# Plant Science in the Next Century

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Contemplation of the future of plant agriculture in the next century is exciting. A great many things happened during the 1990s and progress is expected to continue apace in the 2000s. Some of the events that impacted plant agriculture during the 1900s include the rediscovery and application of Mendelian genetics, the change from horse driven to mechanized machinery, the development of hybrid corn, advent of private seed companies, use of fertilizer, use of pesticides, concern about dietary intake, advent of biotechnology, search for new uses of present crops, and search for uses of new crops which may be adapted to the area.

Technology will continue to have a major influence on the direction that agriculture follows. Information will become more critical to farmers and they will need greater access to private and public consultants to help make decisions. Consultants will need up-to-date information regarding varieties or hybrids, planting dates, planting methods, fertilizer recommendations, pesticide application, and pest monitoring to make their recommendations on. The recommendations will be based on information resulting from research by university and private company scientists.

Farmers will need to maintain records on the history of each field, including crop and variety produced, soil fertility level before and after addition of fertilizer, amount and date of any pesticide applied, and yield records. All fertilizer and pesticide applications will need to be cleared through a monitoring agency and the amount applied will be limited by law. Crop rotations will need to be managed to reduce soil erosion as much as possible. These restrictions will reduce the probability that the soil or crop is treated with excess amounts of fertilizer or pesticide, residues of which may end up in groundwater or the food chain.

Plant breeders have been very successful in improving many crop species. These improvements have been related to grain yield, crop maturity, plant height, kernel size and weight, resistance to lodging and shattering, quality, and pest resistance. Quality means different things for different crops, but may include factors like protein content, oil content, starch content, enzymatic activity, sugar content, loaf volume, storability, product color and palatability, and dough mixing properties. Pests include numerous diseases, insects, and weeds, and breeders work with pathologists and cereal chemists to develop varieties with resistance to diseases, insects, and herbicides. The North Dakota Agricultural Experiment Station is committed to continuation of these programs, utilizing appropriate inputs from traditional plant breeding programs, from biotechnologists, and also from consumers/users.

Plant pests are very adaptive and respond in their own way to efforts to control them. For example, some weed species have developed resistance to certain herbicides. This phenomenon has resulted in changes in how we attempt to control the weed species. Rotation among various herbicides may be necessary to prevent the weeds from building populations that are resistant to any one type of herbicide. Hand weeding small populations of herbicide resistant weeds may be beneficial in preventing spread to other fields. Another example of an adaptive pest is the stem rust organism that attacks wheat and other small grains. The stem rust races are monitored each year so that plant breeders can incorporate resistance to each new rust race into new varieties.

Biotechnology will play a very important role in variety development programs. Biotechnology should increase greatly the number of beneficial genes available for use in plant species of economic importance. Biotechnologists will work in concert with plant breeders to identify genes which control important characteristics. The genes will need to be isolated, attached to a "carrier," and inserted into a crop variety. Several of the procedures to accomplish this series of events still need to be worked out in most of our crops. Plant breeders will incorporate the genes into adapted varieties and test the performance of the "new" plants. Biotechnology will not reduce our need for plant breeders, but should make the variety improvement team of breeders, pathologists, cereal chemists, and now biotechnologists more productive. A discussion of the impact of plant biotechnology on agriculture can be found in the November-December 1990 issue of North Dakota Farm Research.

One of the present thrusts of our biotechnology work is in the area of wheat germplasm enhancement. This is a new area of research at NDSU and is the result of legislation passed by the 1989 North Dakota legislature. One of the first targets of this

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project is to improve the level of resistance in wheat to the disease organisms that cause tan spot and septoria. Satisfactory levels of resistance to these diseases have not been found in cultivated wheat or in grass species which can be hybridized with wheat.

This interdisciplinary program, including crop and weed sciences and plant pathology, will use the various techniques of biotechnology to screen for cells or groups of cells which have greater levels of resistance to the disease toxin. Cells which show improved levels of resistance will be regenerated into whole plants. Seed from these plants will be subjected to the organism in the laboratory, greenhouse, and field to verify that they do indeed have improved tolerance to the disease. If the plants continue to show added resistance, they can be hybridized with our best varieties. Progeny from the hybridization will be evaluated so that an adapted variety with the improved resistance can be released to North Dakota producers.

Previously in this article, expected regulations requiring that farmers maintain records of all crop varieties were mentioned. These requirements likely will be legislated by the federal government. The legislation likely will also change the Plant Variety Protection Act to restrict ability of farmers to sell, as seed, any plant variety that has been granted 'protection.' This legislation will make it possible for those who develop new plant varieties, private companies and universities, to recover their costs of development by assessing royalties on the seed planted by farmers. Traditionally, the NDAES has not protected varieties, and thus does not collect royalties (although varieties can be protected without collecting royalties). It is anticipated that this position will not change unless the North Dakota legislature decreases support for variety development

The NDAES is concerned about the trend by private industry and some universities to seek patents on plant genes or on physiological processes controlled by certain genes. The NDAES has taken the position that naturally occurring plant genes are in the public domain and should not be patented. However, the patent office already has granted some patents on genes and physiological processes, so a precedent has been set. Holders of patents will be eligible to collect royalties from any one who uses the gene or genetic process in a new variety. These royalties will, of necessity, be passed on to the person planting the variety. A more serious consequence of patenting will be the diminution of free exchange of germplasm among plant breeders as they each try to protect their materials. This reduction in germplasm exchange may slow the progress that breeders can make in variety development.

"Industrial utilization" is the new catch phrase as we work with industry to find uses for the crops our farmers produce. However, agricultural experiment stations already have a long history of cooperating with industry by developing, through plant breeding, varieties which meet their requirements. For example, barley varieties which are to be used for malting must meet strict quality standards, including plump kernels, relatively low grain protein, large amounts of soluble carbohydrates, adequate enzymatic activity, and many other characteristics. All of these characteristics are genetically controlled, and the plant breeder, working with pathologists and cereal chemists, must select those new varieties which have the best combination of all these traits. Similar examples could be provided for each of the many crops we work with.

We also are searching for new uses for old crops. One example of this activity was reported in the most recent issue of "The Barley Bulletin," where waxy hull-less barley was reported to be a valuable food item in providing dietary fiber for humans. Genes for the waxy and hull-less characters are being incorporated into barley varieties which are adapted to North Dakota. Another example is research on flax seed, which shows evidence of reducing serum cholesterol and blood pressure in humans when small amounts of ground flax are ingested each day. Flax seed has very large amounts of fiber, compared with cereal grains, and contains good levels of omega-3 fatty acid. The search for new uses of crops will continue to go on worldwide. There are many examples of this type of research, and ethanol from starch and many products from sugarbeets are only two of numerous possible illustrations.

Weed researchers at NDSU are making important contributions to reducing the impact of pesticides on the environment. An example is a cooperative program with Agsco Chemical in which adjuvants made from vegetable oil were developed and are being marketed as "SunIt" or "Scoil." These adjuvants, when mixed with certain herbicides, reduce the amount of herbicide needed to provide weed control. Research on environmental effects and application method effects on weed control from herbicides has led to more precise application rates for effective weed control under variable conditions. Researchers also provide considerable data for registration of herbicides for minor use crops. This latter activity is becoming increasingly important because of the reluctance of chemical companies to register or reregister herbicides unless there is good probability of recovering their investment costs. Weeds have been part of agriculture since farming began, and we can hope to only minimize their impact on crop production by using combinations of cultural, chemical, and, when possible, biological practices. Research on weed biology and physiology will provide farmers with information needed to best combat the weed problem.