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Consultant Final Report
IICA/EMBRAPA-PROCENSUL II

RESEARCH ACTIVITIES IN WHEAT GENETICS AND BREEDING

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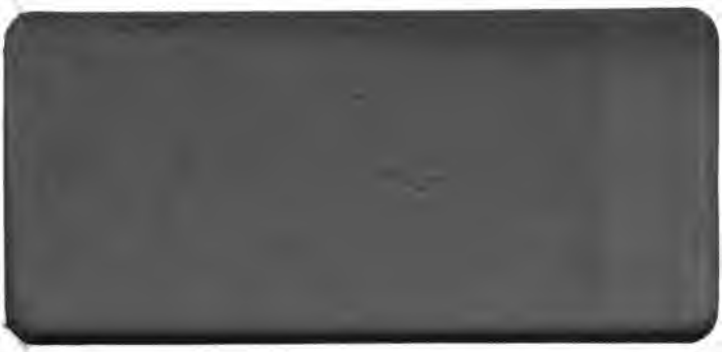

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James Mac Key

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INSTITUTO INTERAMERICANO DE COOPERAÇÃO PARA A AGRICULTURA
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APRESENTAÇÃO

A reprodução e difusão dos Relatórios de Consultores, no âmbito restrito das Diretorias das Unidades do Sistema Nacional de Pesquisa Agropecuária, vinculado à EMBRAPA, tem como objetivo principal o de divulgar as atividades desenvolvidas pelos consultores e as opiniões e recomendações geradas sobre os problemas de interesse para a pesquisa agropecuária.

As atividades de consultoria são realizadas no âmbito do Projeto de Desenvolvimento da Pesquisa Agropecuária e Difusão de Tecnologia na Região Centro-Sul do Brasil-PROCENSUL II, financiado parcialmente pelo Banco Interamericano de Desenvolvimento-BID e a EMBRAPA conforme os contratos de Empréstimo 139/IC-BR e 760/SF-BR, assinados em 14 de março de 1985 entre o Governo brasileiro e o BID.

As opiniões dos consultores são inteiramente pessoais e não refletem, necessariamente, o ponto de vista do IICA ou da EMBRAPA.

A coordenação dos Contratos IICA/EMBRAPA agradeceria receber comentários sobre estes relatórios.

Horacio H. Stagno
Coordenador Contratos IICA/EMBRAPA

P R E F A C E

The present consultancy period covered the effective time of October, 6 to November, 4 1987. It has been concentrated to Centro Nacional de Pesquisa de Trigo (CNPT) at Passo Fundo, RS, Brazil and has included short visits to the University of Passo Fundo and the Federal University of Rio Grande do Sul.

Being my first visit to Brazil, it is difficult to say who in this cooperation have learnt most from all exchanges of ideas, experience and knowledge. The research on wheat, ryewheat, barley and at the two universities on oats is highly advanced and skillfully performed by well-trained experts. The breeding programme is in a transitionary stage where terms like harvest index and ideotype have become key words. With the complex environmental conditions in Southern Brazil, it is not easy to know exactly what such terms imply when adaptability and reliability are just as important concepts. It is my feeling that the discussions have helped if not always directly in showing the right way so at least how to find it.

I am greatly indebted for all concern during my stay shown by Luiz Ricardo Pereira and Aroldo Gallon Linhares, Directors of the center as well as the always helpful sectretary Dulci Stagmeyen.

I have had the pleasure at CNPT to meet many interesting persons of different categories. Unfortunately, linguistic barriers hindered me to go into more detailed discussions on practical matters with devoted and skilled technicians. It was thus mainly discussions and laboratory, greenhouse and field visits with staff members responsible for different activities. Among the plant breeders I have had close contact with Ottoni de Sousa Rosa and Cantídio Nicolas Alves de Sousa in wheat, Gerardo Nicolas Árias Duran y Veiga in barley, Augusto Carlos Baier in ryewheat and Francisco Antonio Langer in more general matters including systems for varietal trials. Cytogenetics, species crosses and varietal instability have been discussed thoroughly with Maria Irene Baggio de Moraes Fernandes, who also helped me to arrange contacts and in many other matters. Conservation of germplasm was discussed with Ana Christina Albuquerque Zanatta. Plant pathology and resistance problems were discussed with Elisa Thomas Coelho in stem rust, Amarilis Labes Barcellos in leaf rust, Walesca Iruzun Linhares in powdery mildew, Ariano Morais Prestes in leaf blotch and Erlei Melo Reis in scab. In addition, Agostinho Dirdeu Didonet took part as plant physiologist in some of the group discussions.

In addition, I had the pleasure of meeting Elmar Luiz Floss and see his oat experiments at the University of Passo Fundo and likewise Fernando I.F. de Carvalho and Luiz Carlos Federizzi at the University of Rio Grande do Sul at Porto Alegre. During my seminar course, I had also the privilege to meet several researchers from other centers. A more penetrating discussion on mutation breeding was held with Augusto Tulmann Neto from Centro Energia Nuclear na Agricultura, Sao Paulo. I was also fortunate to be able to be together with Vanderley da R. Caetano from Pelotas, who stayed at CNPT for a few days and with whom I had much in common as to philosophy of plant breeding.

S U M M A R Y

Brazil has shown difficulties in raising grain yield per heactare of wheat if its result is compared with many other countries. There may be special explanations, but it is indeed a challenge. The Brazilian wheat breeding is just now in a transitionary stage leaving the well adapted, old more straw than grain-rich varieties for a Mexican-inspired, short-statured type. The transition process has to go via as little compromise as possible with adaptation and reliability. Correlative growth pattern for shoot and root and increased dependence on disease resistance at high harvest index appear to give problems needed to be understood and overcome. For proper guidance, production of a series of isogenic lines is suggested able to analyze and demonstrate consequences of changing different agronomic traits. In addition, proposals are given how to approach sterility and instability problems which appear to have increased by going over to the short wheats. Associated problems in barley have been pointed out as well. Breeding for race-specific resistance should be easier to maneuver, if the gene-for-gene relationship also could be used to identify resistance genes in cultivars and breeding material. Restricted availability of right kind of races will at least in the beginning need assistance from abroad. Existence of race-specific resistance against *Helminthosporium* ought to be investigated. The research programmes at CNPT is very skillfully handled at a very advanced level.

F I N A L   C O N S U L T A N C Y   R E P O R T

Since the green revolution started in the late 1960's, several countries of different categories have considerably increased their yield per hectare of wheat. Many countries have almost doubled their national average yield performance and have changed import dependence to self-sufficiency in spite of a simultaneous population increase. Brazil appears not to have been able to follow this general trend.

There exist of course more than one explanation. Wheat has expanded to the north where less appropriate conditions, new situations, less experience and skill may have resulted in low yields of wheat. When a crop arrives in a new area, it will in the beginning be less haunted by diseases which gradually will adapt and act as a considerable hinder for yield elevation. Improvements in more traditional regions may thus have been counterbalanced when it comes to the national average yield. The supported programme on sugar cane and ethanol or other restructurilizations in the Brazilian agriculture may have caused wheat to be taken out from more fertile soils, again influencing the overall average. In addition and not least important, unpredictable weather may to considerable extent have made it difficult to foresee the right kind of preparations or to prevent damages to the wheat crop.

THE TWO MAJOR INPUTS IN CROP IMPROVEMENT

Inputs to improve crop productivity have to go via better management procedures and/or a progressive plant breeding. Several independent evaluations made in different countries have reached to very much the same conclusion as to the relative importance of these two approaches towards higher yields. About half the increase has been found to be explained by different ways of intensifying management or rendering it more efficient. The other half is to be attributed to the development of more productive and reliable cultivars achieved through plant breeding. There seems to be no indication why such an estimate should not also hold true for Brazil.

It should, however, at the same time be recognized that the two types of investments often are able to substitute for each other. Examples on how plant breeding is able to take over from management are frequent. Breeding for resistance against diseases, pests and edaphic stresses generally implies that management becomes simpler and cheaper. The recent; successful approach in biological control is an example where the ease goes in the opposite direction. Neither is it seldom that first by exploring resources offered on both side, a satisfactory control of the situation is reached.

An interesting idea, through which both ways may be able to profit, is recently taken up at CNPT and should be encouraged. It concerns the development of a wheat type adapted for sowing right after the harvest of soybeans. The primary intention is to avoid soil erosion on bare land. It appears not impossible that such an adaptation could also lead to improved potentials for yield, thus having a twofold positive effect. The type should above all be given a prolonged vegetative growth, preferably achieved by a more slow-growing, broad meristem. This would allow the design of a short-statured wheat with a good tillering and crown root development, a coarse straw and a big ear. The long vegetative growth should allow more assimilates to be accumulated in roots and shoot for reallocation to the grain at onset of maturation. In addition, slow growth is likely to improve P uptake. In the acid and Al-rich, Brazilian soils, P unavailable for plants is always in equilibrium with P available for plants. If the plant is forced to grow faster than the rate constants for the release of unavailable forms of P, the plant will become P deficient. Slow growth is thus by itself a means of a better P economy.

Improvements by management per se will be somewhat outside the scope of the present consultancy programme. It appears nevertheless appropriate to support yet loose ideas around possibilities to develop a forecast system for epiphytotic diseases and pests. Rio Grande do Sul is an important state for farming with fluctuating conditions where a pilot research could be thoroughly tested. A warning for farmers would be of great help. Yields could be made safer, expenses on biocides could be reduced and this would again decrease environmental pollutions. Knowledge in this particular field of research is drastically increasing abroad, i.a. by use of space satellites and systems of remote sensing. Experience already gained in other countries should be possible to exploit with rapid progress in sight. The first, more stumbling steps taken in Brazil in ambition to build up a forecast system for farmers are thus to be encouraged.

The impressive cereal breeding programme at CNPT is in a much more advanced stage. It is not easy to point on something that has been neglected or items where improvements are needed. Below is, however, an attempt to discribe the major problems that have been taken up during the short consultancy period.

ISOGENIC LINES AS MEANS OF UNDERSTANDING THE APPROPRIATE IDEOTYPE

Wheat breeding in Brazil is in a transitionary stage where the old, vegetatively luxurious and tall wheats are gradually being replaced by short-statured types with improved harvest index. With a changeable climate and problem soils together with a wide spectrum of diseases and pests, it is difficult to predict exactly how to proceed in order not to go wrong or to be fumbling too much. The complexity of correlated constraints and other intervening factors appears too difficult to overview without a more analytical approach.

Apart from pure trial and error, the way used by nature and common also among plant breeders not giving themselves enough time for reflection, there are basically two ways of gaining a deeper understanding of how to proceed. One approach would be carefully to study characteristics of cultivars already produced and experienced to show high phenotypic stability and wide adaptation in combination with good yield performance. There are biometric methods available whereby such types can be more easily recognized and picked out from state, regional and federal trials of past years, i.e. where one trial is repeated at several locations. Cultivars that over years and locations have proved to carry these extra abilities are in a way examples of what constitutes a successful type. Much can certainly be learnt from them. It must, however, be recognized that such information may be only partly or indirectly of guidance in a situation when an entirely new type is being introduced. The short-statured, modern wheats with harvest index almost pressed as high as possible are certainly more difficult to give the desired reliability, and they will likely imply other problems than those that can be learnt by studying the old, tall types. In addition, this approach will only be able to give the overall view of what creates a successful plant. Due to the above-mentioned complexity in effects, the implication as to individual traits and how they interfere may not be easy to understand. The plant breeder would thus need a more analytical procedure as well.

Isogenic lines with presence and absence, respectively, of a single trait provide a way of step by step analysis. Such sets of pairwise isogenic lines will have to be produced by six to seven backcrosses to one and the same genetic background, a receptor line. The more such pairwise isogenic lines for different relevant traits are produced, the more complete will the analysis and the understanding of cause and effect be. Dependent on the complexity of the breeding goal and the available resources, it is likely that features like stature, shape of stem, leaves and ears, growth rythm and reaction to relevant stresses should be considered. Each trait can be separately examined including all its pleiotropic effects. Because of a common genetic background it is also relatively easy to combine different characters and examine their compound effect. In this way the merits, drawbacks and the reliability of the two alternatives or combinations of such sets can be studied preferably in trials over locations and/or years.

Traits governed by one or a few genes will normally be easy to transfer by repreated backcrosses to the selected receptor. Hesitation to go on will rather arise when inheritance is insufficiently known or where polygenic control can be taken for granted. It should, however, be observed that the mere attempt to produce the relevant isogenic pair of lines implies an effective way of accumulating the failing knowledge. The ease by which a trait is fully transferred is proportional to the number and phenotypic strength of the genes involved. In addition, it is more likely to succeed in getting available genes accumulated, if a programme is allowed to concentrate only on this ambition and not be an integrated part in an ordinary, multi-purpose breeding project. It is thus likely that the production of isogenic lines for each even more complex trait is more practical than it superfluously may appear. If the receptor cultivar is chosen among the own well-adapted material, such isogenic lines will become valuable crossing partners in the ordinary programme.

The above arguments as well as a complete list of traits that might be considered was presented first in a written version and then thoroughly discussed in a group meeting with relevant staff members of CNPT. Since there already had been a feeling of the necessity to proceed via isogenic lines for a proper understanding of some decisive traits, it was decided to try to expand these ambitions to a more comprehensive programme. By delegating the production of specific pairs of isogenic lines to different and for each trait specially qualified members of the group, it was found that a considerable programme could be achieved without too much extra burden for each one. IAC 5, Maringá was chosen as genetic bachground for all part programmes as being already used in some height and disease resistance studies and as being a reliable representative for the Southern Region. The outcome and value of such a Maringá isogenic series for this region should determine whether similar sets later should be constructed for the other two regions and for the special conditions with wheat grown under irrigation.

In order not to make the programme unnecessarily comprehensive, it was also decided to go step by step taking up the most relevant or easily produced pairs of isogenic lines first, judge their informative value and then hopefully proceed. The trait pairs found to be of interest to produce for a better understanding of their role in the overall ideotype concept, are listed with a ranking as to priority. The score of 1 implies high priority, 2 indicates medium importance and 3 less urgent. The different traits are grouped as originally arranged in the first proposal with the ranking figure decided upon placed in front of each trait pair. In addition, some explanatory comments are added whenever considered of value for judging the ranking.

Variation in physiological traits

1 { Susceptibility - tolerance against low pH.
Susceptibility - tolerance against high Al/Fe/Mn.
Susceptibility - tolerance against low P. }

3 Susceptibility - tolerance against water logging.

3 Susceptibility - tolerance against drought.

3 Susceptibility - tolerance against frost at flowering.

Although there exists information in the literature that tolerance against low pH, toxically high contents of Al, Fe and Mn and low content of P in the soil are partly independent varietal properties, it was decided in the first step to handle them together as a compound feature. They are anyhow partly interrelated. The urgent problem is to understand the impact of such a general tolerance to the common soil type in Rio Grande do Sul in relation to the correlated changes of the root system as an effect of introducing short-strawed types.

Variation in growth habit

2 Late - early maturity.

3 Long - short vegetative growth phase.

3 High - low - no vernalization requirement.

Selection for earliness appears to influence plant height as well with a tendency to give a shorter straw. This consequence of an associated structural change ought to be better examined in connection with the present introduction of dwarfing genes. - The above-mentioned idea of developing a wheat adapted for sowing in April or early May would profit from access to lines clearly different in vegetative growth length and vernalization requirement. The concentration on a special trait characteristic of isogenic line production will help in understanding to what extent these two features are interrelated. In the present situation, high vernalization requirement will mean a winter wheat (*vrn1, vrn2,vrn3,vrn4*) with low winter hardiness, and no vernilization requirement is obtained by introducing *Vrn1* in any wheat.

Variation in crown node characteristics

1 Low (1-2) - medium (3-4) - high (5-) number of crown nodes.

1 Compact - elongated crown nodes.

3 Crown node region partly above - completely below soil surface.

Number of crown nodes is highly correlated with formation of crown roots, and compact crown nodes are expected to increase the number of crown roots even more. Both features appear to have associated consequences on general growth stature of the plant, an interaction that has to be understood. Crown nodes below soil are associated with types preferred by Dr. Vanderley Caetano, Pelotas but may result in impaired anchorage of the plant. Climatic conditions in the Southern Region make it important to know what to prefer.

Variation in plant height

1 Semidwarf (*Rht1,rht2*) - tall (*rht1,rht2*) stature.

1 Semidwarf (*rht1,Rht2*) - tall (*rht1,rht2*) stature.

1 Dwarf (*RHT1,Rht2*) - tall (*rht1,rht2*) stature.

This programme is already on its way but not in the well-adapted Maringá. Other genes for reduced height (*Rht3* - *Rht8*) are known but experience in other coutries makes them less interesting. All dwarfing genes have an associated influence on root development, an important correlative constraint fully to understand.

Variation in tillering capacity

1 Low (2-3) - high (5-) number of tillers in average drill stand.
3 Narrow - wide angle between main culm and tillers.

Difference in tillering has to be selected under some standard situation. The trait is likely to have a complex association with other features like plant height, vernalization requirement and earliness and will have some kind of negative correlation with straw diameter and ear size. - The ability to develop a high number of fertile stems per unit area of land may be interconnected with angle of tillers formed.

Variation in leaf type

1 Narrow - broad leaves.
1 Horizontal - curved - upright leaves.
2 Thick - thin leaves.
1 Few (3-4) - many (6-7) leaves in main culm.
1 Long - short peduncle, i.e. distance between flag leaf and ear.
1. Waxy (*w1*,*w2*) - waxless ($W1^I$ or $W2^I$) leaves.
3 Hairy (*Hl*) - hairless (*hl*) leaves.

There appears to be some interrelation between leaf width, leaf angle and leaf thickness but to what extent is not exactly known. All three traits will have influence on solar penetration and other bioclimatic parameters in the stand. Leaf width versus leaf thickness will learn whether a large assimilating area is preferable compared to a high photosynthetic capacity per unit leaf area, a preference dependent on prevailing type of climate. - Number of leaves and peduncle length will certainly have some association with plant stature. - The manipulation with waxiness and hairiness, two monogenically controlled features, are thought to throw some light on whether wax or hairs may offer some physical hinderance against some diseases and pests. Such advantages have been observed in other countries but with other problems.

Variation in ear characteristics

1 Lax - medium dense ear carrying same number of spikelets.
1 Awned (b_1) - awnless (B_1) ears.
3 Normal (*p*) - large (*P*) glume size.
1 Normal (3-4) - high (6-7) florets/seeds per spikelet.
1 Waxy - waxless ear only.
1 Hairy (*Hg*) - hairless (*hg*) glumes.
1 Cleistogamous - open flowering with anther extrusion.

The green surface of the ear region is the most important part supplying assimilates to the grains. There are different ways to manipulate the size and shape of this surface. The interrelation with penduncle length and size of flag leaf will to some extent interfere as well, interconnections that have to be understood for each general climatic situation. In addition, the source:sink interrelation can also be adjusted by number of spikelets and number of florets per spikelet. - Waxiness, hairiness and cleistogamy are thought to throw some light on effects from heavy rains and penetration resistance to diseases like scab. Today, the latter possibility for improving resistance is not explored, since the needle infection technique used at CNPT ignores such eventual hinders by passing through.

Variation in pest resistance

1 Susceptibility - resistance against aphids.

Such a programme is already under way. Isogenic lines will also be useful for assessment of damage caused and will help understanding the economic value of biological control.

Variation in disease resistance

1 Susceptibility - resistance against leaf rust (appropriate *Lr*-genes).
1 Susceptibility - resistance against stem rust (appropriate *Sr*-genes).
2 Susceptibility - resistance against powdery mildew (appropriate *Pm*-genes).
1 Susceptibility - resistance against *Septoria* leaf blotch.
1 Susceptibility - resistance against *Helminthosporium* leaf blotch.
3 Susceptibility - resistance against scab.
1 Susceptibility - resistance against soil-born wheat mosaic virus.

It was first discussed whether use of fungicides should be able to control disease problems in relation to the understanding of what constitutes a proper ideotype for Rio Grande do Sul. Such an easier approach will, however, not allow a study of the interrelation between a certain disease and the plant architecture including its impact on the bioclimate of the stand. Only in connection with powdery mildew, a chemical control will be satisfactorily selective. - A programme of producing isogenic lines in Maringá is already under way for rusts. For the ideotype analysis, an accumulated transfer of an effective set of resistance genes should be enough. More complete series of isogenic single-gene lines should be more a decision related to pure plant pathology and breeding for resistance.- Similarly as to the resistance to pests, isogenic lines carrying resistance against a particular disease will allow a more acurate assessment of its economic importance.

It was understood that special experiments going on to study the interaction between cultivar type on one hand and sowing date, stand density and fertilization on the other will add to relevant knowledge. Other types of experiments instructive for the understanding of the genotype-environment interaction could be defoliation and artificial lodging trials. The technique was discussed and demonstrated in the seminar series.

GENETIC DISEASE CONTROL

The climatic conditions in Rio Grande do Sul makes control of diseases an urgent problem. Whenever plant breeding offers an effective and sufficiently reliable alternative to application of fungicides, it has all the advantages. This evaluation is also clearly reflected by the imposing emphasis at CNPT on this particular field of wheat research. By the introduction of short-strawed types with high harvest index and thus little green surface in reserve, an observant control of diseases will become even more important.

The inventory of leaf rust and stem rust races is highly efficient using isogenic single-gene resistance lines predominantly obtained from Canada. The more recent discoveries of new resistance genes are followed ambitiously. For the annual race survey, all is thus well taken care of. It would, however, be advisable to transfer into Brazilian wheat background resistance genes found to offer resistance against all or most races observed in Brazil and its neighbour countries. This would allow the breeders more rapidly and easily to use them in their recombination programme whenever found desirable. At the same time, it will be better understood how these genes will react in the background typical of Brazilian wheats. Several of the new genes discovered are moderate in their resistance reaction and thus likely subjected to influence from modifiers. It is a good sign that the programme on powdery mildew will now follow along the same line of genic precision and include an analogous race inventory as well.

Race distinction based on single-gene resistance lines offer the highest degree of information as to the concerned pathogen population. Available data seem to support the opinion that both rusts are asexually propagated as uredospores and locally maintained over seasons by volunteer wheat plants. The precision of the gene-for-gene survey could allow for more detailed studies as to the strategy of the concerned rust populations when it comes to the meaning of virulence genes observed, their individual frequency, race stability, race complexity and preferred or rare gene combinations. As long as the exact host selection pressure is not fully known, such analyses can only partly be accurately interpreted. It would e.g. be interesting to know whether virulence genes matching *Lr1* and *Sr8* or *Sr14* have their abundance as a result of general fitness only or from a consistent host selection pressure.

Also for the service to the breeders, it would be highly desirable, if a system could be developed whereby genes for resistance are detected by their matching genes for virulence with the same precision as is now made the other way round. Such an identification system would also greatly help in the complex recombination breeding for resistance to different diseases. Since such an identification system would need access to specific races, cooperation with other rust laboratories may be necessary for some identifications. If all Brazilian B-races were preserved, it would have been possible to identify several genes for resistance by mere testing of two races. If available data are used, *Lr3ka* could have been identified by observing the different reactions towards race B6 and B7, *Lr10* by B1 and B2, *Lr14b* by B4 and B10, *Lr21* by B3 and B4, *Lr23* by B10 and B11 etc. Several genes for stem rust resistance could be identified by the same procedure applied on the C-races.

Genetic control of diseases like rusts and mildew are only partly governed by the more unreliable, race-specific resistance. Nonspecific resistance constitutes a kind of insurance against devastating backlashes and should be continuously followed up in the breeding programme. In connection with a complete race-specific protection, this more polygenically controlled type of resistance is, however, impossible to follow. It could, therefore, be of value, if a systematic accumulation of nonspecific resistance genes, preferably in the beginning as an isogenic pair with low versus high resistance, was carried out and then introduced in the ordinary breeding programme. Both laboratory and field selection techniques (so-called monocyclic and polycyclic tests) are elaborated and described in the literature.

A similar, more concentrated and narrow selection in order rapidly to accumulate available genes for resistance should also be recommendable in connection with resistance to scab, leaf blotch and soil-born wheat mosaic virus as already argumented for in the preceding chapter. It should be observed that race-specific resistance, although of a somewhat different kind to that characteristic of obligate pathogens, has been found in *Helminthosporium*.

In connection with visits to the different greenhouses and net gardens, some technical improvements were thoroughly discussed. They concerned temperature control limited to only the compartment rows for rust identification and use of simple designs for automatic watering.

GENERAL BREEDING METHODS

The crossing programme each year is quite impressive at CNPT. Many different approaches are being tried, indicating an uncertainty exactly how to go in the transitionary phase from the old, tall to the Mexican inspired, short type. It is the hope that the above described, analytical programme based on isogenic lines will give the necessary guidance allowing for a more systematic strategy.

The individual combinations were found interestingly and skillfully designed and so their successive treatment towards new, progressive varieties. Interesting research is going on trying better to evaluate merits and drawbacks of the hybrid bulk test. During visits in the experimental fields, it was more of a pleasant approval to everything, may it concerns wheat, triticale or barley.

The only, perhaps not entirely irrelevant question was why randomized block design was preferred before an optimal plot distribution in the breeder's own unique trials. Randomization is based on the principle of repeating the same trial over locations and/or years. If a trial is laid out only once, any arrangement using an optimal plot distribution more or less based on the principle of Latin squares is definitely to prefer in attempts to avoid the effect of soil unevenness. In addition, some of these designs (e.g. Kristensen's split plot modified Latin square) can preferably be used for a systematic arrangement of the different lines of a trial according to type. The same sequence will be repeated in n-1 of the replications. Since it is easier to observe differences in a repeated, fixed sequence rather than between randomized plots, the field notes will be easier and more exact to take.

DISTURBANCE RELATED TO SEED SET AND CULTIVAR STABILITY

The climatic and edaphic situation in Rio Grande do Sul exerts high pressure on the metabolic balance of plants. The meiotic phase and the fertilization process are particularly sensitive for such outside disturbances. Temperatures may drop to levels causing frost injury or may raise to levels causing severe heat chocks. Rapid changes from one extreme to the other may enhance the disturbing effects. When wheat and barley are flowering, shifts in temperature from -3° to +32°C have been recorded within 24 hours. Moisture situations may be just as fluctuating from long-lasting, heavy rains to exhaustive droughts. In addition to situation of water logging or drought, the soil is low in pH, toxically high in soluble Al, Fe and Mn but low in available P and humus content. The stresses are thus many and changeable especially since variation in weather automatically influence spectrum and severity of different kinds of diseases and pests. Apparently, there are several factors that may intervene as explanation to the great fluctuations in annual average yields as well as to more specific traits like seed set and cultivar stability.

Studies on sterility problems

If sterility reaches levels as possible to record in barley (up to 35%), it becomes an important yield limiting factor. Losses in seed set inflicts upon an ontogenetically late yield component and thus with less chances to be compensated. Only increased seed size is able to outbalance the negative effect of impaired seed set. Since sterility will cause florets to stay more and longer open, chances for outcrossing and infection of certain diseases will increase.

One type of sterility often observed is a kind of self-regulating system for the plant to adjust number of sinks to source capacity. This kind of failure in seed set is concentrated to the last developed spikelets of the ear or in wheat also to the last developed florets within the spikelet. This implies that spikelets at the base, sometimes also in the tip of the ear may be empty as well as the top floret(s) of a spikelet.

This so-called atrofication may even set in soon after primordia development resulting in incompletely differentiated or malformed spikelets and florets. It is generally associated with a favourable early growth followed by stress during late vegetative phase and/or flowering. If a constant varietal characteristic, this waste of energy at early growth stage indicates an ecological misadaptation and should thus be selected against. Since atrofication belongs to the regulatory devices of the plant in its ability to meet environmental changes, this type of sterility is a natural reaction and should not need to be further investigated.

There are, however, other causes of sterility and disorders that need better to be clarified in order to be properly handled in the breeding programme. This type of disturbance appears to be especially common under the ecological conditions above described for Southern Brazil. Comprehensive studies in cooperation between the University of Rio Grande do Sul and CNPT have indicated two categories of environmental influences and one related to genetic constitution. The outside factors appear to depend on one hand on the fluctuating weather situations as to temperature and moisture, on the other on more permanent stress factors such as Al toxicity or perhaps also heavy disease or pest attacks. Definite differences in genotypic tolerance to both kinds of environmental stresses are observed, but recurrent selection has hitherto given confusing results. Many of the Brazilian wheat cultivars are of the stable type while one of the most important material used in the CNPT cimbination programme, the short-statured Mexican wheats, has shown considerable and disturbing instability under conditions in Rio Grande do Sul.

It is far from clear how to avoid and select against this more complex type of sterility and disorder. It appears very likely that the disturbances observed and comprehensively analysed in wheat do also occur in barley. The association has not been made, because the symptoms are different.

Both species belong to the same tribe *Triticeae*, are autogamous and originally adapted to the temperate climatic zone. They ought thus to react similarly as to disturbances in their DNA synthesis and/or chromosome behaviour. Barley is, however, diploid and bread wheat is hexaploid. Their reaction on cytological disturbances is thus expected to differ. The polyploid constitution of wheat will give a considerable, genetic 'buffering effect' resulting in a tendency to carry induced disturbances over to the next generation. Wheat will for that reason react by chromosomal instability rather than extreme sterility. Barley is not that tolerant and will react by sterility in the flowers subjected to the disorder.

It is thus of great interest to understand, if the two different symptoms in wheat and barley originally depend on the same events. More penetrating research has been concentrated to wheat where the symptoms of mitotic and/or meiotic irregularities are the laborious and more difficult ways of registration. If,. and it appears very likely, partial sterility in barley is just another way to have the same genotype-environment disturbances expressed, pilot experiments ought first to be planned in this species. Sterility is particularly easy to register in barley due to its special spikelet morphology and can be done by the most unqualified technician.

The possibility to design different experiments for a proper understanding of the more important environmental factors thought to cause the cytological or physiological disorder will greatly increase within a set economic frame. First when clear information is gathered as how barley is reacting to different stresses arranged, it will be time for checking the behaviour of wheat. Likely they will react very similar to critical stesses, which would imply that the more circumstantial experiments with wheat can be made with maximum precision.

The first step should be to compare the liability of barley to react by cytological disturbances on certain provocations already proved to influence wheat. Wheat and barley should be planted in pots and in controlled phytotron environment be subjected to stresses of experienced kind. Effects on meiotic stability should be compared with and accompanied by fertility analyses.

The next step would be systematically to try to ring in the major environmental causes for the disturbances in wheat recorded as cytological disturbances and in barley as sterility by using the latter in the pilot experiments. It appears to be an acceptable working hypothesis that sudden temperature chocks and perhaps also long-lasting rains can be responsible for physiological as well as genetical disorders both leading to sterility in barley. It might also be worth while to examine whether improper application of chemicals has to do anything with the genetic disturbances observed in farmers' fields. Apart from such more acute stresses, disturbances as an effect of problem soils will deserve their separate analysis. As more cronic stress factors, heavy infection of diseases or pests might also be considered. It appears advisable to try to separate effect due to low pH and high Al, Fe or Mn from each other and try to understand how N, P, K, Ca and B may be able to intervene. Consultations with soil scientists and plant physiologists should guarantee the right kind of experimental designs. The synergetic effect on plants stressed by soil toxicity and then subjected to a temperature chock should also be considered.

The experiments can preferably be made under controlled environments in the phytotron, but they could also be laid out in the field on specific types of soil or under inconventional times for sowing in order to increase chances for temperature stresses. It is an advantage, if one barley cultivar earlier known to show little sterility and one with tendency to show high sterility will be running parallel over all experiments.

The treatments causing the more severe and obvious disturbances should be repeated in wheat. They must also be examined, if they really represent events typical and reproducible under field conditions. If so, research should be undertaken how best to expose material for such stresses in routine plant breeding in order to provide a selection procedure as efficient as possible for both barley and wheat.

Studies on outcrossing problems

Originally, ancestors of both wheat and barley were cross-fertilizing. Wild representatives of both species show higher tendencies to outcrossing than do modern cultivars. Under certain weather conditions, outcrossing in modern wheat and barley may still be considerable, particularly when a cool period stopping up anthesis is suddenly followed by warm weather. Frequencies of 1-5% outcrossing are far from uncommon. The varying weather in Rio Grande do Sul is expected to favour events of increased outcrossing.

Since the above discussed sterility and disorder result in florets being more and longer open, chances for outcrosses will increase even more. Male-sterility is even a method to produce hybrid wheat. For that reason both wheat and barley being subjected to varietal purification must be handled as if they were cross-fertilizers. An easy arrangement is to sow purification plots of wheat isolated in the middle of a barley field and vice versa. If such a safe isolation should be difficult to arrange because of too large a purification programme per year, a series of purification plots could be placed in a field of another crop. Every second purification plot must in such a case be sown at such a different time compared to the plot between that flowering will not at all coincide. Plot size should in such an arrangement not be under 20-25 meter in order to guarantee sufficient isolation.

Mere isolation is, however, not enough. Every off-type plant in the purification plot will not only reproduce itself but also be able to add to impurity by outcrossing. This undesirable situation should be especially disturbing in short-statured cultivars. Tall plants will here have competitive advantage and will more efficiently be able to spread their pollen over their shorter neighbours.

In order to avoid these sources of continued impurification, the following procedure is recommended. Select 50-200 plants or ears from the line/cultivar to be purified. Thresh them individually and sow them in the same way as plant or ear progeny rows side by side and sufficiently well isolated from other material of the same crop in order to avoid outside pollen sources. Examine each row carefully just prior to heading and during early anthesis and cut away every row with the slightest deviation from type or with tendencies to segregate or contain off-types. These rows are not allowed to cause further outcrosses or reproduce chromosomal instabilities. All outcrosses between exactly equal rows are not expected to be different from true autogamy. Repeat the selection of 50-200 plants or ears in the most constant and typical rows, thresh and sow this material in the same way, with the same precaution and under the same safe isolation in the next season. Eventual recessive off-type genes not discovered in their heterozygous stage the year before will now be revealed and the contaminated rows will again be cut away prior to flowering. The approved rows of typical and constant appearance are bulked at harvest and will constitute the new foundation seed.

The above-mentioned procedure has the advantage better than mere roguing to be able to get hold of recessive heterozygotes. In addition, it will under the instability provoking conditions in Southern Brazil help to get rid of all unstable plant/ear progenies. It appears also to be the most rational way strictly to separate impurities caused by outcrosses or environmentally caused disorders in individual plants from those that may be inherent as a varietal constitution. In the latter case, about the same number of off-type rows, not being explained by outcrossing and segregation, should occur in the two succeeding trials. This will be an information that has to be respected as describing an inborn characteristic and has be to accepted as such be seed inspection officers.

Ongoing experiments at CNPT with the aim to study and evaluate degree of outcrossing under field conditions should continue. They will add to the knowledge connected with maintenance breeding. It might be interesting better to understand to what extent tall off-types in short-strawed cultivars are able to increase both by reproducing themselves and by their increased chance to spread pollen over their shorter neighbours. Risks for contamination is certainly higher here than between awned and awnless of the same height as now under examination.

Studies on nature of inherent instability

Inherent instability is likely to impose less problems in diploid barley compared to hexaploid wheat. Barley will react with sterility and will thus be self-cleaning, not carrying the disorders further to next generation. In addition, selection for low sterility is easy to perform in barley. In wheat, inherent instability should offer more problems, since chromosomal disturbances may easily result in chain reactions allowing new aberrants to occur.

Although far from conclusively, there are some indications from earlier studies that some wheat genotypes may carry inherent instability per se. It appears, however, not clear whether it is more a matter of genotype-environment interaction. The very trying climatic and edaphic situation in Southern Brazil may expose particular sensitivity or misadaptation towards certain stress or combination of stresses. If chromosomal disturbances are an inherited trait without any kind of stress intervening, the above-mentioned approach for varietal purification should substantially help to separate this phenomenon from general outcrossing and damages to individual plants.

It has been suggested that mutable genes, transposons, or special karyological instability patterns might be responsible for such an inherent disbalance per se. Mutable genes are known to occur in other species but not yet in wheat. Reciprocal backcross experiments with cytological controls at every step would probably be the best way to detect an eventual transposon supposing it is dealing with a major gene. Chromosomal configurations likely to induce continued instability should be possible to trace at meiosis. Possible causes are aneuploidy, deficiency-duplications, dicentric chromosomes, isochromosomes, nucleolar disturbance and nucleus-cytoplasm incompatibility.

Considering different explanations and available results from various investigations, it appears not necessary to explain the observed disorders as due to instability per se. Symptoms recorded rather suggest some kind of more general disturbance in the DNA replication and/or synchrony at cell division. Such an explanation like a varietal inability to hinder e.g. Al to enter the metabolic system appears more attractive. It could be the sole reason or it could just initiate a destabilization released by some chock effect. Such an interpretation would also fit with the fact that short straw is associated with a shallower root system, and short types appear to have exposed instability more clearly than tall types. The advice is thus to wait for the results from the above-mentioned experiments aiming to understand the genotype-environment interaction and first thereafter see, if inherent instability per se is a reality.

INTERSPECIFIC CROSSES

Wheat is the most important crop plant in the world and one of the geographically and climatically most wide-spread species. The total international investments in wheat genetic research is correspondingly imposing. In many countries advanced chromosome engineering based on interspecific crosses is going on with wheat as recipient. These projects are often complicated and long-lasting with several unpredicted problems arising. Since most of such advanced plant breeding research is carried out at federal or state institutes or university departments, the results and the genetic stocks produced are generally available without restrictions.

When planning programmes on interspecific crosses, it is important to avoid repeating, i.e. to use similar sources for the search of the same kind of genes. Earlier work on interspecific crosses, mainly with the aim to transfer specific genes for disease resistance, has centered around stem, leaf and stripe rust, powdery mildew, eyespot, wheat streak mosaic virus and greenbugs. Some in Brazil very important diseases on wheat appear not to have been considered such as *Gibberella*, *Septoria*, *Helminthosporium* and soil-born wheat mosaic virus (SBWMV). There are thus good reasons to give them some kind of priority. In addition, it would be attractive to search for good Al tolerance to be transferable to barley. Possibilities to gain a better tolerance against water logging via interspecific crosses might be worth to explore for both barley and wheat.

It is important to stress that any interspecific combination programme ought to have the same distinct goal as applied in more conventional cross breeding. Crosses should be preceded by studies of relevant literature and by screening for the wanted trait among related species and genera. Such a preparation would need cooperation between experts on cytology,stock preservation, plant pathology, soil science etc. Such a cooperative system is available at CNPT and must be well explored. Especially knowledge how properly to grow more exotic material is an experience that has to be shared in order to be able to make relevant tests and be able to rescue crossing efforts. Since high competence exists, no further comment should be needed.

One of the programmes already well advanced is centered around crosses between emmer wheats (AABB, 2n=28) and *Aegilops squarrosa* (DD, 2n=14), the amphidiploid result being of the same genomic constitution as bread wheat (AABBDD, 2n=42). The main idea has been to transfer genes for rust and powdery mildew resistance from parents to hexaploid level with further introduction in the ordinary breeding programme for control of these diseases. It also appears as if some features can be found of interest to scab resistance. It is possible that such a programme could be used for a better understanding of phenotypic expressability of genes moved from lower to higher ploidy levels.

PRESERVATION OF GERM PLASM

The taxonomy of wheat is rather confusing due to too many diverging ideas. It was advised to keep *Aegilops* and *Triticum* apart as separate genera. With ryewheat on the programme at CNPT, it might be more advisable to follow a suggestion to include *Triticale* into *Triticum* as a separate section. This would greatly facilitate the handling of intermediate types between wheat and ryewheat. Such types have become more and more common after the observed merits to let genome D introgress into genome R in hexaploid ryewheats.

Detailed hierarchical, taxonomic systems should be avoided as soon being obsolete as plant breeding changes the architecture and appearance of plants. Accessions could preferably be arranged as to origin (country or state). Such a grouping, preferably with year of release or for landraces year of collection, would function as a kind of numerical taxonomy. Countries or states have their characterisitc climate, soils, demands, breeding problems and skill. All these becomes imprinted in their cultivars.

Gene banks have the responsibility to preserve indigenous material of the country or region, although it is not the accessions most frequently requested by the breeders. Breeders are particularly interested in the most recently developed cultivars where improvements are accumulated. Such material is often collected directly by the breeder himself due to his good international contacts. He skims so to say the cream and has learnt the principle of discarding in order not to be overcrowded. He follows the same necessity of strictly preserving only the very best also when handling his own breeding material.·This shortsightedness must be counterbalanced with the responsibility laid upon the gene bank staff. The organization of CNPT allows for these diverging attitudes to function side by side, but only if those who have to preserve now and when go over the breeder's field with their special ambition in mind. From experience, personal contacts with the breeders and their material are often decisive for an efficient use of a gene bank. It will otherwise easily be a concern of its own, since breeders seem to be too engaged in what they are able to collect by themselves via colleagues.

A gene bank should take great interest in collecting and preferably even producing material like isogenic lines or other special so-called genetic stocks. The catalogue of gene symbols for wheat and the corresponding for barley will give information of most of what is available and where to obtain it.

SEMINARS HELD

In the very beginning of my stay at CNPT, I held a seminar presenting my own research fields which over years predominantly have covered methods of autogamous plant breeding, mutation research, wheat taxonomy and cytogenetics, yield structure analysis of cereals and race-specific resistance in cereals.

In October 27-28, a regular seminar course was arranged with several researchers from outside CNPT attending as well. The themes taken up in agreement with the CNPT staff were:

Evolution and taxonomy of wheat
General inheritance pattern of wheat
Breeding for yield and the ideotype concept
Strategies in breeding for disease resistance
Plant breeder's varietal trials and maintenance breeding

My own reaction from this seminar course was that it is a good idea to invite European scientists for this kind of short term consultancy. The thinking in plant breeding in Brazil follows much the North American pattern. In Europe less emphasis is generally laid on biometric approaches and more of evolutionary aspects with an ambition to understand underlaying principles. This implies new impulses and a widening of attitudes to several problems related to an evolution now generated by man himself.

Passo Fundo, November 3, 1987

James Mac Key

James Mac Key

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Responsáveis pela reprodução: Jadir José dos Santos e Murillo Sodré da Silva.

Programa II. Geração e Transferência de Tecnologia

O Programa de Geração e Transferência de Tecnologia é a resposta do IICA a dois aspectos fundamentais: (i) o reconhecimento, por parte dos países e da comunidade técnico-financeira internacional, da importância da tecnologia para o desenvolvimento produtivo do setor agropecuário; (ii) a convicção generalizada de que, para aproveitar plenamente o potencial da ciência e da tecnologia, é necessário que existam infra-estruturas institucionais capazes de desenvolver as respostas tecnológicas adequadas às condições específicas de cada país, bem como um lineamento de políticas que promova e possibilite que tais infra-estruturas sejam incorporadas aos processos produtivos.

Nesse contexto, o Programa II visa a promover e apoiar as ações dos Estados membros destinadas a aprimorar a configuração de suas políticas tecnológicas, fortalecer a organização e administração de seus sistemas de geração e transferência de tecnologia e facilitar a transferência tecnológica internacional. Desse modo será possível fazer melhor aproveitamento de todos os recursos disponíveis e uma contribuição mais eficiente e efetiva para a solução dos problemas tecnológicos da produção agropecuária, num âmbito de igualdade na distribuição dos benefícios e de conservação dos recursos naturais.

INSTITUTO INTERAMERICANO DE COOPERAÇÃO PARA A AGRICULTURA

O Instituto Interamericano de Cooperação para a Agricultura (IICA) é o organismo especializado em agricultura do Sistema Interamericano. Suas origens datam de 7 outubro de 1942, quando o Conselho Diretor da União Pan-Americana aprovou a criação do Instituto Interamericano de Ciências Agrícolas.

Fundado como uma instituição de pesquisa agronômica e de ensino, de pós-graduação para os trópicos, o IICA, respondendo às mudanças e novas necessidades do Hemisfério, converteu-se progressivamente em um organismo de cooperação técnica e fortalecimento institucional no campo da agropecuária. Essas transformações foram reconhecidas oficialmente com a ratificação, em 8 de dezembro de 1980, de uma nova convenção, que estabeleceu como fins do IICA estimular, promover e apoiar os laços de cooperação entre seus 31 Estados membros para a obtenção do desenvolvimento agrícola e do bem-estar rural.

Com um mandato amplo e flexível e com uma estrutura que permite a participação direta dos Estados membros na Junta Interamericana de Agricultura e em seu Comitê Executivo, o IICA conta com ampla presença geográfica em todos os países membros para responder a suas necessidades de cooperação técnica.

As contribuições dos Estados membros e as relações que o IICA mantém com 12 Países Observadores, e com vários organismos internacionais, lhe permitem canalizar importantes recursos humanos e financeiros em prol do desenvolvimento agrícola do Hemisfério.

O Plano de Médio Prazo 1987-1991, documento normativo que assinala as prioridades dc Instituto, enfatiza ações voltadas para a reativação do setor agropecuário como elemento central do crescimento econômico. Em vista disso, o Instituto atribui especial importância ao apoio e promoção de ações tendentes à modernização tecnológica do campo e ao fortalecimento dos processos de integração regional e sub-regional.

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Essas áreas de ação expressam, simultaneamente, as necessidades e prioridades determinadas pelos própios Estados membros e o âmbito de trabalho em que o IICA concentra seus esforços e sua capacidade técnica, tanto sob o ponto de vista de seus recursos humanos e financeiros, como de sua relação com outros organismos internacionais.

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Coordenação dos Contratos IICA/EMBRAPA
Escritório do IICA no Brasil
Caixa Postal 09-1070
Brasília, DF. 71.600

Tel. (061) 248-5477

INSTITUTO INTERAMERICANO DE COOPERAÇÃO PARA A AGRICULTURA
SHIS QI 5 CONJ. 9 BL. D COMERCIAL LOCAL CAIXA POSTAL 09-1070, BRASÍLIA, D.F. BRASIL
TEL. (061) 248-5477 - TELEX 611959 INAG-BR - CORREIO ELETRÔNICO 1536.