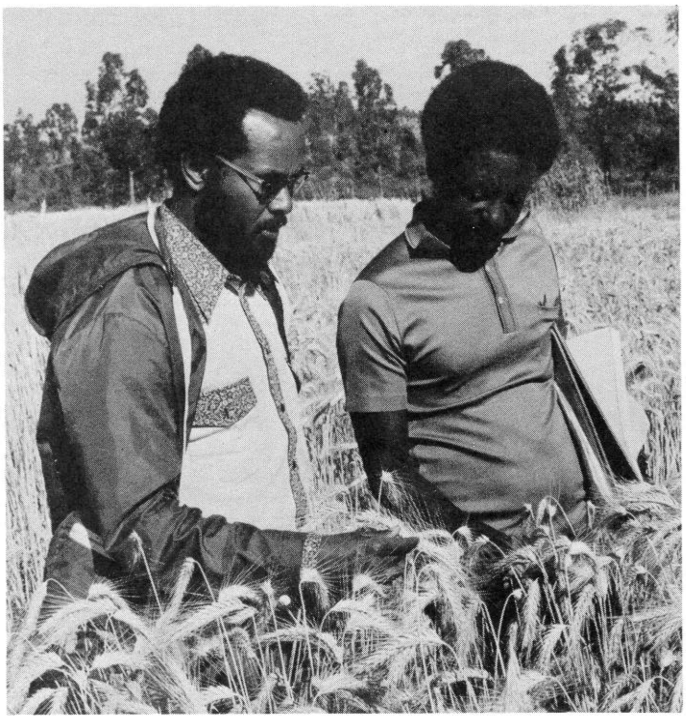


TRITICALE:

Closing the gap between scientist and farmer

Bob Stanley

As Nobel Prize-winning scientist Norman Borlaug tells it, it was near dawn one warm March Mexican night in 1967 when capricious mother nature played one of those tricks that help to keep scientists humble.

"While scientific man was still in bed," says Borlaug, "one promiscuous, venturesome stray wheat pollen grain with a potent and valuable 'genetic load' from the nearby wheat breeding plots floated across the road under cover of darkness and fertilized a sad but permissive tall, sterile, degenerate triticale plant."

Even couched in such unscientific language, it does not sound like a particularly significant event. But, says Borlaug, it was the "largest and most important step" down the long road of triticale research. One year and two generations later the scientists began noticing some unusually promising plants in their triticale plots — plants resulting from that "illicit" cross and exhibiting many of the characteristics that decades of intensive research had been unable to produce.

Ruefully, Borlaug adds: "This seems to me to be nature's way of telling scientists not to become too arrogant."

Yet for all that, triticale represents a remarkable scientific achievement. It is the first truly "man-made" cereal plant. A cross between wheat and rye, it combines the high yield and nutritional value of one with the hardiness and adaptability of the other — and it is now showing the potential to outshine both in all departments. To understand the lengthy development of triticale (the word comes from the generic names of wheat and rye, *Triticum* and *Secale,* and is pronounced "trit-ee-kay-lee") and to appreciate the significance of that Mexican accident, it is necessary to go back 100 years — to Scotland.

It was there that botanist A. Stephen Wilson produced the first known cross between wheat and rye, reporting to the Edinburgh Botanical Society that, while the plant exhibited some of the properties of both its parents, it was unfortunately sterile. The first fertile cross was made in 1888 by a German breeder named Rimpau. However, the plant was a reluctant breeder and poor in appearance, and was thus regarded as little more than a curiosity for almost another 50 years.

Finally, in 1937 came the first breakthrough. A French scientist, Pierre Givaudron, developed a technique for doubling the chromosones of sterile triticales (the name had been officially adopted two years earlier) by treating the hybrid seedlings with an alkaloid solution called colchicine. Givaudron's discovery made possible the routine production of fertile triticales, and opened the door to the development of a new potential cereal crop.

All that remained, then, was the painstaking process of breeding improved varieties of the new cereal — a process that in wheat required from 20,000 to 30,000 years! Triticale is not a single plant, like many other members of the grass family it is capable of an almost infinite number of variations. Like good detectives the plant breeders must use a combination of science, intuition and luck to breed in the desired characteristics and breed out the undesirable ones.

Much of the pioneer work in the "modern era" of triticale research was done in Canada at the University of Manitoba, beginning in 1954. Bringing together the world's first comprehensive collection of primary (first generation) triticales, the Manitoba team began producing scores of new varieties. This marked the beginning of an unprecedented international research effort to bring triticale to the point of successful commercial production. In 1963 began a program of cooperation between the Manitoba group and the Centro Internacional de Mejoramiento de Maiz y Trigo (CIMMYT), the international maize and wheat improvement centre in Mexico, where Borlaug had developed the dwarf wheat strains that won him the Nobel Prize.

The problems facing the researchers were formidable. While it was generally resistant to rust, triticale proved to be susceptible to a variety of other diseases. It had inherited rye's ability to withstand cold, altitude and poor, sandy, acidic soils, but its yield was barely half that of the best wheats. It also tended to produce a shrivelled, malformed seed, and under the Mexican sun the Northern-bred plants would grow impossibly tall, and eventually fall over.

Nature lent science a hand in 1967 with that freak cross between a dwarf Mexican wheat and a triticale known only as X308, resulting in a new strain now known as Armadillo. The scientists were quick to capitalize on the happy accident, and advanced Armadillo strains proved to be superior in almost every way to earlier triticales, leading the way with higher yields, shorter straw length and improved nutritional quality. Much has also been done to solve the problem of shrivelled seeds, and the new varieties are also free of ergot, a poisonous fungus that affected some of the earlier varieties.

Today Dr Edward Larter, who heads the Manitoba research team, is able to say that, in a scientific sense, there are no major obstacles left to be overcome. Not that the work is complete — far from it. There is still plenty of room for improvement, says Dr Larter, and he predicts that within five years many of the new lines currently being developed will easily outproduce today's crops.

The same optimism is echoed by Dr Leonard Shebeski, the University of Manitoba's dean of agriculture, who points out that as far back as 1973 their top triticales were outyielding top feed wheats. He foresees triticale in serious competition with bread wheats as one of the world's most important food crops within a dozen years.

At CIMMYT in Mexico, Dr Frank Zillinsky sees the most important work now as the development of the most rugged, high-yielding varieties to provide more food for the world's hungry people, and getting those varieties into the fields of farmers in the developing countries. "We've got to close the gap between the scientist and the farmer," he says. "Here learned papers don't mean a thing. All that counts is to produce food."

To fulfill Zillinsky's vision, however, meant finding some way to compensate for triticale's lack of natural evolution: in a matter of a few decades it had not had the opportunity to develop the versatility that other plants had acquired through thousands of years of constant cultivation. As a result it would do well in test plots in a controlled environment, but adapted poorly to changes in latitude and climate. In 1969 CIMMYT began an international triticale testing program, which received a boost two years later when the Canadian International Development Agency (CIDA) put up $3.25 million to be used for the development of triticale as a food crop for the countries of the Third World. The newly-formed IDRC was asked to manage the program.

By 1975 CIMMYT had cooperators in 73 countries, 338 trials were being carried out, and the demand for seed far outstripped the supply. The result has been an evolutionary shortcut that in just five years has provided a vastly expanded gene pool and a remarkable improvement in triticale's ability to adapt to environments as widely different as the arid lands of the Middle East or the foothills of the Himalayas.

Food technologist at the Holetta Research Station in Ethiopia conducts triticale protein analysis.

Today the IDRC in cooperation with CIMMYT and the University of Manitoba, supports a worldwide network of projects concerned with all aspects of triticale research, from agnonomy and nutrition to utilization and information.

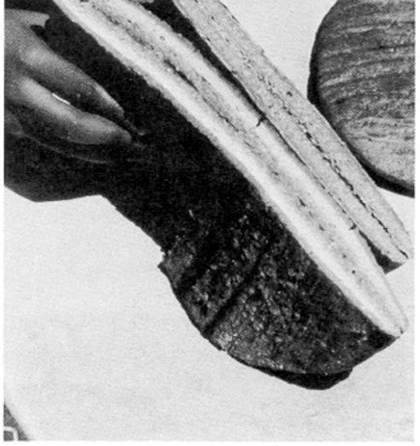
Perhaps nowhere is the need for increased self-sufficiency in food more urgently felt than in India, and it would be hard to find a more challenging testing ground for triticale than the Himalayan region of northern India. The agro-climatic conditions vary enormously. Farms are to be found at altitudes ranging from 2,000 feet to 10,000 feet. Annual rainfall may vary from a few inches up to 10 feet, but most of it falls in the monsoons, not in the growing season. Soil types vary from acid to alkaline. Little wonder, then, that yields of cereals such as wheat and barley have been persistently low in unirrigated areas of the plains and the hills, or that triticale, with its potential for drought resistance, hardiness and high yields, should appeal to Indian agriculturalists in the region.

In 1974 the Indian Council of Agricultural Research (ICAR) asked for the IDRC's support in expanding an existing small-scale triticale improvement program. They had already demonstrated that a number of triticales could outyield some bread wheats under these conditions. The three-year project, now well under way, is aimed primarily at improving the standard of living of the small farmers who make up the bulk of the population in the region.

A wide range of spring and winter triticales is being tested under varying conditions, with the objective of producing lines that are high-yielding, disease resistant and nutritionally superior to traditional local grains. In addition, triticales that can do well here must be able to compete economically with other crops, and the flour produced should be suitable for making *chapati*, the unleavened bread that is a staple in many Indian homes.

This emphasis on the use of triticale in the home is best seen in Ethiopia, where, in addition to breeding, testing and selecting new varieties, researchers at the Holetta Research Station have experimented with the preparation of local foods. Triticale has been substituted for the traditional ingredients in products such as *enjera* and *kemuse*, local forms of bread, and triticale has been made

Ethiopia — kemuse made the traditional way, and with the addition of triticale flour.



Ethiopian family enjoys a meal prepared from triticale: they won't feel hungry again quite so soon.

available to families in the area to be tested in their own kitchens.

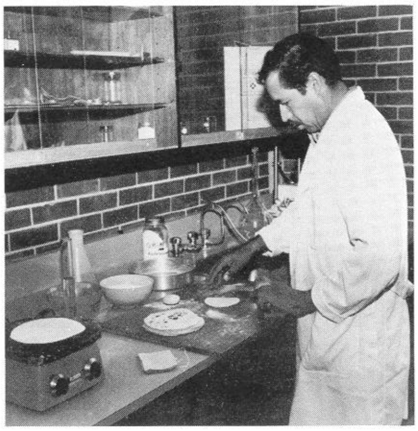
This combination of laboratory and home trials has produced encouraging results, and the people generally find the new products to be better than those they had been used to. Most important in an area where wheat is a marginal crop and malnutrition is widespread, families reported that after eating a meal prepared from triticale they did not become hungry again as soon as they would after a meal of traditional foods.

The project is now in its second phase, and although it is supported by IDRC funds, is run entirely without expatriate help. As work continues in breeding the most promising varieties for Ethiopia's ecological conditions, training local scientists and managers and developing new products, it may well be that Ethiopia will become the first developing country where triticale is accepted as a commercial cereal crop.

The commercial success of triticale, however, will depend to a large extent on its resistance to disease — particularly to rust, a fungal parasite that infects many plants, including wheat. The IDRC's Director of agriculture, food and nutrition sciences, Joseph Hulse, describes neighbouring Kenya as "a natural rust laboratory, since nowhere on earth are more species of rust fungi known to exist." Kenya was therefore an ideal location to develop rust-resistant varieties for the international triticale network.

At the National Plant Breeding Station at Njoro in the Kenyan Highlands, scientists deliberately innoculate promising triticale seedlings with rust spores. Those that exhibit the best resistance undergo yield trials. New varieties arriving from CIMMYT and Manitoba are subjected to similar treatment. It is simply survival of the fittest, and the attrition rate is high — of 1,600 varieties tested since 1974, just 62 superior varieties advanced to preliminary yield trials. Of the 161 outstanding varieties included in the 1975-76 preliminary trials, 17 produced excellent results and will be tested next season in the national yield trials.

If the project can produce rust-resistant varieties, triticale could be grown with far less risk in many parts of Kenya where wheat is presently established, and also penetrate into the regions at higher altitude or with poorer soils where wheat is at best a marginal crop. Equally important, the samples of the most resistant varieties returned to



Experimenting with tortillas made from triticale flour at CIMMYT.

CIMMYT become valuable additions to the international triticale network.

Around the world the effort continues, and there is now little doubt in the minds of most researchers that it is only a matter of time before triticale becomes as familiar as other cereals on the world's grain markets. More important, it should become equally familiar in the chapatis and enjera breads of the developing countries — opening up marginal farmlands and providing much needed additional protein for the millions of people in rural areas for whom malnutrition is a normal state of existence.

If that sounds overly optimistic, consider the words of Dean Shebeski, of Manitoba, who has worked with triticale for more than 20 years. He told an international triticale symposium in Mexico three years ago: "Over the next 15 years yields of triticale will improve much more rapidly than wheat, and should plateau at a level approximately 50 percent higher than those of wheat.

"This is no idle speculation. Surely the phenomenal improvement that has taken place in triticale in 10 short years ....should clearly indicate that with rapidly expanding programs and a quickly widening genetic base, with improved fertility and seed density, with improving worldwide cooperation, the improvement over the next 15 years will greatly surpass all improvements that so far have been attained."

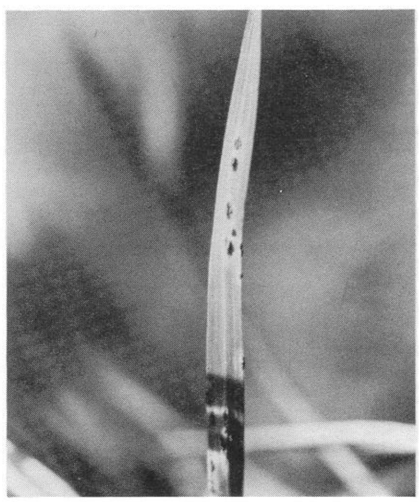
There is one futuristic footnote to the triticale story. According to all the basic biology courses, wide crosses such as that between wheat and rye are all but certain to be as sterile as mules. The development of fertile triticale showed that this particular "law of nature" could be at least bent, if not broken, and in doing so it opened up new vistas for plant scientists.

At the Prairie Research Laboratory in Saskatoon, Canada, the IDRC is funding an attempt to produce a fertile cross between sorghum and maize, a cross that would combine sorghum's remarkable resistance to drought and poor soils with the high yields and pest resistance of maize. Both plants are staples in many parts of the Third World, and there have been numerous attempts to produce a fertile hybrid in the past — all unsuccessful.

The Prairie Research Laboratory, however, has developed a new technique that has already been successful in producing hybrid cells of soybean-barley, pea-carrot and rapeseed-soybean on an experimental scale. It is the stuff that science-fiction is made of. But then there is triticale, living proof that today's science-fiction might just become tomorrow's matter-of-fact. □

Dr Geoffrey Mathenge innoculates triticale seedlings with rust spores at the National Plant Breeding Station at Njoro, Kenya.

Seedling attacked by rust: survival of the fittest.



Photos: Neill McKee