor Aita	Feb. 78
Entomology	Luiz Antonio B. de Salles	Mar. 78
Plant Breeding	Milton Costa Medeiros*	Nov. 71
Soil Fertility	Otávio João F. de Siqueira*	Nov. 71
Plant Breeding	Ottoni de Sousa Rosa	Dec. 74
Soil Fertility	Rainoldo Alberto Kochhann*	Nov. 71
Farm Management & Economics	Roque Gilberto Annes Tomasini	June 75
Plant Breeding	Sérgio Roberto Dotto*	Nov. 71
Plant Pathology	Walesca Iruzun Linhares	Nov. 71
Soil Conservation	Werner Arnaldo Wünsche	June 75
Agro-meteorology	Wilmar Wendt	Jan. 78
Germplasm Bank	Ana Christina A. Zanatta	May 78
Diffusion of Technology	Armando Ferreira Filho	Jan. 78
Diffusion of Technology	Benami Bacaltchuk	Aug. 75
Entomology (soybeans)	Gabriela E. L. Marques	Nov. 76
Soil Fertility	Geraldino Peruzzo	Mar. 77
Plant Breeding (barley)	Gerardo N.Arias Duran y Veiga	Feb. 77
Seed Technology	Jorge Luiz Nedel	Sept. 78
Agricultural Machinery Res.	José Antonio Portella	Oct. 78
Plant Pathology	José Maurício Cunha Fernandes	Jan. 77
Plant Breeding (soybeans)	Paulo Fernando Bertagnolli	Jan. 79

(1) Assumed new functions in March 1979;
* Counterpart staff originally assigned to Project.
** All personnel employed full-time.

UN SF PROJECT 381 (FAO/BRA/69/535) International Staff Movement ANNEX No 5.



Increase and Development of
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ANNEX No 6.

PROJECT REVISION "E" (23 NOV 1974)
(two-year extension untill 31 DEC 1976)

1. Revised Work Plan (Summary):

The Review Mission recommended two-year extension of the Project, to enable continuation of the studies initiated during the first period, and to initiate new researches connected with wheat production : wheat-soybean rotation compared with other productive wheat cropping systems, use of chemical control against wheat diseases, control of soil erosion, technical assistance of the Project Staff in the region north of 24°S parallel.

The problems of soil fertility are beeing gradually taken over by the counterpart staff, as several of them hold Master Degrees.

With the resignation of the FAO Agronomist (Soil Fertility), this post is discontinued and replaced by another Agronomist (Production Systems).

The retirement of the FAO Agronomist (Field Trials) allows recruitment of an Agroeconomist (Farm Management).

2. Revised Budget (estimation)

2.1. UNDP Inputs	m/m	US $
Experts	120	300,000.-
Consultants	15	37,500.-
Evaluation Mission, Admin. support		17,000.-
Project Personnel, sub-total :	135	354,500.-
Sub-contracts		5,000.-
Training (fellowships)	53.5	51,000.-
Group Training		10,000.-
Training Component, sub-total:	53.5	61,000.-
Equipment Component		89,838.-
Miscellaneous Component		13,000.-
GRAND TOTAL :		523,338.-

2.2. Counterpart Contribution in Kind	m/m	Cruzeiros
Personnel Component	828	2,495,800.-
Equipment & Miscellaneous		1,132,000.-
GRAND TOTAL :		3,627,800.-
or, in US Dollar*equivalent:		505,265.- US $

(*): Nov. 1974 prevailing UN operating exchange rate of One US Dollar = 7.18 Cruzeiros.

Increase and Development of
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ANNEX No 7.

PROJECT REVISION "M" (30 JUN 1978)

(three-year extension untill 31 DEC 1979)

1. Revised Work Plan (summary):

The following activity is added to the already fixed in the original Plan of Operation :

- to assist in the development of Farm Management Economics and Production Systems research, in order to promote wheat production through rational use of the farming enterprise resources, having always present the need of conserving the soil.

The integrated study of the wheat crop in its biological, technical and economical aspects, and its relations to other activities of the agricultural enterprise through interdisciplinary approach is the most important improvement of the Work Plan.

2. Revised Budget (estimation):

2.1. UNDP Inputs :	m/m	US $
Experts	96.8	450,288.-
Consultants	30.2	140,482.-
Admin. support, Official Travels		8,810.-
Project Personnel, sub-total:	127	599,580.-
Group Training		23,042.-
Equipment component		10,200.-
Miscellaneous component		9,864.-
GRAND TOTAL		642,686.- US $

2.2. Counterpart Contribution in Kind (pour mémoire)

Increase and Development of
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ANNEX No 8.

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LIST OF FELLOWSHIPS AWARDED

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On 135 men/months fellowships initially planned, a total of 101 men/months has been awarded, as following below :

Ariano Moraes PRESTES : fellowship in Plant Pathology; from 14 SEPT 1972 to 13 JUN 1974, The Washington State University (Pullman, Washington, USA); obtained M.Sc.Degree; sponsorship has been transferred from FAO to AID/purdue contract to provide 24 months extension to pursue Ph.D.Degree; this fellow has been employed on return at the CNPT.

Milton Costa MEDEIROS : fellowship in Plant Breeding; from 18 JUN 1973 to OCT 1975, The University of Manitoba (Winnipeg, Canada); obtained M.Sc.Degree; this fellow haw been employed on return at the CNPT.

Cantidio Nicolau Alves de SOUSA : fellowship in Plant Breeding; from 20 MAR 1973 to 23 MAR 1975, The University of Sydney (New South Wales, Australia); obtained M.Sc.Degree; this fellow has been employed on return at the CNPT.

Francisco António LANGER : fellowship in Plant Breeding; from 5 MAR 1973 to 5 NOV 1974, The Federal University of Rio Grande do Sul (Porto Alegre, RS, Brazil); obtained M.Sc.Degree; this fellow has been employed on return at the CNPT; he is now Technical Deputy Chief of the CNPT.

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ANNEX No 9.

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LIST OF MAJOR ITEMS OF EQUIPMENT PROVIDED BY UNDP (above 1,000 $)

Nb.	Items	Value $	Nb.	Items	Value $
1	Vehicle Chevrolet 1971	3,678.-	1	No-till.drill Bettinson	6,084.-
1	Station-wagon Volkswagen	1,870.-	1	Seed-drill Nordsten	2,637.-
1	Station-wagon Chevrolet	4,748.-	1	Greenhouse Lord & Burnham	11,559.-
1	Vehicle Chevrolet opala	3,516.-	1	Centrifuge International	1,614.-
3	Trucks Pick-up Chevrolet	13,584.-	3	Wheat ear threshers	1,370.-
2	Tractors Agria 19 HP	4,580.-	1	Microtome cryostat	2,593.-
1	Plot Combine Hege 125	5,070.-	3	Incubators Percival	3,510.-
2	Plot Combines Hege 125B	15,778.-	2	Incubators Percival I59L	2,736.-
2	Seed drills Weihenstephan	2,934.-	1	Tresher Labor Ear	1,151.-
3	Plot drills Øyjord	18,294.-	1	Grain counter GEP	1,397.-
1	Packeting mach. Ballard	4,392.-	1	Balance Mettler P.1210	1,690.-
2	Plows Huard	1,260.-	1	Spray-tower Burkward	2,833.-
2	Hoes Agria	1,790.-			

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Total UNDP Contribution as adjusted on 5 June 1979 (Revision "0") ANNEX No 10.

	TOTAL		Initial Phase I 1971-1974		1st extension 1975-1976		2nd extension 1977-1979	
10.Project Personnel.								
11. Experts	m/m	US $	m/m	US $	m/m	US $	m/m	US $
1101.Project Manager	77.1	259,030	33.1	82,773	21.8	79,615	22.2	96,642
1102.Plant Breeder	60.0	177,676	36.0	90.025	24.0	87,651	-	-
1103.Agronomist Soil Fertility	29.0	72,520	29.0	72,520	-	-	-	-
1104.Agronomist,F.T.,Prod.Syst	86.6	310,887	26.6	66,519	24.0	87,651	36.0	156,717
1105.Plant Pathologist	72.0	229,915	36.0	90,025	24.0	87,651	12.0	52,239
1106.Consultants	37.6	157,801	0.6	1,500	6.8	24,834	30.2	131,467
1107.Admin. Officer	9.6	24,008	9.6	24,008	-	-	-	-
1108.Prod.Syst.Economist	13.5	50,355	-	-	12.0	43,825	1.5	6,530
1109.Farm Management Econ.	24.0	104,478	-	-	-	-	24.0	104,478
1140.Expert correction	(-1.0)	(-4,353)	-	-			(-1.0)	(-4,353
1199. Sub-total	408.4	1,382,317	170.9	427,370	112.6	411,227	124.9	543,720
13. Admin. support		18,015		8,644		4,006		5,365
15. Official Travels		16,553		-		13,108		3,445
16. Other Costs		31		791		(- 760)		-
18. Prior 1972 expenditures		246,083		246,083		-		-
19. Component Total		1,662,999		682,888		427,581		552,530
29. Sub-contracts		2,856		1,974		882		-
30. Training								
31. Individual fellowships		63,093		47,368		15,725		-
32. Group Training		33,046		1,276		8,728		23,042
33. In-Service Training		4,132		1,344		2,788		-
38. Prior 1972 expenditures		620		620		-		-
39. Component Total		100,891		50,608		27,241		23,042
49. Equipment		258,748		136,173		62,287		60,288
59. Miscellaneous		44,655		23,957		10,884		9,814
99. TOTAL UNDP CONTRIBUTION		2,070,149		895,600		528,875		645,674

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ANNEX No 11.

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LIST OF THE TECHNICAL REPORTS PRESENTED BY THE FAO EXPERTS
UPON COMPLETION OF ASSIGNMENT

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	Author, area of specialization	Date of presentation
Interim Final Report	T.McKnight (Australia), Project Manager	JAN 1974
Final Report	C.L.Pan (China), Agronomy,Field Trials	DEC 1973
Final Report	J.A.Martini (Panama),Agronomy,Soil Fertility	MAY 1974
Final Report	B.S.Gill (India), Plant Breeding	DEC 1976
Final Report	J.C.Santiago (Portugal), Plant Pathology	DEC 1976
Final Report	M.A.Peretti (Argentine), Farm Management	SEP 1976
Interim Final Report	W.F.Kugler (Argentine),Project Manager	DEC 1978
Final Report (1)	*B.R.Bouglé (France),Agronomy,Production Systems	DEC 1979
Final Report (1)	J.C.De Grandi (Argentine),Farm Management	DEC 1979
Final Report (1)	M.A.Beek (Netherlands), Horizontal Resistance	DEC 1979
Consultant Report	J.W.Hendrix (USA), Septoria diseases,root problems	DEC 1977
Consultant Report	J.W.Hendrix (USA), Septoria and root problems	NOV 1978
Consultant Report	L.J.Ashworth Jr (USA), Soil borne diseases	OCT 1975
Consultant Report	J.S.Molina (Argentine), Soil erosion	OCT 1975
Consultant Report	A.P.Guttierrez (USA), Biological Control of Aphids	DEC 1977
Consultant Report	A.P.Guttierrez (USA), Biological Control of Aphids	OCT 1978
Consultant Report	A.H.Granados (Spain), Soil erosion	SEP 1978
Consultant Report	J.Baumgaertner (Switzerland), Biological Control	AUG 1978
Consultant Report	E.Zúñiga (Chile), Biological Control of Aphids	AUG 1978
Consultant Report	P.J.Shipton (U.Kingdom), Root system diseases	(2)
Consultant Report	A.Rovira (Australia), Root rots	(2)
Consultant Report	E.Picard (France), Anther culture,haploidy	(2)
Consultant Report	R.Gonzales (Chile),Biological Control of Aphids (under TCP BRA/8908)	(2)

Remarks: * Acting Project Manager from february 1979.

(1) expected NTE 31/12/1979. If extended, Interim Technical Report.

(2) Consultancies programmed for the last quarter of 1979 (ongoing consultancies)

List and pedigree of wheat cultivars recommended in 1979 by the CNPT (EMBRAPA) for cultivation in southern Brazil (RS, SC, South of Paraná)

No	Cultivars	Cross	Created by	Released in
1	C 33	Veranópolis/Vila Velha	SA-Veranópolis	-
2	CNT 1	PF 11-1001-62/BH 1146	CNPT	1975
3	CNT 7	IAS 51/IAS 20/ND 81	IPEAS-CNPT	1977
4	CNT 8	IAS 20/ND 81	IPEAS-CNPT	1977
5	CNT 9	IAS 46/IAS 49/IAS 46/Tokai 66	IPEAS-CNPT-UFPel	1978
6	CNT 10	IAS 46/IAS 49/IAS 46/Tokai 66	IPEAS-CNPT-UFPel	1978
7	Cotiporã (C 3)	Veranópolis*2/Egypt NA 101	SA-Veranópolis	1965
8	Coxilha (S 46)	Giruá/Purplestraw	SA-J.de Castilhos	1975
9	Glória	Tezanos Pinto Criolo*3/Selkirk	IPB-Herval	1977
10	IAC 5 (Maringá)	Frontana/Kenya 58/PG 1	IAC	1977
11	IAS 61	IAS 51/IAS 20/ND 81	IPEAS	1973
12	IAS 64	Pel 11319-61/IAS 20/ND 81	IPEAS	1974
13	Jacuí (S 63)	S 8/Toropi	SA-J.de Castilhos	1973
14	Mascarenhas	B 4/Toropi	SA-Bagé	1977
15	Multiplicacion 14	Litoral Precoz/Klein 157	Uruguay	-
16	Nobre (S 31)	Colotana 295.52/Colotana 824/Yaktana 54	SA-J.de Castilhos	1969
17	PAT 19	S 12/J 9281-67	SA-CEP	1976
18	PAT 7219	S 12/J 9280-67/Nobre/Toropi	SA-CEP	1977
19	Vacaria (C 51)	Veranópolis/Trapeano/Colotana 1838	SA-Veranópolis	1976
20	BR 3	IAS 46/4/IAS 50/3/VS*4//E 101/T	CNPT	1979
21	BR 4	IAS 20*3/Sinvalocho Gama	CNPT	1979
22	PAT 7392	J 1232 G 67/IAS 55	SA-CEP	1979
23	Santiago	IAS 50/E 11	SA-Bagé	1979
24	+ Cinqüentenário (C 15)	Trintecinco//E 101/T	SA-Veranópolis	1969
25	+ Herval	PF 11-1000-62/Super X	IPB	1978
26	+ Hulha Negra	Toropi/Magnif MG//Klein Impacto	SA-Bagé	1977
27	+ Toropi (S 1)	Frontana/Quaderna A//Petiblanco 8	SA-J.de Castilhos	1965

+ = Late cultivars, all others being early ones.
CEP = Experiment Centre of FECOTRIGO (Federation of Wheat Cooperatives in RS, Cruz Alta).
CNPT = National Wheat Research Centre, Passo Fundo.
IAC = Agronomic Institute of Campinas, SP.
IPB = International Plant Breeder Ltd.
IPEAS = Institute for Agricultural Research and Experimentation in the South, Pelotas, RS.
SA = State Secretary of Agriculture
UFPel = Federal University of Pelotas, RS.

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ANNEX No 13

Characteristics of wheat cultivars recommended in 1979 by the CNPT (EMBRAPA) for cultivation in Southern Brazil (See Annex no 14)

No	Degree of resistance to						
	Powdery Mildew	Rusts		Septoria		Gibberella	Mosaic Virus
		Leaf	Stem	Glume	Leaf		
1	MS	S	S	R	R	S	MS
2	S	S	NU	R	MR	MS	MS
3	S	S	NU	MS	S	MS	MR
4	MS	S*	R	MS	-	S	S
5	S	S*	MR	MR	MS	MS	MS
6	S	S*	S	MR	MS	MS	MR
7	MS	S	R	R	MR	MS	S
8	MS	S	S	S	MS	S	S
9	S	NU	S	MR	-	MR	S
10	MS	S	S	MR	MS	S	S
11	MR	S	S	R	-	MR	MR
12	S	S	R	MR	MR	MR	MS
13	MS	S*	NU	MR	MR	MR	MS
14	HS	S*	S	MR	MR	MS	S
15	MS	S*	S	MS	MR	MR	S
16	S	S	S	S	MS	S	S
17	S	S*	S	MR	-	MR	S
18	S	S*	NU	MS	MR	MR	S
19	S	S	S	MS	-	MS	MS
20	MS	S*	MR	S	MS	S	S
21	MS	S*	MR	S	S	S	MS
22	MS	S*	MR	MR	MR	R	-
23	S	S*	S	R	MR	MS	MS
24	MS	S*	NU	R	S	MS	S
25	MR/MS	S*	R	-	-	S	S
26	MR	S*	R	-	-	MS	S
27	MR	S*	R	R	R	R	S

* = Less infected in the field
NU = Not uniformly infected
R = Resistant
MR = Medium resistant
MS = Medium susceptible
S = Susceptible
HS = Highly susceptible

Increase and Development of
Wheat Production in Brazil
UN SF 381 (FAO/BRA/69/535)

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ANNEX No 14.

CROP LOSS APPRAISAL EXPERIMENT TO EVALUATE THE FIRST RESULTS ACCRUEING FROM HORIZONTAL RESISTANCE

(C.N.P.T. - Passo Fundo,RS - 1978)

Factorial design, 4 replicates, plot size 4 x 9 meters, borders of oats between plots to avoid interplot interference.

Treatments : - No plant protection
- Fungicides (full control of diseases)
- Insecticides (full control of pests)
- Fungicides and Insecticides (full control of pests and diseases)

Wheat varieties ; - Original mixture of the H.R.Programme
+ "Generation 5"
- Nobre
- Jacui

Wheat yields (kg/ha)

	No plant prot.	Fungicides	Insecticides	Fungicides + Insecticides	Average
Original Mixture	2545	2603	2730	3113	2748 (100) b
Generation 5	2939	2756	3106	3310	3028 (110)a
Nobre	2070	2130	2382	2569	2288 (83) d
Jacui	2511	2310	2629	2725	2544 (93) c
Average =	2516 c	2450 c	2712 b	2929 a	
Index =	100	97	108	116	

C.V.= 6.4 % Tukey 5%= 160 kg/ha (testing averages)

ANNEX No 15.

TECHNICAL COOPERATION PROGRAMME

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Project Number	:	TCP - BRA/8908 (M)
Country	:	Brazil
Title	:	Integrated Control of Wheat Aphids
Date of Initiation	:	1st August 1979
Date of Termination	:	31st January 1980 (extended up to 1st.Dec.1980)
National Responsible Institution:		Empresa Brasileira de Pesquisa Agropecuária (EMBRAPA) linked to the Ministry of Agriculture
FAO Contribution	:	US$ 70,000

Objectives:

1) Assist in the implementation of the national programme on biological control of aphids attacking wheat and other winter cereals, and develop techniques for the evaluation of their economic thresholds.

2) Complete facilities and laboratory installations with equipment to be used for inspection of biological material introduced from abroad, its mass rearing, release and colonization in main wheat areas.

3) Train national counterpart personnel in biological control and crop loss appraisal techniques.