TRITICALE

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## Contents

<table>
<thead>
<tr>
<th>Topic</th>
<th>Authors</th>
<th>Pages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Foreword</td>
<td>W. David Hopper</td>
<td>5–7</td>
</tr>
<tr>
<td>List of Participants</td>
<td></td>
<td>8–11</td>
</tr>
<tr>
<td>Historical review of the development of triticale</td>
<td>Arne Müntzing</td>
<td>13–30</td>
</tr>
<tr>
<td>Development of triticales in Western Europe</td>
<td>E. Sanchez-Monge</td>
<td>31–39</td>
</tr>
<tr>
<td>Triticale-breeding experiments in Eastern Europe</td>
<td>Á. Kiss</td>
<td>41–50</td>
</tr>
<tr>
<td>Research work with 4x-Triticale in Germany (Berlin)</td>
<td>K.-D. Krolow</td>
<td>51–60</td>
</tr>
<tr>
<td>Triticale research program in the United Kingdom</td>
<td>R. S. Gregory</td>
<td>61–67</td>
</tr>
<tr>
<td>Progress in the development of triticale in Canada</td>
<td>E. N. Larter</td>
<td>69–74</td>
</tr>
<tr>
<td>Triticale: its potential as a cereal crop in the United States of America</td>
<td>R. J. Metzger</td>
<td>75–80</td>
</tr>
<tr>
<td>The triticale improvement program at CIMMYT</td>
<td>F. J. Zillinsky</td>
<td>81–85</td>
</tr>
<tr>
<td>Prospects of triticale as a commercial crop in India</td>
<td>J. P. Srivastava</td>
<td>87–92</td>
</tr>
<tr>
<td>Triticale breeding experiments in India</td>
<td>N. S. Sisodia</td>
<td>93–101</td>
</tr>
<tr>
<td>Triticale research program in Iran</td>
<td>M. A. Vahabian</td>
<td>103–105</td>
</tr>
<tr>
<td>Triticale research program in Ethiopia</td>
<td>F. Pinto</td>
<td>107–115</td>
</tr>
<tr>
<td>Triticale research program in Algeria</td>
<td>Herb Floyd</td>
<td>117–119</td>
</tr>
<tr>
<td>Triticale program and potential in Kenya</td>
<td>B. A. Nganyi Wabwoto</td>
<td>121–124</td>
</tr>
<tr>
<td>Triticale breeding experiments in Chile</td>
<td>Patricio C. Parodi</td>
<td>125–128</td>
</tr>
<tr>
<td>Expanding the CIMMYT outreach programs</td>
<td>R. G. Anderson</td>
<td>129–135</td>
</tr>
<tr>
<td>Meiotic, gametophytic, and early endosperm development in triticale</td>
<td>Michael D. Bennett</td>
<td>137–148</td>
</tr>
<tr>
<td>Improving seed formation in triticales</td>
<td>F. J. Zillinsky</td>
<td>155–157</td>
</tr>
<tr>
<td>Univalency in triticale</td>
<td>P. J. Kaltsikes</td>
<td>159–167</td>
</tr>
<tr>
<td>Cytogenetics of hexaploid triticale</td>
<td>Arnulf Merker</td>
<td>169–172</td>
</tr>
<tr>
<td>Use of chromosome analysis to detect favourable combin-</td>
<td>M. H. de Sosa</td>
<td>173–180</td>
</tr>
</tbody>
</table>
Preliminary report on the cytogenetics of tetraploid × diploid wheat crosses  
R. J. Metzger and B. A. Silbaugh  
181–185

Triticale diseases review  
Santiago Fuentes Fuentes  
187–192

Triticale diseases in CIMMYT trial locations  
M. J. Richardson and J. M. Waller  
193–199

Agronomy and physiology of triticales  
R. A. Fischer  
201–209

Early steps on triticale breeding at CIMMYT  
Marco A. Quiñones  
211–212

Introduction of new forms and types from wheat and triticale  
Ing. Ricardo Rodríguez  
213–215

Extending adaptability and sources of new genetic variability in triticale  
M. M. Kohli  
217–226

Production of triticale germ plasm  
J. Perry Gustafson  
227–233

Broadening of the triticale germ plasm base by primary hexaploid triticale production  
Armando Campos Vela  
235–236

Nutritional value of triticales as high-protein feed for poultry  
James McGinnis  
237–240

Comparison of the vole, rat, and mouse as assay animals in the evaluation of protein quality  
B. E. McDonald and E. N. Larter  
241–246

Future role of triticales in agriculture  
L. H. Shebeski  
247–250
The Triticale Improvement Program at CIMMYT

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Abstract A triticale program was started at CIMMYT by Dr N. E. Borlaug in 1964 in cooperation with the University of Manitoba. The program was initially funded by the Rockefeller Foundation and in 1971 the Government of Canada undertook complete funding of an expanded program. The major objective was to improve food production and nutrition in the developing countries.

An important advance in triticale improvement occurred with the development of the Armadillo strains. Highly fertile selections from an outcross between triticale and Mexican dwarf wheat contributed greatly to the yield, disease resistance, and nutritional quality of the crop. The plants were day-length insensitive, had an erect growth habit, and one gene for dwarfing.

More resistance to lodging had to be introduced for high production conditions. The sources of dwarfing were the Mexican wheats with the Norin dwarfing genes, Snoopy rye, a dwarf spring rye, and a dwarf triticale possessing a Tom Thumb dwarfing gene developed by Dr Arpad Kiss, Hungary.

New dwarf strains possessing the Armadillo genes for fertility and better resistance to diseases are approaching the yields of the most productive dwarf wheats in Mexico. Reports on triticale performance from international trials indicate that triticale strains are already competitive with other cereals in some regions. Among these are: (1) sandy soils with moderate rainfall in Europe and Mexico; (2) areas of high elevation and high moisture, such as Kenya, Ethiopia, Northern India, and South America; (3) under growing conditions where the night temperatures regularly fall below freezing but rise sufficiently during the day to produce growth.

Most of the reports on quality evaluation indicate that triticale strains are generally higher in protein and have a better amino acid balance than wheat. Bioassays on meadow voles, rats, chicks, and laying hens show that most strains of triticale support good growth and produce a relatively high growth efficiency index. Indications of growth inhibitors have been reported from bioassays studies and from chemical determinations. The importance of these compounds in the grain has not been determined.

Research on utilization of triticale as human food is in progress in many countries. The present strains of triticale do not produce a bread loaf of equal volume and identical texture to that of the best bread wheats. However, in mixtures with bread wheat, and with modification of techniques, bread of satisfactory appearance, taste, and keeping quality can be produced. Research on production of food products in the developing countries has indicated that chapatis, injera, and tortillas of acceptable quality can be made from triticale.
To help utilize triticale for production in developing countries CIMMYT is increasing its effort in training scientists for national programs, assigning staff to specific regions, gathering information on production practices, and distributing seed to cooperators in many countries.

Résumé C'est en 1964 que Monsieur N. E. Borlaug a lancé le programme triticale du CIMMYT, en collaboration avec l'Université du Manitoba. Ce programme fut financé au départ par la Fondation Rockefeller, puis, en 1971, le gouvernement du Canada a pris à sa charge le financement total d'un programme élargi dont l'objectif principal est l'amélioration de la production alimentaire et de la nutrition dans les pays en voie de développement.

La création des souches Armadillo a marqué un progrès important dans l'amélioration du triticale. Des sélections à haute fertilité, obtenues à partir d'un croisement triticale/blé nain mexicain, ont énormément contribué à l'amélioration du rendement, de la résistance aux maladies et de la valeur nutritive du triticale. Les plants obtenus étaient insensibles au rythme nyctéméral, avaient un port érigé et comportaient un gène nanissant.

L'accroissement du rendement a nécessité l'introduction du caractère résistance accrue à la verse. Les transmetteurs du nanisme étaient des blés mexicains, possédant les gènes nanisants Norin, le seigle Snoopy, seigle nain de printemps, et un triticale nain possédant le gène nanissant Tom Pouce, créé en Hongrie par M. Arpad Kiss.

Les nouvelles souches naines possédant les gènes de fertilité Armadillo, en même temps qu'une meilleure résistance aux maladies, ont des rendements voisins de ceux des blés nains les plus productifs du Mexique. Les compte-rendus sur les essais internationaux de triticale indiquent que ces souches de triticale sont déjà, dans certaines régions, concurrentielles par rapport aux autres céréales. Cela concerne en particulier: (1) les régions d'Europe et du Mexique à sol sableux et pluviométrie modérée; (2) les régions d'altitude très humides comme il en existe au Kenya, en Ethiopie, dans le nord de l'Inde et en Amérique du Sud; (3) les régions où la température nocturne tombe régulièrement en dessous du point de congélation mais où la température diurne s'élève suffisamment pour permettre la croissance.

Selon la plupart des compte-rendus d'appréciation qualitative, les souches de triticale ont en général une teneur en protéine et un équilibre des acides aminés supérieurs à ceux du blé. Les essais biologiques effectués sur campagnols, rats, poulets, et pondesuses démontrent que la plupart des souches de triticale sont favorables à la croissance et ont un indice de taux de croissance relativement élevé. L'étude des essais biologiques et les déterminations chimiques ont indiqué l'existence d'inhibiteurs de croissance, mais on n'a pas pu encore déterminer dans les grains l'importance de ces éléments.

De nombreux pays effectuent actuellement des recherches sur l'utilisation du triticale pour l'alimentation humaine. Les souches actuelles de triticale ne permettent pas de réaliser des pains d'un volume et d'une texture identiques à ceux obtenus à partir des meilleurs blés de panification. Il est cependant possible, en mélangeant le triticale à du blé et en modifiant les techniques de panification, d'obtenir des pains d'aspect et de saveur satisfaisants et qui se conservent bien. Selon les recherches sur les produits alimentaires effectuées dans les pays en voie de développement, il est possible de fabriquer à partir du triticale des chapatis, du ndjira, et des tortillas de qualité acceptable.

Afin de promouvoir l'emploi du triticale au stade de la production dans les pays en voie de développement, le CIMMYT accroît ses initiatives visant à la formation de chercheurs pour les programmes nationaux, affecte des cadres à des régions précises, rassemble des renseignements sur les méthodes de production et distribue des semences aux intéressés dans de nombreux pays.

The CIMMYT triticale program was initiated by Dr. N. E. Borlaug in 1964 in cooperation with the University of Manitoba. The project was initially funded by the Rockefeller Foundation but in 1971, the Government of Canada undertook the complete funding for
an expanded program at CIMMYT with the University of Manitoba collaborating. The major objective of the triticale program was to produce a crop competitive with other cereals for the developing nations.

The early breeding efforts were focussed on introducing day length sensitivity and disease resistance into triticales from the Mexican bread wheats. A major advance in triticale improvement came in 1968 with the isolation of highly fertile strains, which were labeled Armadillo. Armadillo arose as a spontaneous outcross to a Mexican dwarf bread wheat, and carries genes for day length insensitivity, erect growth habit, improved seed type, and nutritio nal quality, as well as one gene for dwarfing and resistance to disease. Yield increases of 50–60% were obtained with these strains over the best strains previously available in Mexico.

Improving Resistance to Lodging

Three important sources of genetic dwarfing were used to improve lodging resistance: (a) the Norin genes previously used in the bread and durum wheats; (b) a dwarf rye "Snoopy" isolated from an open pollinated population of Gator received from Dr Darrell Morey, Tifton, Georgia; (c) triticale dwarfs obtained from Dr Arpad Kiss, of Kesckemet, Hungary, possessing Tom Thumb dwarfing genes.

A wide range of plant heights have been obtained among the triticales. We have experienced difficulty in maintaining the high fertility of Armadillo among selections possessing three dwarfing genes. Two gene dwarfs have been produced, such as Cinnamon, that are more resistant to lodging and more productive than Armadillo under conditions of intensive production.

Diseases on Triticales

In Mexico triticales are hosts to the same pathogens that attack wheat and rye. Some of these are more serious on triticale than on wheat, such as yellow dwarf, bacterial stripe, snow mold, and leaf rust. Other pathogens, such as stem rust, stripe rust, scab, loose smut and bunt, find triticale a less suitable but still susceptible host. Diseases, such as ergot, foot rot, etc., cause serious damage to triticales in other countries but as yet have not been a problem in Mexico. At the present time control measures are limited to screening for resistance in the Mexican nurseries and in screening nurseries sent to cooperators in numerous countries. A triticale nursery containing about 100 entries and having the best resistance to diseases common in Mexico will be distributed in 1974.

Yield Improvement

The yielding capacity of triticales has improved continuously since the first yield tests were established in Mexico in 1967–68. At that time the best strains produced about one-half as much grain as the Mexican dwarf bread wheats. The development of strains, such as Armadillo and Cinnamon, have improved yields considerably and are now within 90% of those of the best wheat varieties. Further yield increases in triticale are expected with the addition of genes for tillering, additional dwarfing, and better grain test weight.

Broadening the Adaptation

Triticale strains distributed from CIMMYT in the first international trials were generally poorly adapted to conditions outside of Mexico. This was particularly evident in regions above 35° north and south latitude. Selecting in segregating populations at two widely differing environments in Mexico, the Toluca Valley and the Yaqui Valley, has helped broaden the adaptation of the newer strains. Further improvement is expected from utilizing, as parents, selections made by numerous cooperators in repeated cycles of hybridization and selection.

The adaptation of triticale lines to certain specific environments is very encouraging. It appears that triticale strains have specific adaptation to three distinct environments:
(a) in areas where temperatures approach or reach the freezing point during the early growth period — such conditions occur in the southern United States and south central Europe during the winter season; (b) in high elevation areas found in Ethiopia, Kenya, India, Mexico, and Colombia, where triticale strains are competitive with other cereals; (c) in sandy soils under moderate rainfall, which also appear to favor triticale. Reports of favorable performance of triticale on sandy soils have been received from Hungary, Spain, and Mexico.

**Nutritional Quality**

Dr Eva Villegas is in charge of the chemical and nutritional evaluation of the grain. Screening for better protein quality is done by making a rapid DBC analysis. This identifies lines having either a high protein content or a high per cent lysine. Lines having high DBC values are then evaluated for protein and lysine content.

Bio-assays with meadow voles and chicks have been used as early screening for nutritional quality by Drs Fred Elliott, Michigan State University, James McGinnis, Washington State University, and Reinald Bauer, CIMMYT. Although the voles appeared to have merit as a screening technique requiring small quantities of grain and short feeding periods per assay, they tend to have too wide a variation in growth response among animals and they discriminate against corn in favor of wheat and triticale. Chicks on the other hand require more grain and their protein requirement is too high to be satisfied from cereal grains and must be supplemented. Both meadow voles and baby chicks are sensitive to growth-inhibiting substances in diets and can be used effectively to screen against samples containing such compounds.

**Utilization of Triticale**

Triticale appears to be suitable as a forage crop or feed grain. A high proportion of the 200,000 acres of triticale grown in the USA is used for grazing or cut as forage for livestock. As a feed grain triticale is equal to, or better than wheat for poultry and probably for swine. Early feeding trials showing adverse effects of triticale as a feed grain may have been influenced by contamination of the grain with ergot.

As human food, triticale does not equal wheat in total extraction of flour nor does it produce bread of equal loaf volume. Utilization research in India and Ethiopia indicates that chapatis and injera of quality equal to that of wheat can be made from triticale. Experiments at CIMMYT have shown that tortillas of acceptable taste and quality can be made from triticale. Some strains of triticale appear to have high enzymatic activity. The commercial distillation of alcoholic beverages from triticale grain is already underway in some countries.

A serious drawback in the current triticales is the shrunken appearance and low test weight of the grain. Screening for better seed quality is being done by visual and mechanical means in the segregating generations.

**Agronomic Research**

Triticale is now approaching a stage of development where it will enter commercial production in competition with other cereals. There is a need to develop production practices to obtain optimum yields. Information is also required to determine the environmental limitations of the available strains for commercial production. Dr Matthew McMahon joined the triticale staff in 1973 to provide the answers and to develop production techniques. His investigations will also include the tolerance of triticale strains to herbicides, saline soils, sandy soils, and drought conditions. During the next cycle an experiment will be conducted on the competitive position of triticale as a substitute crop for wheat or sorghum as a feed grain for poultry and hogs.

**Cytological Research**

During the past year, two staff members have been acquired to conduct cytological
research on triticales. Dr Arnulf Merker and Mrs Margarita Sosa were both trained on triticale cytology at the Institute of Genetics, University of Lund, under Dr Arne Müntzing. Their work will be directed mainly to the routine determination of chromosome numbers, meiotic stability, and occurrence of aneuploidy in triticale breeding material. Cytological research will also be directed toward the development of techniques for identifying chromosomes of different progenitors so that material from wide crosses can be characterized cytologically.

**Triticales on the International Scene**

Since the triticale program is directed toward improving food production in developing countries, it is necessary to encourage the utilization of triticales in national programs. This involves: (1) the training of scientists in breeding, production, and extension practices to develop programs in their own countries; (2) the cooperation with other agencies such as IDRC, FAO, etc., who are encouraging the development of triticale production in developing nations; (3) the distribution of triticale strains and segregating material to cooperating institutions and government programs; (4) the development of a package of production practices that can be used as a starting point in the production of triticales where scientific capabilities in national programs are limited; (5) in some countries or regions the assigning by CIMMYT of expatriate staff to help governments establish programs for the commercial utilization of triticales.