



Agronomy Branch Report

OVERSEAS STUDY TOUR REPORT

Field Crop Evaluation and Seed Production

T.G. HEARD

Senior Research Officer, Crop Agronomy

Funded by:

Australian Extension Services Grant

and

Australian Wheat Research Council

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I. Introduction

The major aims of the study tour detailed below were -

1. To discuss cereal, and where possible other crop, breeding programmes and more particularly the evaluation of new cultivars both in the field and the laboratory.
2. To investigate progression of new cultivars from breeders to commercial usage with particular reference to production, maintenance and certification of seed.

The tour was planned to enable visits to a number of the major cereal research centres in the United Kingdom and North America. Attendance at the Fourth International Wheat Genetics Symposium at Columbia Missouri placed some limitations on the timing of visits to certain centres.

In South Australia the field testing of cereals is largely carried out by the Department of Agriculture and is somewhat divorced from both the breeding and the quality assessment units. In other states of Australia the situation is more akin to that generally found overseas with breeding, field evaluation and quality assessment being closely associated within the one organisation.

Because of this overseas association of breeding and field evaluation, particularly in Canada and United States of America discussions on field testing of cultivars were usually held with those primarily concerned with breeding. Although not engaged in cereal breeding myself there is strong liaison between the crop agronomy section of the South Australian Department of Agriculture and breeding organisations particularly those at the Waite Institute and Roseworthy College. It is believed that some of the information gained from these discussions could be of interest to cereal breeders in Australia.

II. Plant Breeders Rights

On more than one occasion breeders in the United States indicated that some restrictions were being placed on cereal breeding activities of university and United States Department of Agriculture personnel. It was suggested that increased basic research should be carried out to compensate for the reduction in breeding activities. The restrictions on breeding were being brought about through a decrease in the funds available for these activities and it was suggested that pressure from private breeding organisations had led to this reduction in funds. A somewhat similar philosophy was expounded by directors of Rothwell Plant Breeders in England who felt that government organisations should carry out fundamental research and hand over practical plant breeding to the private sector.

It appears that this movement in England could be tied to the advent of plant breeders rights in the United Kingdom in 1964 with the passing of the Plant Variety and Seeds Act. It may well be that the situation is somewhat similar in U.S.A. where the Plant Variety Protection Act was passed in 1970.

The advent of plant breeders rights has apparently led to an upsurge in private plant breeding in the U.K. On the other hand the fear exists among the public cereal breeders of the U.S.A that schemes of this type may tend to restrict the free interchange of material between breeders. There is no similar scheme operating in Canada as yet but legislation is being prepared. It was suggested by leaders of the seed trade that such a scheme could probably not be implemented in less than five years.

In the U.K. although a number of cultivars from government breeding institutions are covered by plant breeders rights, particularly the wheats from the Plant Breeding Institute (P.B.I.) at Cambridge, it appears that no royalties are collected on these. The current royalty on wheat in the U.K. is approximately £4 per tonne. It is of interest to note that of the 18 wheat cultivars recommended in England in 1973 none had been bred by private U.K. breeders though seven were from P.B.I.

The situation with regard to royalties appears somewhat similar in the U.S.A. It was indicated that 4 new cultivars likely to be released in late 1973 by the University of Nebraska would probably be covered by the Plant Variety Protection Act. A royalty would not be sought on these though a levy of 10 cents per bushel is usually placed on privately bred cultivars covered by the Act.

In order to be covered by the relevant acts in the U.K. or the U.S.A a new cultivar must be distinct, uniform and stable. In the U.K. these aspects are decided on by the Plant Variety Rights Office following trials conducted by the National Institute of Agricultural Botany (N.I.A.B.). This appears to be a relatively simple and inexpensive process though the list of characters used by officers of N.I.A.B. in describing cultivars appears far above that used in this country.

In the U.S.A patent rights are obtainable on new cultivars. Breeders must submit a description of the new cultivar to the Plant Variety Protection Office. This organisation does not carry out trials on new material along the lines of those run by its sister organisation in the U.K. It appears from discussion with plant breeders in U.S.A. that their scheme is basically similar to normal patent law and appears to require a number of law orientated officers to run it.

The cost of covering a new cultivar in U.S.A. in 1973 was \$750. It was estimated that this was likely to increase to \$2500 in the relatively near future merely to cover the paper work associated with the act. There appears to be a considerable waiting time in obtaining a patent on a new cultivar. A leading wheat breeder indicated that of 350 patents filed on new cultivars of all plants in the previous 12 months it had been found possible

to investigate only 28 of these. This despite a staff of over 100 in the Plant Variety Protection Office.

The apparent problems of the U.S.A. system should be fully investigated before any final decision is made on the question of plant breeders rights in Australia.

III. Breeding and Evaluation Programmes

Breeding and evaluation programmes were discussed at a number of centres. While these generally related to wheat the opportunity was taken where possible to also discuss similar programmes with barley, oats, triticales and to a lesser extent crops likely to be alternatives to these winter cereals. Wheat programmes included winter and spring types, white and red grains.

1. Spring Wheat

(a) White Grain

This type of wheat is probably of most direct interest to Australia.

The programme in Tunisia is largely dependant on material originating from the CIMMYT programme in Mexico. Both red and white grained material is being used with a slight preference for the latter. The cultivars likely to be released in the future will be selected in Tunisia from early generation Mexican material. Possibly some of these could be looked at in Australia as conditions in Tunisia appear somewhat similar to those operating in parts of South Australia.

The overall aim of the wheat breeding project in Tunisia is to introduce higher yielding cultivars to an area which has been partly dependent on generally poorly adapted European cultivars. The most widely grown bread wheat at this time is Florence Aurore produced by the crossing of two Australian cultivars. Disease resistance is of major importance with stem rust and septoria being examined most closely.

Attempts are being made to lift the bread making quality of cultivars grown. There is a local user preference for hard amber grain so there is little breeder interest in producing soft cultivars. This preference is often translated into the growing of mixed durum and bread wheat crops to be used by the farmer. As part of the search for increased bread making quality protein determinations are carried out on material from F5 onwards when first yield trials are carried out. At a slightly later stage the mixograph and micro bread making techniques are used to assess material.

White spring breeding programmes are also being undertaken in the north west United States of America (U.S.A.). Centres were visited at Washington State University, (W.S.U.), Pullman Washington and Oregon State University (O.S.U.), Corvallis Oregon. Winter wheat is of more importance in these areas because of its higher yield potential - 90% of the wheat area in these states is sown to winter types. In 1973 approximately 30% of the area originally sown to winter wheat in Washington was reseeded with spring types following extreme winter killing.

Approximately 80% of the grain from this area is exported with the Japanese taking a major portion. Both hard and soft types are grown and, surprisingly, mixed on receipt to form the Western White grade. This grade also contains club wheats and is used in Japan for noodle production.

The aims of the programmes are to generally improve both yield and quality. Extensive testing for the Pacific North West programmes is carried out at the Western Wheat Quality Laboratory at W.S.U. The cookie spread test (C.S.T.), and the alkaline water retention capacity (A.W.R.C.) test are used extensively to test soft material. It is considered at W.S.U. that a combination of results from the mixograph and A.W.R.C. are the most useful for early generation selection. High correlations have been obtained between the widely used C.S.T. and the micro A.W.R.C. test developed at W.S.U.

Disease resistance is considered to be of extreme importance in this area. Resistance to stem and leaf rusts, common bunt and flag smut are considered essential for all new cultivars released in the region.

Post harvest dormancy in wheat grain is of concern in the Pacific North West region. It appears that dormancy is present in most red grained types to some extent. However dormancy appears to be present in relatively few white grained cultivars and even in these its effect is nowhere near as great as in the red types. The Japanese market, a major purchaser of soft white wheat from this area, has particularly indicated its dislike of sprouted grain. The need for some dormancy must be tempered by the knowledge that in some areas dormancy in winter types may be a problem when the time lapse between harvesting and reseedling is quite short. Post harvest dormancy is also under investigation in Canada and this would appear to be an area in which Australian breeders could possibly make an increased effort.

(b) Red Grain

As previously indicated a part of the breeding and evaluation programme in Tunisia is concerned with red grained cultivars. No problem is apparent or envisaged in growing and using of a mixed red/white sample. Tunisia is still not self sufficient in wheat so the mixture may be of no concern until the country embarks on an export programme. Such a programme was envisaged for the relatively near future, at least with durum types.

Both spring and winter types are grown in England with the Plant Breeding Institute at Cambridge (P.B.I.) being the centre of state controlled breeding operations.

Disease resistance is seen as a major factor in any new cultivar with yellow rust being the greatest problem. It appears that major gene type resistance has generally broken down within 3-4 years of release and attempts are now being made to obtain field resistance from some of the old "land races" of wheat grown in England over the past 100 years. *Septoria nodorum* is also a problem throughout most of the wheat crops in England.

Attempts are being made to increase bread making quality and these appear to have been successful in some of the more recent releases from P.B.I. and private organisations.

While wide field testing of new material and cultivars is carried out by private breeding organisations in England the testing procedures for state produced lines and indeed for all material seeking registration is somewhat similar to that operating in South Australia. In England the National Institute of Agricultural Botany (N.I.A.B.) is concerned with the wide scale field evaluation of new material. In some respects the Trials Branch of N.I.A.B. is similar to the Crop Agronomy section of the South Australian Department of Agriculture being responsible for cultivar evaluation but divorced from the actual breeding operations. I believe that while there may be some advantages in having an independent organisation responsible for final field evaluation of new cultivars as we have in South Australia, it appears that amalgamation of breeding, field testing and laboratory testing into one organisation would be much more efficient.

The trial sequence organised by N.I.A.B. is as follows:

Statutory Performance Trials - These test a large number of entries at a few centres (normally 3) for two years. These trials contain material from private breeders as well as from P.B.I. New cereal cultivars must be included in these trials before seed of them may be sold in United Kingdom. A charge of £90 is made for each entry included.

Main Trials - These include promising cultivars transferred from the statutory performance trials after the first or second year of testing. Main trials are conducted for 3 years at a wider range of sites (17 for spring cultivars). New cultivars are not considered for recommendation until after at least 2 years in main trials.

Under the E.E.C. scheme it is envisaged that there will be an amalgamation of statutory and main trials with all entries being tested at a bigger range of centres for 3 years before gaining a place on the National list or being discarded.

A.D.A.S./N.I.A.B. Secondary Trials - These trials are carried out by the Agricultural Development and Advisory Service on commercial farms. Entries include cultivars recently added to the recommended list together with cultivars in the final year of main trials and cultivars of local interest. These trials are usually carried out at approximately 10 sites each season. In many respects these trials are similar to the District Trials currently carried out by District Agronomists in South Australia.

Quality assessment of entries in statutory and main trials is made by the Flour Milling and Baking Research Association. N.I.A.B. has facilities to carry out only hectolitre weight, 1000 grain weight and protein content determinations. Besides providing figures on flour colour, milling yield, water absorption, dough extensibility, loaf score etc., the Flour Milling and Baking Research Association also comments as to the suitability of new

material for either bread or biscuits. To the breeder or agronomist, untrained in the deciphering of the mass of figures coming from quality laboratories, these latter comments would seem to be highly desirable. This method is being currently used by the Bread Research Institute of Australia in reporting on entries in the Interstate Wheat Variety Trials.

In north America hard red spring wheat is grown extensively in North Dakota and the Canadian prairies with smaller areas in South Dakota, Montana and Minnesota. Programmes visited were at North Dakota State University (N.D.S.U.) Fargo, North Dakota and Canadian Department of Agriculture (C.D.A.) at Winnipeg. Both these programmes have similar aims with increased yield and at least maintenance of quality being sought. Despite the striving for higher yields there appear to have been only minimal gains in this area in the past 20-30 years. This has been particularly so in Canada where maintenance of dough quality, equivalent to that of Marquis is of over riding importance. Canadian breeders indicated the frustrations of working under this rigid system. It has been asserted that buyers of Canadian hard red wheat have relied on the Marquis type quality and this must be maintained at all costs. Attempts are being made to improve milling yield and protein content provided this does not compromise dough quality.

Semi dwarf parents are being used in both programmes with an estimated 30%-40% of the material in the N.D.S.U. programme having some dwarf parentage. These appear to be leading to some increases in yield and disease resistance but quality is being lost necessitating back crossing to the better quality parent. There appear to be other problems associated with the dwarf habit which are causing concern to both organisations. These include shattering and lodging (surprising considering their height). The reduced length of straw may also lead to problems with swathing which is the rule throughout the area.

In the two programmes a search is being made for sources of high protein content despite the fact that hard red spring types in the area already average 2% higher in protein than the hard red winter types. It is believed that the Atlas 66 type of higher protein will not be of any use to the H.R.S. programmes.

New cultivars are field tested for several years by the breeders before the best are entered in wide scale testing programmes. In Canada, advanced material is included in Western Wheat Co-operative tests at approximately 20 sites through Manitoba, Saskatchewan and Alberta. Material from N.D.S.U. is more often included in the Uniform Regional Spring Wheat Nurseries which are grown at a similar number of sites through north central U.S.A. and into Canada.

Regional trials of this type appear to be a feature of cultivar testing throughout north America. To date in Australia only the Interstate Wheat Variety Trials appear to be on this type of organised basis. It is believed that more of this type of co-operative effort should be initiated with other aspects of wheat testing and with other crops.

Grain from individual breeders trials and from co-operative trials is subjected to extreme quality testing in line with the need to maintain the high standards of hard red spring wheat. Well equipped laboratories are available at both N.D.S.U., Fargo and C.D.A., Winnipeg. In both laboratories protein determinations are carried out by either Udy or Kjeldahl method depending on the quantity of grain available and the accuracy required. Both laboratories have Neotec Grain Quality Analysers on order. The Mixograph is also used extensively in both programmes together with final baking tests.

Such is the Canadian emphasis on quality control that even after quality testing as indicated above samples of new cultivars are distributed throughout the world prior to release in order to obtain buyer reaction to the new material. It would appear that Australia could possibly follow suit in this type of approach to overseas markets. While it is not suggested that Australian quality standards should be as rigid as those applied to Canadian hard red spring it is possible that the maintenance of a type similar to an accepted standard in each of the grades at present marketed would be of considerable advantage for future marketing.

Disease poses a major threat in the north American hard red spring wheat areas. The most important of these is stem rust. Stem rust generally moves northwards from Mexico through the United States mid west to the hard red spring areas. It has been suggested that the recent upsurge in wheat breeding in Mexico may have influenced the rust races now appearing in the northern areas. All cultivars released in the area in recent years have been resistant to stem rust. The growing of alternative generations of the HRS breeding programme in Mexico has assisted breeders to keep ahead of changes in the pattern of stem rust races.

C.I.M.M.Y.T. headquarters in Mexico also has a large spring wheat breeding programme. This is discussed separately as this programme also includes winter types.

2. Winter Wheat

(a) White Grain

The only white winter wheat breeding programme visited was that at W.S.U. Pullman Washington. As previously indicated approximately 90% of the wheat grown in the Pacific north west region is of the winter type. Both hard and soft types are coming from this programme.

Considerable use is being made of lines from the Nebraska programme in an attempt to increase protein content. As with the spring types, comprehensive disease resistance is considered essential before the release of a new cultivar in this region.

(b) Red Grain

The majority of comments previously made on the spring wheat breeding and evaluation programmes in England also apply to the winter wheat programmes in that country. The only winter types produced in England and recommended in that country are those bred at P.B.I.

Semi dwarf material is being included in the P.B.I. winter wheat breeding programme and some of the progeny appear promising although there appears to be a positive relationship between the dwarf habit and the incidence of Septoria. Both *Septoria nodorum* and *S. tritici* are major problems of winter wheat in England. Workers at the Welsh Plant Breeding Station are preparing isogenic lines of winter wheat differing only in a single gene from Bulgaria 88 which provides resistance to *S. tritici*.

Entries in statutory performance trials and main trials are much larger with winter than with spring types. The two series of trials are conducted at a similar number of sites.

In north America centres engaged in breeding of hard red winter (HRW) wheat were visited at Kansas State University (K.S.U.) Manhattan Kansas, University of Nebraska (U.N.) Lincoln Nebraska and North Dakota State University (N.D.S.U.) Fargo North Dakota.

Some of the material emerging from the K.S.U. programme is in the soft, rather than hard class. If released such cultivars could find a place in the adjacent state of Missouri as the Kansas-Missouri state line represents the approximate boundary of the hard and soft areas in that part of the country. Because of the variability of environment within Kansas it appears that there is a large genotype-environment interactions, necessitating the testing of cultivars at a large number of sites. Early general material is tested by the plant breeding section at up to 11 sites within the state. The best lines from this programme are then tested at a further 17 sites for 2-3 years before material is released or discarded. The 105 county agents scattered throughout Kansas may also run trials on released cultivars adding greatly to the knowledge of this material.

The objectives of the U.N. wheat breeding programme are:-

1. increased winter hardiness
2. increased stem rust resistance
3. increased quality and protein content
4. increased yield
5. shorter, stronger straw.

The aim in relation to protein content is to maintain a level of at least 12%. The average figure for the state of Nebraska has been slightly below this level over the preceding two seasons. The programme dealing specifically with the search for higher protein levels will be discussed in more detail later.

Stem rust resistance in current Nebraska cultivars is good but it was apparent that the annual movement of stem rust from the southern areas posed a constant threat. It was asserted that the state average wheat yield of 2,500 kg/ha obtained over the previous 8 years was largely due to the release since 1966, of a succession of rust resistant cultivars. Average yields over the period 1960-65 had been of the order of 1600 kg/ha.

Semi dwarf material is being used in the Nebraska programme but to date no semi dwarf cultivars have been released. Some disadvantages have been noted in the type, casting some doubts on their usefulness. It was suggested that introduced semi dwarf lines and their first crosses were poorly adapted returning low yields in poorer seasons. A poorer root system of the short material was suggested as the major reasons for this. It is also contended by a number of wheat breeders in the U.S.A mid west that the dwarf types suffer from "heat lodging" with stems breaking off at lower nodes if extremely hot weather is encountered near maturity. This appears not to be a problem in cooler areas.

Poor adaptability of semi dwarfs has also been noted in the N.D.S.U. winter wheat programme. This breeding programme has been operational for only 5 years. It is envisaged that winter wheat in North Dakota will find a place only in the south west of the state where winters are relatively mild. In the northern areas of the state winter temperatures may drop to -40°F and preclude the growing of winter types.

The objectives of the N.D.S.U. winter wheat breeding programme are much the same as those of U.N. with winter hardiness, stem rust resistance and increased yield and quality being sought. Winter hardiness is being pursued by examination of the U.S.D.A world collection of winter wheats while higher protein content is being sought both from spring types which are normally about 2% higher and also from the Nebraska higher protein lines.

A potential disease problem exists throughout the area from Kansas to North Dakota in that a number of the widely grown cultivars share genes for stem rust resistance. Alternative sources of resistance are being sought. Septoria appears to have increased considerably in recent years in many areas of U.S.A. and as in England there is the suggestion that this may be associated with the dwarf habit and the microclimate associated with it.

Field testing of cultivars follows a similar pattern in the three H.R.W. wheat producing states visited. The basic aim appears to be to distribute new cultivars as quickly as possible and some variation in a line is not considered of great importance. The procedures adopted by U.N. breeding and testing group is typical.

Initial selection is carried out in the F₃, these may be variable but not much attention has been paid to this particularly as to date there has been no application for plant protection on any cultivars produced. This may change in the future. Quality tests - protein and mixograph are carried out in F₅ or F₆ depending on seed supplies. Yield trials begin at 5 stations in F₇. In the following year the material is tested at 15 sites throughout the state with the best of it being included in an additional 25 regional trials covering the HRW area. This procedure is repeated in the following year. These results from 80-90 field trials provide the basis on which the cultivar is released or rejected.

Emphasis is again placed on the use and value of regional testing. The H.R.W. regional nurseries extend from northern Mexico to Lethbridge in Canada. Yield results together with agronomic data are obtained from each of these. In addition quality data are available on composites of a cultivar from several sites.

A further extension of the regional nurseries is the International Winter Wheat Performance Nursery organised in 1968 by U.S.D.A. and Nebraska Agricultural Experiment Station. The objectives of the nursery are to:

1. Test the adaptation of winter wheat cultivars under a range of latitudes, daylengths, fertility conditions, water management and disease complexes.
2. Identify superior winter cultivars to serve as recipient genotypes for high protein and high lysine genes.
3. Test the degree of expression and stability of the high protein and high lysine traits in an array of environments.

The first nursery in this series was grown in 1969 at 23 sites throughout the winter wheat growing areas of the world. In 1973 the nursery was grown at 52 sites.

3. The C.I.M.M.Y.T. Programme

CIMMYT (Centro Internacional de Mejoramiento de Maiz y Trigo) is a private, autonomous, non profit making, scientific and educational institution headquartered in Mexico and engaged in the improvement of wheat and maize production throughout the world. Its programme is considered separately for although the wheat programme is largely based on spring types it produces both red and white grained material and is also using winter types.

The stated objectives of the wheat programme are:

- (1) To assist in the development of food grain improvement programmes and to supply materials and technology for those programmes which will benefit the largest possible number of farmers, especially in developing countries.
- (2) To increase the efficiency of grain yields, as measured by yield per land unit and by lowered production costs per measure of grain in order to help the grower achieve a greater net income, and to ensure an adequate food supply available at economical prices to the entire population of wheat growing countries.
- (3) To improve the nutritional quality of wheat, especially in protein quantity and quality.

The pooling of expertise and information by a team in the development of new cultivars was evident throughout north America. Particularly at Lincoln, Fargo and Winnipeg, breeders, chemists, pathologists, entomologists and agronomists combined their efforts in a team approach aimed at the rapid production and release of new cultivars. Nowhere was this team approach more evident than at CIMMYT.

Once Again it must be stressed that in South Australia it does appear that each of these specialists is often working in isolation hindered because of their speciality but more particularly because of the organisation to which they belong from assisting fully in the team approach evident at many overseas centres.

Approximately 5000 crosses are made each year in the bread wheat programme of CIMMYT. Two generations are grown each year within Mexico greatly increasing the possible evaluation. Almost 50% of the crosses are discarded after the first generation and less than 1% will ever be released. CIMMYT does not name and release cultivars. Early generation material is made available to CIMMYT personnel or to local breeders in developing countries for selection, testing and release by the local authorities.

Disease resistance plays an important part in the programme in Mexico with inoculation of F2 plants with stem rust spores being employed. In addition to rust, septoria and fusarium are of importance. Fusarium nivale wiped out large areas of commercial crops and experimental areas in Mexico in 1973.

Grain quality is of lesser importance in the programme. This is in view of the CIMMYT concern for breeding for developing countries in which bread is not always an important part of the diet. Despite this, well equipped quality laboratories have been set up at El Baatan.

Winter types are being examined and crossed in one section of the programme in Mexico with a view to producing material suitable for areas of Turkey, Iran and Afghanistan. In addition a programme has recently been initiated of crossing together spring and winter types. Material from these crosses is being selected both in Mexico and Oregon. It is anticipated that following F5 the best lines will be included in international trials at approximately 20 sites.

4. Durum Wheat

Durum breeding programmes were briefly discussed in Tunis, Fargo, Winnipeg and Mexico City.

Durum cultivars are not of importance in Mexico but CIMMYT conducts a breeding programme in that country to provide material for developing countries. Consumption of durum in Tunisia is approximately the same as that of bread wheats but the durums grown are very low yielding. Material is becoming available from the Mexican programme. Higher yield, better quality, earlier maturity and better disease resistance are each available in one or other of the new cultivars but none appears to have combined all these attributes.

Ninety percent of the United States durum production is in North Dakota with 60% of this being exported. The dry conditions late in the season coupled with the cool night temperatures of this north central region appears to favour the production of high quality durums.

The objectives of the N.D.S.U. durum breeding programme are:

1. acceptable semolina and spaghetti colour
2. increased yield
3. height of approximately 90 cms.
4. earlier maturity - approximately 110 days
5. resistance to weather damage at maturity.

It appears that the colour of the product is of overriding importance and if not acceptable then the new line should be discarded in spite of any other outstanding attributes it might possess. The quality laboratory for testing of durums at N.D.S.U. has outstanding facilities being the equal of bread wheat laboratories visited.

The majority of the Canadian durum area of approximately 1m. ha. is in southern Saskatchewan adjacent to North Dakota. Durum breeding work in Canada was initiated in 1956 using North Dakota material and the two programmes have basically similar objectives. Semi dwarf material from Mexico is now being incorporated into the Canadian programme with the aim of reducing plant height by about 10% from the present 90cms. Some problems appear to have arisen from the use of the dwarf material. These include a tendency to later maturity, a high proportion of starchy kernels and a tendency to produce shrivelled grain.

5. Other Wheat Programmes

Several wheat breeding programmes could not be categorised as easily as those already discussed. These programmes at the Universities of Manitoba, Saskatchewan and California at Davis are aimed at the production of a high yielding cultivar not necessarily suited for the production of bread.

A utility grade of wheat was initiated in Canada in 1969 with the licencing of Pitic 62. It was intended that this cultivar with baking quality inferior to that of the traditional H.R.S. types and with easily distinguishable grain characteristics should be used primarily for animal feeding. There are indications of a large domestic feed grain market in Canada with the opinion being expressed that feed lots were turning to the use of wheat as a feed grain rather than barley.

A second utility cultivar, Glenlea, was licenced in 1972. This red spring type outyields the traditional HRS cultivars by 25% but is inferior to Marquis in bread making quality. Like Pitic 62, Glenlea is distinguishable from HRS on kernel characteristics.

These two cultivars are now segregated together to form the utility grade. Consideration was also being given to the licencing following 1973 trials of a hard white cultivar currently designated UM 607. If licenced this would be segregated into the utility grade. Field trials for this type of cultivar are along the same lines as those employed for HRS types except that final yield evaluation is in the Western Non Bread Wheat Co-operative Tests at 20 sites analagous to those for the HRS cultivars.

Considering the great similarity of the licenced HRS cultivars in Canada and the homogeneous nature of their grades the establishment of a utility grade containing Pitic 62, Glenlea and U.M. 607 appears incongruous. If the sole purpose of the grade was to provide animal feed than the heterogeneous nature would appear to be of little consequence. Opinions were expressed by Canadian breeders that further segregation could take place in the future with feed and utility grades being segregated instead of the single utility grade as at present. The feed grade could possibly be distinguished by coloured aleurone.

There are at present no quality requirements for cultivars received outside of the H.R.S. classification; the only requirement is that they must be distinguishable from H.R.S. on kernel characteristics. Canadian breeders are however of the opinion that in the future utility types might have to measure up to some quality standards.

The production of a medium - good quality white wheat would appear to pose a distinct threat to the Australian wheat industry which is largely based on this type of grain. White grain is preferred to red in a number of markets. If it were in direct competition, Canada could have a freight advantage over Australia in some situations. Throughout the United States there were rumours that U.S. wheat breeders in the traditional red grain areas were also quietly interested in the production of white grained cultivars. No U.S. breeders volunteered the information that they were working on such a project but it must be considered a distinct possibility in view of the Canadian situation.

The current annual Canadian wheat production is in excess of 16m tonnes. The demand for H.R.S. grain by local users and regular overseas customers is approximately 12m tonnes. Some Canadians consider that the national aim should be to produce 12m tonnes of H.R.S. wheat together with 4m tonnes of the new utility grade. This could probably best be grown in higher rainfall areas as the lower protein content of grain from these areas would not be a problem.

The breeding programme of the University of California at Davis is not specifically aimed at the production of a feed type grain but does approach this. Traditionally the low protein soft white wheat produced in California has been used largely for poultry feed. At the same time the majority of wheat for human consumption has been imported from other states. The Californian programme is now largely concerned with the evaluation of material from the CIMMYT programme in Mexico. Increased grain yield is

of paramount importance and this was achieved along with better milling and baking quality with the release of the cultivar Anza in 1971. This line from the CIMMYT programme has been released under a number of names in different countries. It has been widely used as a parent in Australia under the designation WW15. Anza is considered to be "a fairly respectable bread wheat" in California.

6. Barley

The opportunity was taken wherever possible to discuss barley breeding and evaluation in view of the importance of barley growing in South Australia where the majority of cereal growers produce both wheat and barley.

Disease resistance forms a major part of the barley breeding programmes in the United Kingdom. At P.B.I. powdery mildew (*Erysiphe graminis*) is considered to be the major barley disease problem. In higher rainfall area, particularly in Wales scald (*Rhynchosporium secalis*) assumes equal importance and greater attention is paid to this disease in the Welsh Plant Breeding Station (W.P.B.S.) barley programme. The problem of scald appears to be greater with shorter strawed cultivars and some attempts are being made to breed away from this type where possible. Several sources of resistance to this disease are available and currently polygenic resistance rather than major gene type is under investigation.

Screening of material for resistance to cereal cyst nematode is currently being carried out in Wales. The cultivar Sabarlis, resistant to 2 of the 3 races of cereal cyst nematode was released in 1968 somewhat reducing the commercial problem. The value of repeatedly cropping with resistant cultivars on an infested site thereby reducing the nematode population has been clearly demonstrated in some of the Welsh work.

At both P.B.I. and W.P.B.S. interest is being shown in the production of a feed barley with high lysine content. Hiproly and a Danish mutant are both being used in the programme. Results from Hiproly have been disappointing.

Approximately 25% of United States barley production is from the 1.2m hectares sown in North Dakota and considerable barley breeding and research is being carried on at N.D.S.U. Approximately 85% of this effort is directed towards 6 row cultivars, the interest in 2 row material being fairly recent. In the drier western area of the state both types yield equally well.

Approximately 85% of the barley malted in the U.S.A is of the 6 row type. The maximum permissible protein content for this grain is 13.5% while levels up to 12.5% are allowed in 2 row grain for malting. The majority of U.S. Breweries use about 40% adjunct and rely on the 6 row types with their higher enzyme activity, but lower extract, to convert the added carbohydrate. Interest is being shown in some 2 row types which have enzyme activity similar to that of the 6 row types. All the 2 row types and the majority of the 6 row types malted have a white aleurone. Tests with isogenic lines have indicated no differences in the malting quality of blue and white aleurone types.

The Canadian Department of Agriculture has separate breeding programmes for 2 and 6 row types at Winnipeg. As in North Dakota the interest in 2 row types is relatively recent. The Canadians see a market for their 6 row malting types to the U.S.A. which has traditionally used this type of grain. However as in Australia, U.S. brewers are conservative and may resist changes to Canadian cultivars. Additionally Canadian malting barley must have a blue aleurone to meet their own licencing requirements.

The Canadian interest in 2 row malting types stems from the obvious preference of other countries for 2 row malting types with their higher malt extract. This awakening interest by the Canadians in overseas markets should be noted by Australian producers and marketing authorities just as we should be acutely aware of their interest in the production of white wheat. Attempts by Canadian geneticists to transfer the desirable enzyme systems, resulting in faster modification, of the 6 row type into the 2 row type should also be studied.

The overall objectives of the breeding programmes in North Dakota and Canada are similar. The complex of diseases is seen by all as the biggest problem. These include scald (*Rhynchosporium secalis*), net blotch (*Pyrenophora teres*) and spot blotch (*Helminthosporium sativum*).

Short, strong straw is also being sought in the north American programmes. Present cultivars are approximately 95cms high and it is suggested that this could be reduced to 85-90cms but anything less than this would be undesirable as the practise of swathing requires a reasonable length of stubble to keep the cut heads off the ground.

The north American programmes visited were equipped with good facilities for the evaluation of malting quality. The laboratories at N.D.S.U. in particular micro malt approximately 700 samples each year and micro brew about 20 of the most promising producing 1 litre of beer of each. As in Australia the maltsters and brewers appear very conservative in regard to change and prefer to use the known cultivars despite the much lower grain yield of these compared with newer ones. Industry insists on testing of car lots of new cultivars for 2-3 years before making decisions on them.

The demand for feed barley has increased rapidly in both U.S.A. and Canada in recent years. Eighty five percent of Canadian barley is now used for animal feeding. In the past feed barley in the U.S.A., as in Australia, has been that which didn't qualify for the malting grades. Programmes have been set up by N.D.S.U., C.D.A. at Winnipeg and University of Saskatchewan to investigate the production of a feed type barley.

There is general agreement that many of the features required in a good feed barley are also needed in a good malting type. The most important aspect of feed barley lies in the digestible energy produced per unit area. Unfortunately no laboratory criteria are available to adequately screen large numbers of feed grains for energy. Work at Saskatchewan had indicated positive

correlation of kernel plumpness with calculated digestible energy and total digestible nutrients. Mice breeding and feeding experiments have also been set up at several centres to determine the relationship, if any, between chemical composition of barley cultivars and their feeding potential.

The primary objectives of feed barley programmes in north America are to -

increase yield

increase bushel weight

decrease fibre content

increase starch content

increase lysine and change the amino acid balance.

7. Oats

As in Australia the oat crop and oat breeding and research appeared to receive relatively little attention in the countries visited. Of the centres visited only at the W.P.B.S., N.D.S.U and C.D.A. Winnipeg did there appear to be any great interest in the crop.

The early oat breeding work at Aberystwyth was concerned with increasing grain yield and improving grain and straw quality, by developing cultivars adapted to specific environments. In more recent years there has been increased emphasis on the development of widely adapted cultivars. Present work is largely concerned with the breeding of cultivars with additional disease resistance. The major diseases under attack are crown rust (*Puccinia coronata*) and powdery mildew (*Erysiphe graminis*). Cereal cyst nematode (*Heterodera avenae*) is also being investigated and it is of interest to note that the Australian cultivar "Mortgage Lifter" is among the cultivars being used as sources of resistance.

One of the major aims of the north American oat breeding programmes is to increase grain protein content. A cultivar is currently available in the region with a protein content of 18-20%. This is approximately 3% higher than that of other cultivars and is being grown under contract for the production of breakfast and baby foods.

Shorter, stronger straw is being sought in north America to enable the use of higher fertilizer application rates and subsequent higher yields without fear of lodging.

In Canada where approximately 25% of the oat crops is cut for hay there is some emphasis being placed on specific cultivars for forage production though none have been released as yet. There is also pressure from livestock interests for the breeding of a cultivar with a higher fat content in the grain.

Some Australian cultivars, in particular Swan, Irwin and Kent, have been included in the Winnipeg programme. These have generally proved to be of little use in Canada because of poor

tillering and slow maturity. Kent is however being considered in the breeding programme because of its large grain size.

8. Triticale

Triticale breeding programmes are in operation in Mexico (CIMMYT) and Canada (University of Manitoba). In addition research is being carried out in U.S.A. by private research organisations, particularly the Jenkins Foundation for Research. The opportunity was taken while in Mexico to briefly discuss the CIMMYT programme.

The aim of this programme is not to replace bread but rather to produce an alternative source of food for developing countries which may not be able to produce wheat or may not have a taste for bread as we know it.

Triticales are already being used commercially in Texas as an alternative to oats for grazing and Triticale pancake mixes are available in U.S.A. "Bread" has been produced from 100% Triticale flour though this apparently differs somewhat from wheat bread and a modified milling process is necessary.

Kernel development is still a major problem with this grain though it appears that this is being overcome in the CIMMYT programme with crossing of Triticales to bread wheats. Hectolitre weights of the best lines are now approaching 75 kilogrammes. This material is now being crossed back to Triticales in an effort to restore the head size which was lost in the initial crosses to bread wheat.

The fertility of the CIMMYT lines generally appears to be quite good though apparently this is not the case with other material available.

Over the past 5 years with increased development Triticale yields have increased from 3,000 kg/ha to 11,000 kg/ha, the latter in small plots under irrigation. While the protein content of the more recent Triticales is well below the 18%-20% of the earliest lines it is still at least equal to that of wheat. In addition Triticales are considerably higher than other cereals in the essential amino acids, lysines and methionine.

Triticales appear widely adapted particularly to lighter soils. Material has been obtained through the curator of the Australian Wheat Collection for testing in the South Australian environment with particular reference to lighter soil areas.

9. Oil Seed Rape

Where possible oil seed rape breeding and production were briefly discussed in view of the possible increased growing of this crop in South Australia in the future. It appeared from information obtained in England that while future European production would be aimed towards the low erucic acid types there was no price differential being paid on this type.

In Canada, it appeared that possibly 95% of the local crop was of the zero erucic acid type with the Department of Health placing an upper level of 5% on the content of erucic acid in edible oils. At the same time interest was being shown in the production of high erucic acid types specifically for industrial purposes.

At Saskatoon the hope was expressed that in the near future *Brassica napus* and *B. campestris* lines with both zero erucic acid and zero glucosinolates would be available. These would be of immense importance to livestock interests because of the absence of the toxic substances.

Current projects are aimed at the production of yellow seeded lines in both species. It is anticipated that this would reduce the fibre content of the seed by 50% at the same time increasing both the protein and oil contents by about 2%. Reduction in the linolenic acid content of rape seed is causing some problems and mutations are being looked at.

10. Pulse Crop Research

A major project within the Crop Science Department of the University of Saskatchewan aims to evaluate the adaptation of new crops to Saskatchewan conditions. Specifically, research to date has been centred on the pulse crops with primary emphasis on field peas.

Preliminary trials indicated the range of protein content available in field peas. The protein content of 1452 lines from the U.S.D.A. world collection ranged from 15.5% to 39.7%. Further trials are being carried out on the best of these to determine those genetically high in protein content.

Preliminary trials have also been carried out on a number of other pulses. These include faba beans (*Vicia faba*), chickpeas (*Cicer arietinum*) and lentils (*Lens esculenta*). It is of interest to note that of several lupins examined only Unicrop was able to mature normally. In one trial it yielded approximately 1350 kg/ha of seed.

Very little research is being conducted with pulse crops in South Australia. This is despite the relatively large area annually sown to field peas. The basic problem is one of availability of personnel to carry out an experimental programme. In view of the apparent large variation available in the protein content of field pea lines in the U.S.D.A world collection and the proven ability to produce this crop in South Australia it is suggested that moves should be made to obtain material from this collection with a view to evaluating their performance in South Australia.

The Canadian work with faba beans should also be closely considered as another possible high protein grain crop. High yields have apparently been obtained with these in Canada and also in the United Kingdom. Research on the breeding and physiology of this crop is being conducted at the Welsh Plant Breeding Station. To the best of my knowledge little if any work has been carried out with this crop in Australia to date.

11. Cultivar Evaluation Methods in Field and Laboratory

Equipment used in both field and laboratory evaluation of cultivars is of some importance to the Crop Agronomy group of this Department. Particular note of the equipment and methods used was taken at centres visited.

Field

The majority of field trials are seeded with equipment much smaller than that used by farmers, though N.I.A.B. employs a 17 run drill seeding 2, 8 row plots at the one pass. Practically all other equipment for seeding is based on the use of cones enabling a quicker and more uniform seeding operation. These machines range from the basic Oyjord drill which is very flimsy and has no facilities for fertilizer application up to the massive, highly efficient equipment used by W.S.U. This latter machine is based on a belt seeder, different from any others examined. The majority of the cone seeders are set up to sow 4 row plots with the use of a single large cone supplemented by a 4 way splitter. In some cases these machines sow 2 such plots at one pass in line with the equipment at present in use in this Department.

With cone seeders, seed may be either in paper packets or in plastic magazines. While the magazine system is the faster to use in the field several workers, particularly in the U.S.A. indicated the relatively high cost of such a system. The use of packets appears to require more labour, particularly where 2 plots are sown at the one pass, and there appears to be an increased possibility of errors occurring. The use of magazines can more than pay for the additional costs in large programmes by speeding up the "in the field" operations. The system in use at W.S.U. is able to sow plots each 3 metres long and 4 rows wide at the rate of 1000 per hour.

Plots in trials carried out by plant breeding sections generally range from 3 to 6 metres in length. More extensive trials, similar to the secondary cultivar trials of this Department generally have longer plots, up to 30 metres, in line with their use as both research and extension material.

Field trials of advanced material, similar to those carried out by this Department and distinct from early generation trials by plant breeders, generally consisted of 15-60 entries. The basic trial design used is the randomised block with 4 replicates. Although the errors involved in trials of this design were not specifically discussed they were widely used and no need was seen for the use of more sophisticated designs or repeated check plots although in Canada there was some use of moving means for adjusting yields in the larger trials.

Harvesting equipment overseas appeared generally in line with that used in Australia with workers in U.S.A. and Canada in particular switching to the Hege plot harvester. In U.K. the PAM and Claas machines appeared much more popular. Among the workers using the Hege there were differences of opinion on its efficiency. At some centres small plots were harvested with grain samples almost as clean as those obtainable from commercial machines.

Apparently no modifications had been made to these machines. At most centres there appeared to be a need to reclean Hege harvested grain samples prior to weighing. There was general agreement at these latter centres that separation of grain and straw presented some problems. The ultimate harvesting machine appeared to be that designed by O. Vogel at W.S.U. This harvests 1500 plots per day, 3 times the rate of any other, but its costs, along with that of the rest of the field equipment used in this programme would be prohibitive.

Laboratory

Mention has previously been made of some aspects of quality evaluation equipment in the discussion of breeding programmes.

Pelshenke and Zeleny tests once in vogue in North America are used very little today. Pelshenke is still used in very early generation material in Tunisia and Mexico as a measure of gluten strength. These tests are seen as only crude measures in the sophisticated laboratories of north America.

Protein determinations are seen as one of the most important tests and one which can be carried out on early generation material. While the Udy method is used at some centres there is general agreement that kjeldahl digestion, often in association with an auto analyser is the best and most accurate method.

Increasing use is being made of the Neotec grain quality analyser. This machine was originally designed to determine protein, oil and moisture content of soybeans and is now being used or is on order in a number of laboratories in North America. There have been a number of teething problems not the least of which appears to be the need for virtually identical preparation of all sample. The opinion was expressed that while the Neotec may provide reliable results from uniform areas such as the Canadian prairies, calibrations made for other areas would not necessarily be applicable.

Milling equipment inspected varied considerably. At W.S.U. a micro mill is used on F2 and F3 material, 4 samples each of 5 grams are milled at one time enabling a total of 1000 samples to be milled in a day. Evaluation is made on appearance, bran clean up and an estimate of flour yield.

The Brabender junior mill was used at a number of centres on F4 and F5 material with throughputs of 35 grams/sample and approximately 70 samples per day. The resultant flour is used for quality determinations with the mixograph.

Several cereal chemists were of the opinion that the Brabender senior mill was the best available. Despite this assertion one of the proponents of this mill Karl Finney in charge of the Hard Winter Wheat Quality Laboratory has modified the mill. This modification has enabled four times the throughput. Buhler mills were available at a number of centres but did not appear to be in much use.

The mixograph was widely used throughout North America for determination of dough quality. This piece of equipment was seen as the best single machine available for dough testing. It was particularly useful for early generation material as it could be used with only 10 grams of flour. The farinograph was available in most laboratories and was used to some extent and then largely because of its more widespread use in commerce and the need to often equate findings from research and commercial enterprise.

Baking tests were usually carried out with 100 gram doughs though high correlations have been obtained between these and 10 gram doughs. More interest is being shown in the latter. Loaf volume is reported on a per unit protein basis from these tests.

As previously indicated the cookie spread test is the ultimate quality test of biscuit wheats. As this test requires 40 grams of flour it is largely replaced for early generation material by the alkaline water retention capacity test. This test requires only 7.5 grams of flour. High correlations have been obtained between results of the two tests.

IV. IMPROVED PROTEIN CONTENT AND NUTRITIONAL QUALITY OF WHEAT

The amino acids in wheat protein are not present in the proportions required to satisfy the nutritional needs of man. This is illustrated by the following table.

Deviation of Essential Amino Acids in Wheat Protein
from the Requirements of Man (F.A.O. 1957)

<u>Amino Acid</u>	<u>%deviation from mans requirement</u>
Lysine	-55.0
Isoleucine	-16.7
Methionine	-12.5
Threonine	- 3.4
Valine	+ 4.5
Tyrosine	+ 9.7
Leucine	+30.4
Phenylalanine	+40.4

As it has been estimated that 1 billion people rely on wheat as their main staple any improvement in the nutritional value of this crop could have enormous impact.

Research at the University of Nebraska on the nutritional improvement of wheat was greatly stepped up in 1966 under a contract with the U.S.A Department of State. At present there are 24 research staff in the departments of Agronomy and Foods Nutrition engaged in this research at Lincoln.

The broad objectives of the project are to -

1. Analyse the world wheat collection for differences in protein and lysine content.
2. Measure the effects of environment on protein and lysine content.
3. Incorporate genes for these two factors into agronomically acceptable wheats.

4. Attempts to achieve new high levels of these kernel constituents by hybridisation.

The findings to date from this programme are worthy of mention as they would appear to have a bearing on the problem of feeding the increasing world population and be of importance to the future of the Australian wheat industry.

To date approximately 19,000 entries of the U.S.D.A. world wheat collection have been analysed for protein and lysine content. In a sample of over 12,000 bread wheats protein level ranged from 6% to 23% with a mean of 12.9%. The lysine content per unit protein in these same samples ranged from 2.2% to 4.2% with a mean of 3.2%. The positive correlation of lysine per unit dry grain weight and protein indicates that increases in grain protein content could enhance nutritional quality. Positive correlations of lysine with threonine and leucine indicate that genetic increases in lysine would also result in higher levels of the other two amino acids.

Laboratory analyses have indicated that high protein wheat at 17.2% protein will provide more lysine, isoleucine, methionine and threonine per unit weight of dry grain than opaque-2 maize mutant at 10.0% protein levels. It is appreciated that these in vitro analyses may not relate to true biological values based on animal feeding trials.

Preliminary mouse feeding trials have been carried out to assess the nutritional value of wheat demonstrated to possess high protein and/or high lysine. High protein lines have tended to produce better weight gains and better feed efficiency ratios (feed consumption per unit weight gain).

Projects at Lincoln are investigating both kernel morphology and kernel anatomy in relation to variation in protein and amino acids. It has been clearly demonstrated that while kernel plumpness influences protein content it does not influence lysine per unit protein. Separation of kernel fractions is under way to identify those factors associated with protein and amino acid variations.

Several lines, both winter and spring types, from the U.S.D.A. world wheat collection gave indications of high protein and/or high lysine when initially grown in the U.S.A. A number of the high protein lines have been included in international winter wheat nurseries throughout the world to test the stability of the high protein trait in diverse production environments. Three entries in particular in these nurseries, Atlass 66, N.B. 67730 and Purdue 28-2-1, possess genes for high protein content. While these were not as productive as several other cultivars in the trials they were significantly higher in protein content than all but one other entry.

More recently the spring type cultivar Nap Hal has been identified as a source of both high protein and high lysine. Crosses between Nap Hal and Atlas 66 have given indications of transgressive segregation of both high and low protein suggesting that different protein genes are operative in the two cultivars. Crosses between Nap Hal and C.I. 13449, the entry with the highest lysine content in the world wheat collection, have also indicated transgressive segregation for high lysine

content. It would appear logical to investigate the possibilities of using such genes in Australian breeding programmes.

The physiological basis for the production of high protein grain is still under investigation at U.N. and other centres. To date there is evidence that high protein content is associated with differential and more complete nitrogen translocation to the grain during the maturation period. Differential nitrogen uptake by the roots does not appear to be a factor. The nitrate reductase enzyme also appears to be implicated with higher levels of nitrate reductase activity being demonstrated in high protein lines.

V. CEREAL SEED PRODUCTION

Cereal seed production from the breeder to the point of release and then later through certification procedures appears well organised and co-ordinated in a number of overseas countries. The overall aims are to provide a relatively large quantity of seed of a new cultivar at the time of release followed by adequate supplies of high quality seed.

Initial seed build up by the breeder begins when he feels that he has a promising line likely to become a commercial proposition. This build up goes hand in hand with the normal yield and quality evaluation of the material prior to release. Generally 2-3 years before projected release seed of the line (30-300 kgs) is handed over by the breeder to the seed production section associated with the breeder, for intensive seed build up. Basic or breeders seed is maintained by the breeder as the prime source of the material.

While build up of this type goes on in the United Kingdom it might be best illustrated by reference to systems operating in U.S.A. particularly those of Nebraska and North Dakota. Two-three years before projected release of promising material a quantity as little as 30 kg is made available by the public breeder to the Foundation Seed Division in Nebraska or the Seed Stocks Project in North Dakota. Both of these sections are part of the Agronomy Departments in their respective universities. The leaders of these sections are responsible only to the heads of the respective Agronomy Departments.

In both these states seed build up to the point of release is largely carried on at research stations where large areas are made available. In addition the programmes have their own harvesting and seed cleaning facilities. At the Mead Field Station in Nebraska ten headers are used solely for the harvesting of foundation seed and the recently completed seed cleaning facility cost \$75,000.

While some of the seed production programmes are financed from within the Agronomy Department budget others such as that in Nebraska rely on the sales of foundation seed for income and operating expenses. It was generally indicated that none of these programmes sets out to make a profit though in fact most Profits from the Nebraska Foundation Seed Division operation currently provide for 5 technicians in the Agronomy Department have recently provided a Hege harvester for the plant breed section.

Seed increase by these organisations can be extremely quick due in large part to the close co-operation and forward planning of co-operators from all parts of the U.S.A. The Seed Stocks Project of North Dakota has available facilities for seed build up in North Dakota, Arizona and California. It has been demonstrated that with the use of these facilities 30 kg of spring wheat or barley can be increased to 4,000 tonnes in 12 months, sufficient to resow 80,000 hectares.

Seed from the build up programmes is generally made available to neighbouring states at the time of release in parcels of 3-30 tonnes or in smaller quantities one year earlier. This type of co-operation is considered the normal practise with seed being offered. This contrasts markedly with the situation in Australia.

Generally seed build up in other states of U.S.A. and in Canada appears to be along somewhat similar lines though in some areas specialist seed growers build up seed under contract. These growers do not necessarily restrict their operations to wheat or even to cereals and all have their own well equipped cleaning facilities. Seed from these growers is inspected, and rogued by the breeding organisations concerned and in the earliest stages of build up harvesting and cleaning will also be the responsibility of the breeder.

Release of a new cultivar is generally decided on by a committee set up within the relevant breeding organisation. Plant breeders concerned with different field crops are generally involved together with pathologists, entomologists and chemists. It is considered, particularly in the U.S.A., that breeders concerned specifically with e.g. maize or soybeans should be given opportunity to voice their opinion on a new wheat cultivar prior to its release. I think it of particular interest to note that release is decided on by a committee of technical people largely from within the breeding organisation; again this differs from the system operating in many areas of Australia. Although opinions may be sought from local, interstate and even overseas experts on the potential of a new cultivar the final decision on the release of new cultivars in the U.S.A. is made within the breeding organisation.

In Canada breeders of promising new material seek the support of various "Canada Committees" prior to applying to the Minister of Agriculture for the licencing of new cultivars. Separate committees decide on yield, quality and disease resistance with sub committees covering different crops. The committees are made up of specialist representatives of Canadian Department of Agriculture, provincial Departments of Agriculture, universities and private industries. A basically similar, but much smaller committee set up is operative in California for the release of new cultivars.

Following release of a new cultivar the objective in all countries visited is to make this available as quickly and as widely as possible.

In Tunisia basic seed is distributed to as many as 50 farmers by the two seed producing and cleaning co-operatives on a contract basis. The majority of the seed is then bought back, cleaned and resold as certified seed. Similar schemes are envisaged for Algeria and Morocco in the relatively near future.

In the United Kingdom most seed sales are handled by agricultural merchants. At present the grades of seed available are basic, certified, multiplication and field approved. The larger agricultural merchants buy basic (or pre basic) seed from breeders and contract with farmers for further build up. It is estimated that 70% of the cereal seed sown annually in the United Kingdom is handled by these organisations and has therefore passed through some form of certification. The major reason given for this high usage of certified seed is the high rate of out-crossing occurring in cereal crops. It has been suggested that very few farmers in the United Kingdom would use seed saved from a previous crop for more than 5 years before buying in new seed. A similar situation appeared to exist in the Pacific north west of U.S.A. where it was believed that up to 20% outcrossing could occur in one season with some cultivars.

Certification in the United Kingdom is handled by a range of inspectors depending on the grade of seed. At the moment there is no limit on the number of generations of a particular class of seed which may be produced from a higher class of seed. This will change when the United Kingdom switches to the E.E.C. scheme. Under this all cereal seed sold will have to be certified and only first and second generation seed produced from basic seed will be eligible for certification. This scheme will then be more in line with those now operated by crop improvement associations in the major wheat producing states of U.S.A. and the Canadian Seed Growers Association. Some of the largest agricultural merchants in the United Kingdom have been using the E.E.C. scheme for a number of years partly because of their association with breeders and seed producers in Europe.

In the U.S.A. seed certification is generally the responsibility of the Dean of the local College of Agriculture. In many cases he delegates this responsibility to an independent agency - generally referred to as the Crop Improvement Association. Although independent there are still close ties with the relevant universities with office space usually available within the Agronomy Department. The board of directors of these associations are mainly seed producing farmers but the universities are also represented.

In Canada there is only one certification organisation for the whole of the country. The Canadian Seed Growers Association with headquarters in Ottawa is responsible for certification of all agricultural crops except potatoes. This association appears to operate very efficiently throughout the country with the board of directors composed of seed growers and provincial government appointees. The majority of certification in Canada is carried out by officers of the provincial Departments of Agriculture.

The competency of inspectors probably varies throughout the areas visited. In the United Kingdom it appears that the 1300 inspectors under the British Cereal Seed Scheme are very efficient.

They have to pass several examinations in both theory and practise as well as undergoing probationary periods. Retesting of these inspectors takes place every five years. They are each allowed to inspect a maximum of 300 hectares of cereals each year. It is maintained that this is near the maximum which could be expected because of the thoroughness of the inspection.

In the major wheat producing areas of the U.S. mid west less than 10% of the cereal area is sown with certified seed. Field inspectors in this region are each expected to inspect between 1,000 and 2,000 hectares annually. This may include crops other than cereals. These inspectors appear well trained. In some of the western states of U.S.A. certification may not be as exacting with student labour used in some instances.

The policy on the pricing of the early generations of certified seed, in the category of basic or foundation, is to set this at least three times that of commercial seed to enable farmer seed producers selling seed between these two extremes to make a reasonable profit. The price of seed at initial release has been quite high in some instances e.g. \$15/30 kg for Glenlea in Canada and \$16/30 kg for Anza in California. Normal prices appear to be of the order of \$10 for basic seed, \$4-\$5 for certified when return on commercial seed is \$2-\$2.50.

I believe that more attention should be paid to the build up of cereal seed in South Australia prior to release. It appears that most of the cultivars built up overseas prior to release do in fact get released. In the odd cases where final approval is not obtained for the release of a new cultivar then the seed can be delivered to the relevant authority. The loss in these situations is not frequent and is relatively small.

There is need for continued discussion on this topic particularly in South Australia with 2 cereal breeding organisations and 3 centres of seed multiplication. A committee of interested parties should be set up to discuss the orderly build up and marketing of cereal seed. On an Australia wide basis there should be closer co-operation in seed build up at and immediately prior to release. This would largely be dependent on widespread prior testing of material to determine adaptability to different areas. Although the Interstate Wheat Variety Trials are in part filling this latter role some material is only being tested for one, or at the most, two years before release. Somewhat similar schemes could be initiated for barley and oats or at least interchange of material placed on a more formal basis.

The need for a cereal seed certification scheme for Australia or for individual states is to me not clear cut. It appears that schemes of this type are operating in the majority of the agriculturally advanced overseas countries. This could indicate that Australia is the odd man out but I see little clear evidence among the better farmers in South Australia that wheat crops are suffering from the lack of such a system. Current schemes such as that operating in South Australia where Department of Agriculture research centres and Roseworthy College provide seed for build up by registered growers whose crops are subject

to inspection by the Department of Agriculture greatly assist in the maintenance of varietal purity in wheat.

Problems of admixture of barley cultivars has increased in South Australia in recent years leading to the down-grading of many crops. It would appear that the careful examination made of samples from all barley crops by the Australian Barley Board is the factor enabling the detection of these admixtures which might not be obvious in a cursory examination of the growing crop or of the grain at the point of receipt as is the case with wheat. This gives cause to think that more careful examination of wheat crops and grain at delivery could possibly bring to light similar admixture problems.

An even greater problem exists with oats where farmers appear to take very little care in the sowing of clean pure seed. This is probably not surprising in view of the generally low returns for oats and the multitude of end uses of the crop.

The need for cultivar purity is quite evident with malting barley but is possibly less significant with oats as indicated above and also with wheat. With wheat in South Australia admixture of cultivars generally becomes a commercial problem only when mixing of different grades is involved.

At a number of overseas centres stress appears to be placed on the cultivar purity aspect of cereal certification and in some instances certification is only to cultivar. Although this is not the case under the British Cereal Seed Scheme the contention by large seed producing interests in England that outcrossing is the major reason for farmers needing to regularly purchase certified seed adds to the impression, possibly false, that cultivar purity is of overriding importance.

Simple methods are available whereby farmers may keep seed free of mechanical admixture, weed contamination and many seed borne diseases. It is suggested that if these methods were followed the need for certification of cereal seed would be greatly reduced. While as previously indicated it has been contended that outcrossing presents a major reason for certification there appears to be little evidence that outcrossing does in fact lead to yield reduction in Australia. As, in the absence of any commercial bar to admixture, maintenance of yield would appear to be the major objective of certification it is felt that careful consideration should be given to alternative methods of achieving this before embarking on cereal seed certification schemes.

VI. FOURTH INTERNATIONAL WHEAT GENETICS SYMPOSIUM

This symposium held at the University of Missouri, Columbia, Missouri, U.S.A. attracted approximately 350 participants from 30 countries during the period August 6-11, 1973.

Sessions were programmed under the following headings:

Quantitative genetics
 Evolution and speciation
 Alien genetic material
 Triticale
 Induced and natural variation
 Cytoplasmic and Hybrid wheat
 Pests
 Breeding
 Cytogenetics
 Biochemical and physiological genetics.

Unfortunately the sessions on breeding and cytogenetics were run concurrently.

Because of the large number of papers presented in each session there was very little time for discussion. This appeared to be a definite deficiency of the symposium.

A number of papers were presented on the origin of the B genome of common wheat previously considered to be derived from *T. speltoides*. Though serious doubts were cast on these claims there was no final agreement, following discussion, on a definite donor. It appears possible that more than one species could have been involved in the process.

Several papers reported on grain shrivelling in Triticale. Chromosomes in rye and wheat involved in shrivelling have been identified and suggestions made on the possible substitution for these in Triticale in efforts to overcome the problem. The physical basis of grain shrivelling has also received preliminary investigation. The precise mechanisms responsible have yet to be identified.

Several papers were presented on genetic sources of disease resistance with particular reference to stem rust. French workers reported on the location of genes in *Agropyron intermedia* which control resistance to stem rust. These differ from those in *Agropyron elongatum* now used in Eagle and Kite. In relation to breeding for rust resistance, Japanese workers presented a method whereby the generation time for spring wheat could be shortened to 60 days by manipulation of the environment within the laboratory thus enabling 6 generations per year to be achieved.

In the relatively large section on breeding there were a number of papers on methods of breeding and early generation selection. Results of one paper indicated that while selection for yield per plant in F₂ was ineffective, selection for yield per head was well correlated with yield per plot in F₄.

Townley Smith and his associates, in their paper, recommended the use of moving means rather than repeated control plots in the assessment of large numbers of hybrid lines. They also indicated the deficiencies in relying on visual assessment in selecting the highest yielding lines. In this respect breeders were no better than untrained personnel in attempting to select the highest yielding lines.

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APPENDIXInstitutions and Personnel ContactedTunisiaCIMMYT - Tunis

Mr. J.B. Doolette	Agronomist cereals project
Dr. T. Lyons	Agronomist cereals project
Dr. G. Varughese	Wheat breeder
Dr. J. Douglas	Seed production specialist
Mr. R. Mouaffak	Director, Technical Division Office of Cereals
Mr. R. Roberts	Assistant representative for Ford Foundation in North Africa.
Dr. P. Bronzi	Ford Foundation Agricultural Programmes Adviser for North Africa.

United KingdomNational Institute of Agricultural Botany - Cambridge

Mr. R.J. Wellington	Head, Cereals Section
Mr. W. Fiddian	Head, Trials Branch
Mr. A.J. Ede	Head, Systematic Botany Branch
Mr. W.I. Wilson	Technical Officer, Cereal Seeds
Mr. G. Mann	Officer for Cereal Trials
Mr. W. Smeaton	Officer for cereal trials
Mr. L.A. Willey	Officer for Fodder and Root Trials

Plant Breeding Institute - Cambridge

Dr. R. Riley	Director
Mr. J. Bingham	Wheat Breeding
Dr. J. Whitehouse	Barley Breeding
Dr. G. Sage	Wheat Physiology
Dr. A. Taylor	Plant Pathology
Dr. R. Johnson	Plant Pathology

R.H.M. Agricultural Industries - Dunmow Essex

Mr. A. Nicholls	Arable Marketing Manager
Mr. C.G. Hervey-Murray	Cereal Seed Production Adviser
Mr. D. Whitton	Crop Development Officer

Rothwell Plant Breeders - Rothwell, Lincolnshire

Mr. D. Neale	Marketing Director
Mr. M. Summers	Cereals Marketing Manager
Mr. J. Morrison	Senior Cereals Adviser

National Seed Development Organisation Ltd. - Cambridge

Mr. J.P. Newby	Cereal seed production officer.
----------------	---------------------------------

APPENDIX (Contd.)Welsh Plant Breeding Station - Aberystwyth, Wales

Dr. J.D. Hayes	Head Arable Crop Breeding Section
Dr. J. Habgood	Cereal Breeding
Dr. D.A. Lawes	Arable Crop Breeding
Mr. R. Griffiths	Trials Officer
Dr. P.L. Catherall	Plant Pathology
Mr. R. Simmons	Plant Pathology
Mr. R.W. Welch	Chemistry
Mr. R. Pickering	Trials Officer

U.S.A.Kansas State University - Manhattan, Kansas

Dr. E. Heyne	Wheat Breeding
Mr. E. Walter	Co-ordinator of Cultivar Trials
Mr. C. Overly	Foundation Seed Officer
Mr. L. Burchette	Secretary Kansas Crop Improvement Association.

United States Grain Marketing Research Centre - Manhattan, Kansas

Dr. C.A. Watson	Director
Mr. G.D. White	Head, Stored Products-Insects Research Unit.
Mr. G.H. Foster	Head, Grain Handling, Conditioning and Storage Research Unit.
Mr. K.F. Finney	Head, Hard Winter Wheat Quality Research Unit.

University of Nebraska - Lincoln, Nebraska

Dr. V.A. Johnson	Wheat Breeding
Dr. J. Schmidt	Wheat Breeding
Dr. P.J. Mattern	Cereal chemistry
Dr. S. Nelson	Agricultural Engineering
Dr. L.T. Palmer	Extension Plant Pathologist
Mr. R.N. Mills	Manager, Foundation Seed Division
Mr. D. Lancaster	Director, Nebraska Crop Improvement Association.

North Dakota State University - Fargo North Dakota

Dr. J.F. Carter	Chairman, Agronomy Department
Dr. J.R. Erickson	Hard Red Winter Wheat Breeding
Dr. R.C. Froberg	Hard Red Spring Wheat Breeding
Mr. D.C. Ebeltoft	Seed stocks Specialist
Dr. K. Lucken	Hybrid Wheat and Cytogenetics
Dr. J. Quick	Durum Wheat Breeding
Dr. L.R. Joppa	Durum Breeding and Cytogenetics
Dr. E.L. Deckard	Cereal Physiology
Dr. N.D. Williams	Wheat Genetics
Dr. G.S. Smith	Oat Breeding
Dr. G.A. Peterson	Barley Breeding

APPENDIX (Contd.)North Dakota State University (Contd.)

Mr. O.J. Banasik	Head, Cereal Chemistry
Dr. C. McDonald	Cereal Chemistry
Dr. L. Nelson	Cereal Chemistry
Mr. H.D. Wilkins	Extension Agronomist

CanadaCanadian Seed Growers Association - Ottawa, Ontario

Mr. E.T. McLaughlin	Manager/Secretary
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University of Manitoba - Winnipeg, Manitoba

Dr. G.M. Young	Head, Agronomy Department
Dr. L.E. Evans	Wheat Breeding
Dr. J. Clarke	Cereal Chemistry

Canadian Department of Agriculture - Winnipeg, Manitoba

Dr. W.C. McDonald	Director
Dr. A.B. Campbell	Hard Red Spring Wheat Breeding
Dr. D. Liesle	Durum Wheat Breeding
Dr. R.I.M. McKenzie	Oat Breeding
Dr. P.M. Metcalfe	Barley Breeding (2 row)
Dr. K.W. Buchanan	Barley Breeding (6 row)
Dr. V.M. Bendelow	Cereal Chemistry
Dr. J.T. Mills	Plant Pathology

Canadian Grain Commissioners, Grain Research Laboratories -
Winnipeg, Manitoba

Mr. M.M. Ainslie	Chief Grain Inspector
Mr. A. Schaen	Deputy Assistant Chief Grain Commissioner
Dr. P. Williams	Chemistry Department

University of Saskatchewan - Saskatoon, Saskatchewan

Dr. H.M. Austenson	Cereal Agronomist
Dr. G.M. Simpson	Director Crop Development Centre
Dr. G. Hughes	Wheat Breeding
Dr. B. Harvey	Barley Breeding
Dr. F.W. Sosulski	Cereal Chemistry
Mr. R.S. Bhattu	Cereal Chemistry

Canadian Department of Agriculture - Saskatoon, Saskatchewan

Dr. J.E.R. Greenshields	Director
Dr. R. Knowles	Crop Breeding
Dr. W.L. Crowle	Wheat Agronomist
Dr. R. Tinline	Plant Pathology
Dr. G.R. Stringham	Oil Seed Cytogenetics

APPENDIX (Contd.)U.S.A.Washington State University - Pullman Washington

Dr. R.E. Allan	Research Geneticist
Dr. C.J. Peterson	Wheat Breeding
Dr. R.E. Witters	Crop Physiology
Mr. J. Walters	Senior Technician
Dr. G.L. Rubenthaler	Cereal Chemistry
Mr. D.W. George	Cereal Chemistry

Oregon State University - Corvallis, Oregon

Dr. C.R. Cowan	Head, Agronomy Department
Dr. W. Kronstad	Wheat Breeding, Physiology
Dr. N. Goetze	Cereal Extension Specialist
Dr. R.J. Metzger	Wheat Breeding
Dr. C. Graebe	Seed laboratory
Dr. D.H. Brewer	Seed Certification Specialist
Dr. R.J. Redden	Wheat Breeding (CIMMYT)

University of California - Davis, California

Dr. P.F. Knowles	Chairman, Agronomy Department
Dr. C.W. Schaller	Barley Breeding
Dr. C.O. Qualsett	Wheat Breeding
Mr. J.D. Prato	Extension Agronomist
Mr. F. Parsons	Secretary, Crop Improvement Association
Mr. R. Ball	Manager, Crop Improvement Association.

MexicoCIMMYT - Mexico City

Dr. N.E. Borlaug	Director, Wheat Programme
Dr. R.G. Anderson	Associate Director, Wheat Programme
Dr. K.W. Finlay	Deputy Director General Special Programmes
Dr. F.J. Zillinsky	Triticale Breeding
Dr. M. Kohli	Triticale Breeding
Dr. M. Alacla	Overseas nurseries
Dr. S. Rajaram	Wheat Breeding - Pathology
Dr. M.A. Quinones	Durum Breeding
Dr. M. McMahon	Weed Control
Dr. R.A. Fischer	Wheat Agronomy - Physiology.