PRESIDENTIAL ADDRESS:

MAINTAINING AGRICULTURAL PRODUCTION

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INTRODUCTION

World population has increased dramatically over the past 50 years, but increases in agricultural production have more than matched increases in population over this period, so that today food surpluses are common in many developed countries (Wortman and Cummings, 1978; Schuh, 1987). The existence of food surpluses has led to questions about the rationality of continuing support for agricultural research, especially in agricultural exporting countries such as New Zealand.

Many policy makers seem to assume that agricultural production will remain constant in the absence of agricultural research. However, biological, climatic and economic factors which influence agricultural production are constantly changing, often in an uncontrollable manner, and these changes will usually reduce agricultural production in the absence of agricultural research. This is especially true in countries where high levels of agricultural production are achieved with high yielding, genetically-homogeneous plant cultivars. Generally, these yields are achieved with the help of synthetic fertilisers, herbicides, fungicides, insecticides and other chemical products.

BIOLOGICAL FACTORS

Crop and pasture species are constantly subjected to attack by diseases and insect pests. For many species, and especially for major crops such as wheat, barley, maize and peas, the development of genetic resistance to diseases has been a major achievement of plant breeding programmes and a major requirement for achieving high, economically competitive, levels of production. However, the pathogens which cause many important diseases of these crops are genetically variable and are constantly mutating, and the release of resistant cultivars invariably favours the selection of races of the pathogens which can survive and multiply on the new cultivars (Vanderplank, 1984.) To maintain production levels, new cultivars with new resistance genes have been required at regular intervals.

The most dramatic requirement for new types of resistance occurs with the arrival of a new disease, such as occurred with the arrival of stripe rust of wheat to Australia and New Zealand in 1979. Many cultivars of wheat in New Zealand were susceptible to stripe rust and emergency control was achieved by spraying with fungicides at a cost of approximately $2.8 million per season (Burnett and Dunbier, 1982). However, because of the existence of active wheat breeding programmes, resistant cultivars could be rapidly identified, susceptible cultivars removed from production, and production levels maintained without the extensive use of fungicides.

Likewise, the arrival of a new insect pest requires a rapid response, either by formulating successful insecticide strategies or by rapidly developing and releasing resistant cultivars. For example, the blue-green aphid, a serious pest of lucerne, was discovered in New Zealand in 1975 and no resistant cultivars were available at that time. Initially, losses were severe, but a multi-disciplinary research programme developed control methods (Kain and Trought, 1982), and because of the existence of active lucerne breeding programmes, an adapted blue-green aphid resistant cultivar was developed by 1979 (Dunbier and Easton, 1982).

Many examples of pathogens attacking previously resistant cultivars involve single gene, or race-specific, resistances. The use of polygenic resistance has been widely suggested as a method of producing durable resistance (Vanderplank, 1984; Simmonds, 1988). However, although polygenic resistance should be more durable than monogenic resistance, evolutionary trends in pathogens would favour aggressive strains with higher levels of reproductive fitness on any cultivar that is widely grown. On genetically homogenous cultivars, such as modern cultivars of most annual crops, little opportunity for genetic response of the crop exists (except by rare mutations), and production losses will probably gradually increase as pathogen populations shift towards more aggressive strains. Furthermore, polygenic resistance is not easily distinguishable from more vulnerable resistance due to small numbers of genes, so the durability of any new form of resistance is not easy to predict (Johnson, 1984). Currently, cultivars are continually replaced by new, different cultivars, with few modern cultivars being widely used for longer than 10 years (Duvick, 1986). Consequently, little opportunity exists to determine the long-term durability of resistance of any particular cultivar.

An alternative to homogeneous cultivars is heterogeneous cultivars which are similar to the landrace cultivars which were used before the advent of modern agriculture. Mixtures of landrace cultivars are thought to provide stability, but at a lower production level to modern homogeneous cultivars (Plucknett and Smith, 1986). In fact, disease epidemics occurred on mixtures of landrace cultivars for centuries before the advent of modern agriculture (Stakman and Harrar, 1957), so mixtures of landrace cultivars have never provided a guarantee against disease epidemics and crop failures. Heterogeneous cultivars, constructed using the principles of modern genetics and plant pathology, should be more durable (Browning and Frey, 1969), but can never provide a guarantee against changes in pathogen populations. Furthermore, they often have a yield disadvantage.

High and economically competitive levels of production of many crops depend on the use of selective herbicides. However, like pathogens, weeds are genetically variable and long-term use of selective herbicides first increases the prevalence of previously resistant weed species and then increases the prevalence of resistant biotypes of previously susceptible species. For example, in maize, the use of atrazine invariably increases the prevalence of resistant grass species which must then be controlled by using another herbicide in conjunction with atrazine. Later, resistant biotypes of broadleaf species, previously susceptible to atrazine, have appeared, as with the appearance of atrazine-resistant fathen (*Chenopodium album*) in maize crops in the Waikato (Rahman, 1985). Methods for controlling these new biotypes of fathen were developed (Rahman, 1985) but the ability to respond to the changing weed spectrum required an active herbicide evaluation programme conducted by agronomists in New Zealand.

Insects are also genetically variable and resistant strains often increase rapidly when populations are exposed to insecticides (Chapman, 1982). When this occurs, production levels can only be maintained by changing the insecticides in use or by developing alternative methods of control. Again, these changes can only be initiated rapidly by agricultural scientists with local knowledge and experience.

CLIMATIC FACTORS

Climatic factors which influence crop production are constantly changing, and these changes are likely to influence agricultural production in the coming decade.

Favourable weather for the production of summer crops appears to follow a cyclical pattern (Thompson, 1988). For example, in the Corn Belt of the USA, there has been a cyclical pattern of summer weather recurring every 18 to 19 years since 1891 (Thompson, 1988). During each 18 to 19 year cycle, there has been a cluster of 4 to 5 years of very favourable weather and a cluster of 4 to 5 years of very unfavourable weather. The last highly favourable period was from 1978 to 1982, and unfavourable conditions are expected again in the early 1990's (Thompson, 1988). The last period of favourable weather allowed surpluses to increase, but a sustained period of unfavourable weather in the major crop producing areas of the USA will reduce, and possibly eliminate, worldwide surpluses of many crops.

Other changes, which are probably non-cyclical over a period of decades, are also occurring. For example, the atmospheric carbon dioxide level is steadily increasing (Ingersoll, 1983), and this increase will change plant productivity either directly or by changing temperature and rainfall patterns. The magnitude and direction of changes in plant productivity due to changes in climate are difficult to predict but will almost certainly require changes in cultivars and agricultural practices to maintain production efficiency.

ECONOMIC AND SOCIAL FACTORS

The remarkable growth of trade in agricultural products over the past 20 years has produced an international food and agricultural system (Schuh, 1987). Furthermore, the international capital market is now huge and the international capital flow is many times greater than the flow of funds from international trade. Flows of capital, and not international trade, now largely determine foreign exchange rates (Schuh, 1987), and this has serious implications for countries which export agricultural products.

Given the increasing interdependence of world agriculture, exporting countries such as New Zealand must put even more emphasis on selling quality products at highly competitive prices. To compete effectively will require even more efficient production, with an increasing dependence on innovative technology provided by agricultural research. When the new technology must be imported, as will often be the case in New Zealand with chemicals and the products of biotechnology, the speed of adoption will be crucial for maintaining competitive advantage. This will be highly dependent on the ability of New Zealand scientists to adapt the new technology to New Zealand conditions. Technology itself can often be exported, providing additional income for those countries which develop it.

Restrictions placed on the use of insecticides, fungicides, herbicides and other chemical products, because of environmental concerns, are almost certain to increase, but their timing is difficult to predict. When they do occur, agricultural research will be required to develop alternative methods of controlling diseases and pests or agricultural production levels will not be maintained.

CONCLUSION

Because modern agriculture depends on constantly changing biological, climatic and economic environments, production levels can only be maintained by constantly changing production methods. Such changes should include a steady release of new cultivars, with new genes for resistance to pests and diseases, and a steady release of new production technologies. These changes can only be achieved by a pool of trained agricultural scientists in New Zealand. Failure to produce, and adapt, new technologies will not only lead to lower producton levels but decreasing competitiveness on world markets.

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