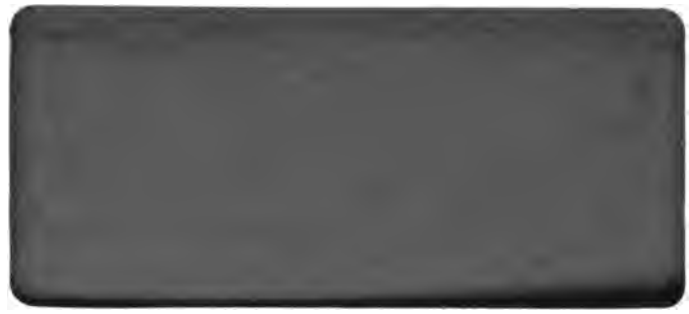
IICA PROCISUR

REPORT OF ACTIVITIES, OBSERVATIONS AND RECOMMENDATIONS

Dr. Roger B. Austin

PROGRAMA COOPERATIVO DE INVESTIGACIÓN AGRÍCOLA DEL CONO SUR

BID/IICA



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REPORT OF ACTIVITIES, OBSERVATIONS AND RECOMMENDATIONS.

By Dr. Roger B. Austin

A study visit made under the auspices of the Cereals Subprogramme of the Technology Transfer Programme of IICA/BID/PROCISUR between 9 and 21 October in Argentina, and between 22 October and 1 November in Chile.

OBJECTIVES OF VISIT

The purpose of the visit was to review wheat growing in Argentina and Chile, the breeding and ecophysiological research which is undertaken in support of wheat production, and to make recommendations for further research.

PART I ARGENTINA

ITINERARY

9 October 1989	Arrival in Argentina at Ezeiza International Airport. Met by Enrique Suarez (INTA Castelar). Transferred to Aeroparque for flight to Rosario. Met by H. Pedrol and Julio Castellarin (INTA, Oliveros). Travelled to Marcos Juarez.
10 October	Introductory discussions at INTA Marcos Juarez involving Srs. Tombetta, Bainotti, Fraschina, Pedrol, Castellarin and Sra. Galich and others. Tour of breeding plots and laboratories and visit to a farm owned by Sr. Rosso, near Marcos Juarez.
11 October	Tour of area and visit to two farms to see variety/ husbandry trials. One farm was at La Chispa, near Murphy, Santa Fe Province. Overnight in Rosario.

12 October	Travelled to INTA Oliveros. Viewed variety, agronomy and variety x agronomy trials. Discussions with Pedrol, Castellarin, Fraschina, Bainotti and Martignone (UNR Santa Fe, Rosario), joined by Pat Wall and Jorge Nisi. Returned to Rosario. Dinner with Nisi, Wall, Fraschina, Bainotti and Miguel Mac Manney.
13 October	Gave seminar at Farmers Club, Rosario. Travelled with Wall to Buenos Aires. Met by Suarez, taken by car to INTA Castelar where gave seminar. Dinner in evening with Wall and Hall (UBA).
14 October	Gave seminar at Faculty of Agronomy, UBA and had discussions with Slafer (postgraduate student) and with Sra. Trapani of the Department. Dinner with Sra. Trapani and Dr. Lemcoff (also of the same Department).
15 October	Spent the day with Dr. Antonio Hall, Faculty of Agronomy, UBA.
16 October	Travelled by air to Mar del Plata where met by two postgraduate students, Pablo Abatte and Maria Otegui. Spent morning in discussion with them and then travelled by car to INTA Balcarce where held discussions with Horacio Bariffi, Elvira Suero and Fernando Andrade. Dinner with Andrade, Abatte and Otegui.
17 October	Gave seminar at INTA, Balcarce. Toured wheat breeding plots and variety trials.
18 October	Travelled to wheat breeding station of Jose Buck near

	Necochea. Toured breeding plots and variety trials with assistant wheat breeder and later had discussions with Carlos Buck. Travelled to Mar del Plata.
19 October	Travelled by air to Buenos Aires.
	Worked on report.
	Dinner with Suarez (INTA Castelar).
20 October	Visited IICA Offices, Buenos Aires.
	Continued to work on report.
21 October	Left by air for Santiago.

OBSERVATIONS

Marcus Juarez and district, including Oliveros.

Agronomy

The agronomists believed that the physical conditions of the soils in the area had declined considerably in the last 40 years. The soils are of a loess type with a high silt content. It may be supposed that prior to the introduction of cropping they had accumulated much organic matter and nitrogen and so would have been very fertile when first cultivated. A rough calculation suggests that the annual decline in organic matter would release about 40 kg N/ha in the top 10 cm of soil with probably a similar reduction below 10 cm, providing say 50-80 kg N/ha for each year's cropping. The amount of nitrogen removed by a wheat crop of 2 t/ha at 12% protein content would be about 40 kg/ha. Thus, very roughly, it may be supposed that so far there has been an approximate balance between nitrogen availability and that removed by the crop. With soil organic matter content now little over 2%, it is clear that yields will begin to decline under continuous cropping unless nitrogen fertilizer is applied, and in such a way as to

be used effectively. While this may prevent or reduce a further rapid decline in soil organic matter and physical condition, additional measures will be required to bring about improvements. Recognising this, INTA agronomists have begun a series of trials on green manuring. Such trials are difficult to carry out effectively in small plots and demand appropriate machinery and skilled operators. While green manuring treatments are worth exploring, short term leys (2-3 years) might be easier and more effective if they could be fitted into the farming system.

Certainly, the present double cropping arable systems are entirely extractive and non-sustainable, so some alternative, albeit less productive, must be found.

I discussed the possibility of deficiencies in other nutrients, including phosphorus, sulphur, calcium and minor elements, but was unable to ascertain whether trials had been carried out to assess whether deficiencies of these elements were limiting yields. If not, it should be a matter for investigation.

Apart from nutrient deficiency, yields of wheat were probably limited by soil moisture deficit of variable severity, duration and timing. The most damaging deficits appeared to occur during the period from sowing to anthesis and this was one reason why responses to fertilizer nitrogen were poor and variable (other reasons being poor soil physical condition and the probable occurrence of deficiencies of other elements). Short of irrigation, which would not be feasible for wheat, the main scope for limiting the severity of water stress lies in having a period of fallow prior to planting and/or delaying planting. If delayed planting is feasible, it may necessitate the use of varieties with a different life cycle.

A most interesting study was in progress at Oliveros, and had been initiated by Dr. Ricardo Martignone of the Faculty of Agricultural Sciences at the University in Rosario. The first year's results from this work had shown considerable response to nitrogen when soil moisture deficit was prevented by

frequent irrigation, but little response in unirrigated conditions. Careful physiological and environmental monitoring had been done throughout, enabling the results to be understood in terms of growth, development, etc. With some modification to the design of the trials, it would be very beneficial to extend them to other areas (see recommendation 1).

Breeding

Wheat breeding was being pursued energetically by two young members of INTA staff. Clearly, reflecting the influence of CIMMYT, the programme was well funded, with a heavy emphasis on yield and disease resistance. The standard of plot work was excellent. I had reservations on whether knowledge of wheat genetics, pathology and physiology was being exploited as fully as it could be and have made recommendations to this effect (see below). As wheat is exported, there is considerable scope for improving bread making quality by breeding for appropriate glutenin subunit composition and ensuring that the 1RS rye translocation (present in CIMMYT Veery wheats) is excluded from Argentinian varieties. This rye translocation contains genes which code for secalin proteins which give bread a sticky texture.

While it is necessary to maintain the effort in breeding and improve its effectiveness, the benefits from improved varieties will not be achieved without improvements in soil conditions and agronomy.

I saw no reason for making so many crosses each year and believe that fewer crosses, between parents chosen for complementary characters and good adaptation, with much larger F2 populations, and a pedigree system, would be an improvement on present practice.

Balcarce district including Necochea area

Agronomy

Several factors contribute to an inherently more stable wheat production in this area than in the Marcos Juarez area. Temperatures are lower and only one crop per year is grown. The rate of oxidation of soil organic matter is lower. Periods of cropping alternate with periods when the land is sown to pasture, allowing soil organic matter and fertility to increase. However, much of the wheat appears to be produced by farmers who rent land on a yearly basis and who have little incentive to maintain or improve soil fertility.

Except near the coast, water deficits between the late tillering stage and anthesis can reduce yield. But some of the crops I saw looked excellent, though the yield expected was not as high as I would have thought. Nevertheless, yields as high as 8 t/ha seem to have been obtained in the most favourable areas. Wheat can be planted over a considerable span of time, but except for experiments at Balcarce in an area not typical of the region as a whole, optimum sowing dates do not appear to have been determined. I would expect substantial gains from the use of nitrogen fertilizer (and possibly phosphorus) but was not told of the results of any experiments with these fertilizers.

Breeding

The programme at Balcarce was run by Horacio Bariffi and appeared to be of similar size, though possibly less well resourced, than that of Marcos Juarez. Bariffi was very dedicated to his work and did not complain about lack of resources. It was organised on CIMMYT lines. At the Jose Buck breeding station there was also a large CIMMYT influence, but apparently more reliance on tried and tested local varieties. The Buck station was well resourced for breeding for high yield, but quality testing did not appear to be emphasised.

Buck varieties have been very successful in the area, and this must owe much to continuity of staffing.

Summary of Observations

1. During the course of a short visit, I was able to see only a few places in the wheat growing areas of Argentina, and to speak to only a few of the breeders and agronomists. Necessarily, my report is based on the limited information I have been able to gather, and this should be borne in mind when reading both the report and recommendations.
2. Yields of wheat in Argentina remain low.
3. The chief biological constraints to production appear to be water stress during the period from sowing to anthesis, particularly in the north, and associated with this, poor uptake of soil and applied nitrogen. These constraints are aggravated in some areas by shallow soils, low soil organic matter (especially in the northern part of Buenos Aires Province), the latter hindering the infiltration of rain, and by the rotation used. All these conditions may favour root diseases, such as take-all, which may also be a factor contributing to low yield.
4. Argentinian scientists are well aware of the limitations to production and some trials are in progress to investigate means of overcoming them.

   Especially at times when monetary inflation is serious or is anticipated to be, it may not be the main aim of farmers (or those who rent the land for cropping) to maximise yield. Instead, they may wish to limit inputs as they may perceive this as a means of maximising the return on their investment. Thus, technology which may be available for increasing yields may not be adopted. This would apply to the use of fertilizers, herbicides and machinery.

Additionally, in areas where two crops are grown each year, the non-wheat crop may be the more profitable, so farmers may adopt measures to maximise the yield of this crop, which may compromise the attainment of the best wheat yield.

Recommendations

1. A careful review of past experiments, together with an examination of typical planting times, and of meterological data, should be undertaken. The information so assembled would enable the conclusions I have reached to be confirmed (or otherwise) and quantified and would greatly aid the planning of further research.
2. In the meantime, experiments should be carried out in the main agro-climatic zones to assess the separate and combined effects of (a) preventing soil moisture deficit by careful irrigation to control the deficit to within 10 mm of field capacity, and (b) applying fertilizer nitrogen at a series of levels of up to about 200 kg N/ha. In these experiments, basal dressings of P and K fertilizer, or micronutrients should be given if P or K deficiency is anticipated, and fungicides applied as necessary to control diseases.

   To help in the interpretation of the yield data, yield components and total above ground biomass at maturity, crop dry mass at anthesis should be measured and the dates of key developmental phases, viz terminal spikelet initiation, anthesis and maximum grain dry matter production should be recorded. To assess whether there have been substantial losses of nitrogen by denitrification the percentage of nitrogen in plant material should be determined at anthesis and maturity so that the nitrogen uptake by the crop at these stages can be assessed and compared

with the amount applied.

Meterological data, particularly rainfall and daily maximum and minimum temperatures and solar radiation (PAR if possible) and relative humidity at 0900 h should be obtained for each experimental site.

3. Once the experimental sites have been selected, a responsible person at each should be identified and an overall coordinator appointed who is competent to analyse and interpret the results. A coordination meeting, where the experimental details would be discussed and agreed, should be held well in advance of starting the experimental work. Adequate funds and facilities for the work are essential if the project is to succeed. The trials should be done for three seasons. They should be sown in each area with the highest yielding variety and planted on a date typical for the area and/or considered appropriate to obtain high yield.

4. Carefully executed and interpreted, the results of these experiments should:

   (a) provide an estimate of the potential yield at each site;

   (b) indicate at which stage of growth in each area water shortage most limited yield;

   (c) reveal the size of the response to nitrogen fertilizer;

   (d) reveal the existence of factors limiting yield other than nitrogen and water availability;

   (e) provide a basis for planning further experiments to investigate practical ways of increasing wheat yields by the modification of farming methods (sowing dates, amounts and timing of fertilizer applications) and by the breeding of varieties better fitted to the climates and farming systems.

I suggest that wheat yields obtained by farmers could be increased two or three times by the appropriate management of improved varieties.

Whether such measures were economic would depend to a large extent on the price farmers obtain for their wheat and how much they have to pay for fertilizer. In parenthesis, it should be mentioned that the cost of nitrogen fertilizer for a given energy cost is largely a function of the scale of production of the fertilizer.

5. Because of the relatively favourable climate for wheat production in the humid pampas of Argentina, wheat can be planted over a considerable span of time.

The optimum time of sowing is likely to vary with the available water in the soil profile at planting, the pattern of water availability during growth, and with genotype and fertility. Because of the influences of these factors and the potential complexity of the interactions between them, it may be difficult to discern any clear optimum at a given location. However, the available data, and its adequacy, should be critically reviewed and new experiments undertaken, where required. The optimum, or preferred, planting dates may change as other factors change, so there will be a continuing need to investigate this matter. In this context it would be most valuable to have a set of closely related genotypes differing in life cycle timing (see 6 below). These could be used as one 'factor' in planting date experiments.

6. Although the primary need is to investigate the opportunities for modifying agronomic practices as a means of increasing yield, there is an important need for ecophysiological studies to support wheat breeding and to improve the definition of the wheat ideotypes for the area. This would require the collaboration of wheat breeders and geneticists. The work would ideally need to be done at two centres, representing the 'centres of gravity' of the wheat growing areas. Obvious possibilities are the INTA

stations at Marcos Juarez and at Balcarce.

The plant characters of main importance for adaptation are likely to include:

(a) life cycle duration and the timing of critical stages;

(b) dwarfing genes, particularly the value of Rht8 versus Rht1 or Rht2;

(c) tillering capacity.

To investigate these characters, the general procedure for each character would be as follows:

(i) identify parents contrasting in the expression of the character;

(ii) make crosses and select in the F2, F3 and F4 generations for contrasting expression of the character (for major gene variation, retain heterozygotes) being careful to impose selection only for the character under study;

(iii) produce 10 low and 10 high lines (or for major genes, duplicate or triplicate isolines) for use in trials;

(iv) evaluate the lines produced for each character over at least two and preferably three years at different locations and under different cultural conditions (e.g. sowing dates for the selections differing in life cycle duration).

Note: It will be important to chose as parents varieties or breeding lines which are reasonably well adapted to the region. If these are not available, a different procedure will be needed. In neither case, have I given the full details of the procedure to be used. This should be determined in discussion with breeders and geneticists (e.g. at INTA Castelar).

The end result of these investigations would be guidance to breeders on the genes/characters they should incorporate into their varieties for

optimum adaptation in the target areas for the varieties.

7. The wheat breeding programmes appear to be organised on CIMMYT lines. Thus the work is extensive and efficient routines for crossing, raising early generations, and trialling have been built up. However, as noted under 6 above and 8 below, there is much scope for the application of existing knowledge on wheat genetics and generally for a more critical, experimental approach to breeding, and this should be encouraged. Close collaboration with breeders at INTA stations and with geneticists at INTA Castelar should be fostered, and provision made for international contacts and liaison.

Although the breeding stations at Marcos Juarez, Balcarce and, I believe, Pergamino each make hundreds of crosses each year, I wonder whether the work of crossing could be shared and more thought given to the specific objectives of each cross in terms of the characters to be combined or introduced. The dominance of the CIMMYT approach may also have the effect of swamping the programmes with CIMMYT germplasm to the exclusion of successful local material which has stood the test of time. Thus it would be interesting to introduce Rht2 and Rht8 and genes for breadmaking quality into local material by backcrossing (but see 6 above), so retaining most of the genes from local material. Also it might be worth while importing traditional varieties from other wheat growing countries with similar climates and crossing them with locally adapted material into which had been introduced appropriate dwarfing and quality genes.

8. Although not asked to review the breeding of varieties of improved breadmaking quality, I enquired about the methods being used and noted that SDS-PAGE was not one of them. While it is possible that the

breeding material for quality wheats is homozygous for the important high molecular weight glutenin subunit alleles on chromosomes 1A, B and D, this is not certain, and it is very likely that considerable benefits would accrue from the application of this technology which is now well established in many wheat breeding centres.

9. There should be much more liaison among Argentinian scientists working on wheat. A yearly meeting to review agronomical issues and research results and to plan and coordinate further work would be well worth the cost. This meeting should include soil scientists, agrometeorologists, specialists in plant nutrition and the CIMMYT regional agronomist. At this meeting, formal presentations of results should be made, and papers circulated in advance. A similar meeting should be held for the breeders, possibly concurrently, with a joint session. The meeting of the breeders should include those from the private sector and geneticists and cytologists from INTA Castelar, and the CIMMYT regional plant breeder.

The value of these coordination meetings for the exchange of information and ideas cannot be over-emphasised.

10. As in any large organisation, senior staff of INTA are inevitably drawn into administrative positions and their skills and experience are lost to research.

Inducements, in the form of career progression and appropriate salaries, should be given to skilled and creative staff to retain them as active research workers for the major part of their careers. This would help to maintain continuity in research and good new entrants would realise that there was a future for them in research.

11. I was asked by the coordinator of the wheat programme, Ing. Jorge Nisi, to discuss the use of models. It was not made clear in advance what kind of models Nisi had in mind, nor what the objectives of modelling were.

However, in discussion with INTA staff and with Dr. Pat Wall of CIMMYT, who visited Argentina during my stay there, it became evident that the models were required for predicting potential yield in the different wheat growing areas so that an assessment of the gap between actual and potential yields could be made. Dr. Wall had an additional objective: by involving staff in modelling, it would help him coordinate agronomic studies in his area (which of course includes countries other than Argentina).

Whilst there are arguments in favour of formal modelling - either comprehensive dynamic simulation models or much simpler 'static' ones involving only major relationships between growth and the environment, I have reservations about their appropriateness for the present purpose. Some of the arguments are summarised below:

(a) models can enable users to benefit from previous knowledge on factors affecting crop growth and yield;

(b) to use simulation models effectively requires a considerable investment of time and effort and appropriate numerical and computing skills, as well as equipment;

(c) existing models would have to be validated and may have to be adapted for the Argentinian environment;

(d) both (b) and (c) could take up much time and could detract from the effort given to experimentation;

(e) while existing models take genotype, temperature, solar radiation, soil nitrogen and water availability into account, they do not model variation in the supply of other nutrients and have limitations in modelling adverse soil physical properties.

I conclude that a limited investment in simulation modelling, either

using the van Keulen and Seligman model (which is fully documented) or CERES-wheat (which is not at present documented) would be beneficial as part of a closely integrated and coordinated wheat programme. The best procedure would be to assign to a suitable qualified and interested scientist the task of mounting the simulation model and validating it for Argentinian conditions. This person would need to develop harmonious cooperation with INTA agronomists and breeders both to acquire existing and new data for testing and to collaborate in carrying out model experiments. He or she would participate in the proposed annual workshops (see 9 above) on agronomy and breeding.

12. INTA staff in wheat breeding and agronomy should be encouraged to publish their work in refereed journals and their publication record should be taken account of in their promotion and career progression. This would help to encourage a suitably critical attitude to the planning and execution of research and ensure that it was of an internationally acceptable standard.

ACKNOWLEDGEMENTS

I am grateful to numerous INTA staff and others for their generous assistance and hospitality. Necessarily, I relied heavily on these people for the information contained in the report, but I take full responsibility for any errors, bias or misjudgments. Also, I am aware that I saw only some of the wheat producing areas in the country. I am particularly grateful to the following: Fernando Andrade (Univ. Mar del Plata); Horacio Bariffi (INTA, Balcarce); Antonio Hall (UBA); Maria Otegui (postgraduate student, Univ. Mar del Plata); Hugo Pedrol (INTA, Oliveros) and Enrique Suarez (INTA, Castelar).

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OBJECTIVES OF VISIT

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PART II CHILE

ITINERARY

21 October	Arrived in Santiago by air from Buenos Aires. Met and taken to Hotel in the city.
22 October	Free.
23 October	Visited Dr. Alfredo Alonso at IICA Office in Santiago for brief discussion. Then visited INIA headquarters where I was received by Sergio Bonilla, director of research, who explained the present organisation of agricultural research and extension in Chile. Met briefly with Emilio Madrid, President of INIA. Travelled by car to Chillán with Sergio Ramirez.
24 October	Visited the offices of INIA E.E. Quilamapu and met the Director, Dr. Carlos Lagos, and seven of his staff. After a brief explanation of the climates and soils in which wheat is

grown in Regions VII and VIII of Chile, visited farms and experimental sites in the nearby area of the Precordillera.

25 October — Gave seminar to staff at Quilamapu then visited a nearby farm in the Secano Interior. In the afternoon viewed the wheat programme at E.E. Quilamapu.

Travelled with Juan Luis Rouanet to Temuco.

26 October — Visited E.E. Carillanca. Had brief meeting with the Director, Dr. Norberto Buttendieck B., following which there was a short meeting with several staff and an exposition by Cristian Hewstone Martinez of the climate and soils and of wheat growing in the area. In the afternoon viewed the wheat breeding programme and also saw briefly the barley, rape and legume programmes.

27 October — Gave seminar at Carillanca and was then taken by J.L. Rouanet to the coast to see wheat growing in the area, and experiments and demonstrations on two farms.

28 October — Travelled by air from Temuco to Santiago. Met by Ignacio Ramirez Arraya, coordinator of INIA's wheat programme in Chile.

29 October — Free.

30 October — Travelled by car to Hidango with Ignacio Ramirez, Jorge Garcia-Huidobro and Rafael Novoa. Viewed breeding work, agronomy trials and wheat growing in the area.

31 October — Gave seminar at La Platina. Viewed agronomy trials and breeding work and talked briefly about assessment of breadmaking quality. Made courtesy call on IICA.

1 November — Returned to U.K.

OBSERVATIONS

Chillan area and E.E. Quilamapu

Agronomy

The regions (VII and VIII) served by this station are very diverse in soil type, altitude and climate. The main areas are the central valley, the Secano Interior and the Precordillera. Wheat in the central valley, under irrigation, can give very high yields, but the land is probably better used for high value crops, wheat being regarded as a supplementary, cash crop. The extensive Secano Interior is now badly degraded as a result of generations of extractive, low-input agriculture. Wheat has to be grown as part of a rotation involving short-term leys including forage legumes. Given modest inputs of nitrogen and phosphorus and the use of herbicides, moderate and profitable crops of wheat can be grown. Being rainfed, yields will be dependent on moisture supply. Appropriate planting dates and the use of varieties with developmental patterns which make best use of available water, minimising the effect of terminal drought, are important research objectives. More detailed information on rainfall distribution in the area would be helpful in this respect.

The Precordillera has soils of volcanic origin which are highly phosphate fixing. There is an excess of rain in winter, but also terminal drought. Rotations are considered essential to avoid devastating losses from take-all. It is not clear whether this is an inherent problem of the particular climate and soil, or whether, given good agronomy, including nutrition and weed control, more than one wheat crop could safely be grown in succession. It is important to establish this point as it has an obvious bearing on the need for rotations.

Breeding

The view was expressed that existing varieties have adequate yield

potential, and that work to relieve agronomic constraints would be more rewarding than additional emphasis on breeding. However, it is unlikely that varieties (or a range of varieties) with optimal life cycle timing exists and attention should be given to this matter. In addition, breeding to maintain or increase the levels of resistance to diseases is required, as in all breeding programmes.

Temuco area and E.E. Carillanca

Agronomy

Despite a very high winter rainfall, this is an area which, by virtue of moderate temperatures and relatively high solar radiation, is exceptionally favourable for obtaining high yields. In these respects it is even more favourable for wheat production than is north west Europe, and some of the highest yields in the world have been obtained here. The soils I saw were also of very good physical properties and the maintenance of high fertility did not appear to be a problem. Despite the high winter rainfall the leaching of fertilizer nitrogen applied at planting was not considered to be serious, partly because winter temperatures were high enough to allow moderate growth. It would be interesting to have more comprehensive information on the fate of early-applied nitrogen. Some studies on this had been done by J.L. Rouanet.

Breeding

As the environment is similar to that of north west Europe, material introduced from England and France is moderately well adapted. To 'fine tune' this germplasm to the environment of Temuco and to increase the already high yields will probably require the detection of rare recombinants and dictates a careful choice of parents and the growing of large F2 populations and F3

progenies. It would be beneficial to modify present procedures to allow this. The change would be aided by improved mechanisation, particularly the use of Monosem and Plot Spider drills.

Some concern was expressed that the feedback of information on quality tests, all carried out at La Platina, was too slow and in due course it may be valuable to provide facilities for SDS sedimentation testing and SDS-PAGE at Carillanca.

La Platina and Hidango

Agronomy

Although in different agroecological zones there are no permanent scientific staff at Hidango, and the work there is supervised during the frequent visits made by La Platina staff. La Platina, in the northern part of the wheat growing area of the Central Valley, has a latitude and climate similar to that of north west Mexico. Thus CIMMYT spring wheat germplasm performs well at La Platina, and high yields are obtained. Although the soil at La Platina has a low organic matter content, long term experiments with bulky organic manures have not increased yields beyond the level that is achieved with the equivalent amounts of N, P and K. Furthermore, wheat can be grown continuously, given fertilizers and herbicide, without any apparent decline in yield. [However, this is a somewhat academic issue, since wheat is not a dominant crop in the area, which is more profitably used for high value horticultural crops and fruits.]

Breeding

Breeding of spring types of bread and durum wheat is carried out at both La Platina and Hidango, but 'alternative' types are also bred at Hidango, the cooler environment. Although there is at present only a small demand for durum

wheats, breeding of this species is supported by local processors and it is perceived that there is some potential for export. Thus breeding of durum wheat receives more emphasis than its present production justifies. For both bread and durum wheat a modified pedigree system is used, with bulk selection of the F2 and F3 generations. Septoria is particularly important at Hidango and affected plants produce fewer and smaller grains than resistant ones, depending on the timing and severity of the infection. Thus, it is believed that selection for large, plump grains in these early generations will favour resistant or tolerant plants, and this method is used. Whether it had been successful, and how success might be judged, I was unable to ascertain. However, it allowed a large amount of material to be handled with only modest resources, so that unless there were any positive disadvantages, there would be no cause to alter present practice. Modification might be needed if selection for major genes, for example those coding for high molecular weight glutenin storage proteins, were to be practised. In addition to septoria, leaf and stem rust, and in Hidango, yellow rust, were also important diseases and selection for resistance was needed. Lack of resources to ensure epidemics of these diseases limited the effectiveness of selection and mist-spraying equipment would make a valuable contribution at La Platina.

The wheat quality laboratory at La Platina was responsible for the quality testing of all material produced at Quilamapu, Carillanca and Hidango as well as that from La Platina. The dough testing and loaf making equipment was probably adequate for the advanced lines (candidate varieties). Selection in early generations (grain appearance characters were assessed locally by the breeders) was based on the scaled-down SDS test. Some breeders were concerned that this test gave very variable results from year to year. A possible reason for this, which I did not investigate, was that the flour was not conditioned (i.e. the moisture content of samples varied) prior to carrying out the test.

As noted earlier, the precision of selection for quality would be greatly aided by the introduction of gel electrophoresis (SDS-PAGE) of grain proteins. It would be particularly valuable for choosing parents, for screening selected F3 lines and candidate varieties.

Summary of Observations

1. INIA's scientists concerned with wheat breeding and agronomy are well informed of the exceptional diversity of the climate and soils in which wheat is grown in Chile and have an integrated research programme aimed at producing varieties suitable for the main growing areas and appropriate agricultural systems for the production of wheat and other crops.
2. In the irrigated central valley and especially in the south of the wheat growing area very high and apparently sustainable yields are obtained, given appropriate varieties and inputs.
3. On the eastern side of the coastal range, the Secano Interior, most wheat is rainfed and the land has been degraded by decades of low-input cropping and by grazing. However, given better management and the use of fertilizers, moderate yields of wheat can be obtained in rotation with other crops and short-term pastures. Production is likely to be quite variable from year to year, reflecting the variable rainfall, except where irrigation can be used.
4. The coastal rainfed area appears to have considerable potential for increased wheat production, but is farmed at present by low input, extensive methods. Although terminal drought will constitute a variable limitation to yields, the climate is otherwise rather favourable for wheat production.
5. Research on cropping systems for the relatively under-developed Secano

Interior, Secano Coastale and the Precordilleras is relatively recent and many options remain to be explored and evaluated.

6. The breeding of wheat varieties for the diverse agroecological areas of Chile presents especial problems because no one area is large enough in terms of wheat production to justify a self-contained breeding programme. Thus the resources which it is reasonable to devote to variety improvement in Chile necessarily have to be thinly spread over these zones.

7. The adoption of improved agronomy and rotations and of appropriate varieties could enable a large increase in wheat production to be achieved, giving a surplus for export. To be competitive in the world markets, however, wheat of very good breadmaking quality would need to be produced. Equally, the production of high quality durum wheat could be undertaken. In either case, much more emphasis would need to be given to factors, genetic and management, which affect quality.

8. As an alternative to increasing production, wheat growing could be encouraged in those areas which are particularly suitable for this crop, and less suitable for other, higher value crops.

Recommendations

1. The chief limitations to production in the rainfed areas (apart from rainfall itself) are poor soil fertility in inappropriate rotations. Research on improved systems, therefore, should be very rewarding. This research requires adequate and sustained funding, and the provision of the requisite machinery and transport. It is labour intensive and requires reliable technical staff as well as a team of research scientists with complementary expertise. Although the benefits from this kind of research and development have been recognised by INIA staff, it would benefit from

increased funding, both in terms of staff and of equipment. A team approach would be most beneficial, so as to plan the most effective research and derive the maximum of relevant information from it.

2. The scientific team should include a crop physiologist, a soil physicist/water relations scientist, a soil chemist/plant nutritionist and, for each of the main experimental sites, an agronomist/farming systems expert. One or more of these scientists should also be expert in experimental design and statistical analysis. A scientist with experience and interest in simulation modelling would be a valuable addition to this team. A good working relationship with the wheat breeders should be ensured. All possible means to promote a team, as compared to an 'individualist', approach should be taken. To ensure a rigorous, scientific approach, it should be made clear that publication of the results in refereed journals would be required. The research should be planned to give useful results in the short term (3-5 years) as well as in the longer term (20 years). The information from this research would be on cropping systems and rotations to sustain and improve soil fertility and physical properties and hence yields and make optimum use of available water (in rainfed systems), while minimising soil erosion. These are, of course, already the objectives of current research but they should be achieved more quickly and with more certainty by better coordination, some additional staffing and facilities.

3. Because of the diverse climates and soils in the wheat growing area and the consequent need for varieties best suited to each condition, the breeders have adopted an extensive approach, both in the production of new lines and in their testing. Because the breeders have carried out trials over several locations and years with at least some entries being included for two or more years, there should now be sufficient data from these trials

to undertake a review of the evidence for genotype x environment interactions. A possible limitation in the interpretation of the results in physiological terms may be the variable severity (over years and locations) of diseases. In the future, measures to avoid or minimise this complication could be taken by including a comprehensive fungicide programme as a factor in variety trials. In carrying out this analysis, specific questions should be asked. These could include:

(a) Are advanced lines and varieties generated by the four sub-programmes (at La Platina, Quilamapu, Carillanca and La Platina) best adapted in the areas in which they were produced?

(b) If so, is this true of spring, intermediate and winter types, and for all dates of sowing tested?

(c) Also, if so, what are the characteristics, particularly life cycle timing, vernalisation and photoperiod response of the varieties and lines, produced by the sub-programmes?

(d) If no evidence is found that (a) is true, do particular lines or varieties display specific or general adaptation, and if so what are the physiological and developmental features of these varieties?

4. The above analyses would suggest new lines of research, requiring the production and evaluation of defined genotypes. Such research would best be done within the framework of the breeding programme, and in cooperation with the breeders, but would require an additional scientist and support staff.

The benefits from this research would be an improved definition of breeding objectives in terms of vernalisation and photoperiod responses, and so life cycle timing, and of other characteristics; an assessment of the most appropriate (and fewest) environments for selection and trialling; and

the introduction of appropriate, effective and practical screening techniques for life cycle timing and (where appropriate) the avoidance of terminal drought.

5. There is likely to be much scope for improving the quality of bread wheat for baking and that of durum wheat for pasta making. Improvements could be made more rapidly and with greater precision by the introduction of SDS-PAGE (gel electrophoresis) of the high molecular weight glutenin sub-unit proteins. The methods and interpretation of the gels are now well established. The best way to introduce the technology into INIA would be to send a young scientist (with interests and knowledge of biochemistry, genetics and preferably baking etc. technology) to a laboratory where the methods are being used. When this person returned he or she would be concerned, on a full-time basis, with the application of SDS-PAGE. The SDS sedimentation test, already in use at La Platina, appears to be giving variable and surprising results and the person being trained in gel electrophoresis should also investigate changes of the sedimentation test which would improve its reliability.

6. Adequate funds for completing and publishing the agroclimatic atlas and climatic data of Chile should be provided.

7. Although appropriate emphasis is given to screening for disease resistance, work at La Platina would benefit from the use of mist spraying to maximize the development of rust diseases and septoria. Equipment for this should be provided.

8. To facilitate handling early generation material in the breeding programmes special seed drills are needed. The 'Plot Spider' drill from Wintersteiger and the Monosem drill would be especially valuable for pedigree breeding (likely to be needed in the future) and should be

acquired for the breeding program. These machines are likely to be especially valuable if farmer labour becomes more expensive.

9. Carbon isotope discrimination may prove to be a valuable test for use in screening parents and advanced lines for good performance in those environments with terminal drought. The value of this technique could be explored in collaboration with overseas institutions who have the relevant expertise and equipment.

Acknowledgements

I am grateful to members of INIA staff for devoting their time so generously to enable me to accomplish my mission. Necessarily, I relied on these staff for much of the information contained in the report, though I take full responsibility for any errors, bias or misjudgments it contains. I am particularly grateful to the following: Ignacio Ramirez A., Fernando Rivero B., Jorge Garcia Huidobro P. de A. and Rafael Novoa S.A. (La Platina); Mario Mellado Z., Pedro de Canto S., Rodrigo Ortega B. (Quilamapu); J.L. Rouanet, Cristian Hewstone Martinez (Carillanca). I am also grateful to Sr. Alfredo Alonso and his staff at IICA's office in Santiago for making local arrangements.

INSTUTO INTERAMERICANO DE COOPERACION PARA LA AGRICULTURA