PRESIDENTIAL ADDRESS

CLIMATE AND CROP PRODUCTION

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In speaking to the 1975 International Conference on "Crop Productivity – Research Imperatives" at Michigan, Professor Reid Bryson(1975) spoke on "climate change". He said that when we are trying to make bumper crops the normal thing, we are trying to adapt the plant to get maximum yield at the normal weather. "But", said Bryson, "we are shooting at a moving target – the climate is not fixed, it changes!" Bryson, along with Professor Kenneth Hare, Canada and Professor Hubert Lamb, England, have done an effective job of alerting the world to the possibility of climatic change. Their task has been made easier by an increasing international awareness of the extreme vulnerability of agricultural production to climate brought about by several significant climatic events of the 1970s. These include the droughts of the sub-Sahara West African region and Central America, excessive rain in the U.S. midwest, the worst drought in the Moscow region for some 300-500 years, long periods of below normal temperatures in the eastern Canadian area of the Arctic and Greenland; quite apart from such comparatively minor events as the succession of dry spells in New Zealand during the same period.

The question of climate change and food production has been examined by several working groups. Of particular interest is the 1975 Bellagio Conference "Climate change, food production and interstate conflict" held in Italy. This was a little unusual in that it brought together specialists from two areas who do not often meet – climatologists on the one hand, and plant breeders and crop production specialists on the other.

The climatologists reported that "there is cause to believe – although it is far from certain – that climatic variability in the remaining years of this century will be even greater than during the 1940-70 period".

On the other side of the coin, it was pointed out that current agronomic testing techniques are designed to take account of substantial year-to-year and place-to-place variations in climate. It was agreed that the current agricultural research methods could take account of future changes of fluctuations in climate reasonably well. Nevertheless several important areas of investigation were recommended for both the agricultural and atmospheric scientists.

The main conclusions arising out of these discussions on climate change are as follows:

1. After a period of relatively warm average global temperatures in the early part of this century, there has been a cooling trend. This trend has been most evident in the northern hemisphere since the 1940s.
2. The direction and extent of future temperature trends cannot be predicted with accuracy. However, it is likely that increased climatic variability, which has been evident in many parts of the world in recent decades, will persist through this century.
3. Climatic variability may cause substantial variability in global food production which, in turn, could have far-reaching social, economic and political consequences.

The major problem with climatic-change studies is that year-to-year variability is an inherent feature of global and regional climates. It is therefore difficult to separate the isolated "bad" year from a trend consisting of a series of bad years with more serious repercussions. The same difficulty lies of course in deciding whether a favourable year is an isolated 'event' or signifies an upturn in the climate. This difficulty is compounded by the fact that reliable meteorological records have only been kept for a little over 100 years.

The subject of climatic change has been reviewed recently by a high level Committee of the Australian Academy of Science (Priestley, 1976). Their report provides a very interesting and balanced account of what is known and what is not known about climatic change. Several of their conclusions are of interest (and also of some comfort to those who might be concerned about another ice-age before the year 2000):

1. Major changes in climate have occurred over geological time, on scales of thousands to millions of years, and they will continue to occur in the future. However, there is no evidence that the global climate is now changing at a rate that can be detected and will continue.
2. The climate of many parts of the world is highly variable. The increasingly severe effects of recent droughts and floods are due more to increased human population than to any increase in climatic variability.
3. There is as yet no reliable method which provides forecasts of climatic fluctuations.
4. Increasing attention should be paid to the inherent short-term random variability of the climate, and its effect on agricultural production, by all those responsible for agricultural and economic planning.

A major impact of climatic variability lies in its effects on regional and national agricultural production. It is this particular point which I want to explore further in relation to New Zealand agriculture.

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Adaptation of crops to the climatic variability in New Zealand:

New Zealand grain yields are good by international standards but we need to examine the potential for improving the year-to-year reliability of yields as well as extending the climatic regions in which a crop can be grown.

Maize is one crop which needs to be examined. Soybeans are another. Perhaps a simple calculation will serve to illustrate the importance of understanding the effects of climate on maize development. Let us consider a maize hybrid which requires 530 degree-days (base 10°C) to develop from sowing to tasselling. If sown in Palmerston North on 1 November this hybrid would, in a normal year, tassel on 31 January. Of course we very seldom get normal years in Palmerston North. If temperatures were 1°C above normal then we would find that the maize tasselled on 20 January, but if the temperatures were 1°C cooler than normal, tasselling would be delayed until 14 February. This spread of tasselling dates is typical of our experience in the Manawatu in recent years. We are now looking to the physiologists and breeders to produce maize hybrids which will grow and develop at the comparatively cool temperatures experienced in the Manawatu and other regions.

However, what we need to remember is that while relatively minor shifts in climate may cause large reductions in food production, it is also possible that minor shifts in crop tolerance of sub- or super-optimal levels of temperature, water supply and nutrients could enhance yields.

If we are to improve the adaptation of crops to our variable climate then it is necessary that research on temperature and water stress physiology be continued. Patterson (1977) emphasised the need to give high priority in plant breeding programs to improving the stability of the plant to climatic stress.

The current methods of selecting cultivars for commercial release are based on the established procedure of running comparative trials in several regions over a number of years. This procedure gives an idea how the new cultivar will perform under the climates of the 3-5 year test period but is unlikely to define the performance under the full range of climates to be experienced by the cultivar in its 10-30 year life. Perhaps we could improve on this approach by using the skills of the agronomist and the climatologist to model the relationship between crop development, yield and the environment. This could provide the breeder with more precise information on the characteristics and variability of the climate for which he is engineering plants. It may also provide better criteria for deciding where cultivar trials should be located.

As cropping increases in New Zealand we can expect to see many crops being grown outside their traditional climate zones. This development will be encouraged in those areas where two crops a year are practicable.

In summary, if we cannot change the weather, maybe we can do more to change the plant so that it is less affected by the normal variations in the weather.

Modification of the crop environment so that reliability of crop yields are increased:

The crop environment can be modified to reduce the effects of water shortages and excesses, wind and temperature on the crop. The effort and resources invested in the modification will depend both on the value of the crop and the degree of risk involved.

Water balance data (N.Z. Meteorol Service, 1973) for Hamilton, Palmerston North and Lincoln bring out some interesting points and illustrate that drainage and irrigation problems are significant in several cropping regions. Average annual rainfall at thise locations is 1197, 1002 and 689 mm, respectively. However, estimated drainage and/or runoff losses are 600, 358 and 167 mm, respectively. Therefore, the net rainfall for Hamilton, Palmerston North and Lincoln is 606, 636 and 495 mm, respectively **but** potential evapotranspiration at these sites ranges from 830 to 864 mm/year (Coulter, pers.comm.).

Drainage systems are required on many soils making them much more suitable for cropping, particularly for those crops such as peas and potatoes which do not produce under short-term flooding or water-logging. Nationally it is important that all soils suited to arable farming are drained, as there is no alternative way of reducing the effects of poor aeration associated with water-logged soils (Bowler, 1973).

Increasingly, border-dyke, sprinkler and trickle irrigation systems are being used for crop production. In shallow soils and in the drier area of the country irrigation is required to ensure reliable yields.

There are a few direct environmental modifications which can be used to increase or reduce temperatures. An exception being the frost prevention practices adapted for high production crops. However temperature modification can be an indirect result of other changes to the environment. Drained soils will be warmer than similar undrained soils particularly in critical periods such as the spring when soils are beginning to dry. In many situations shelter belts will alter the environmental temperatures.

Windbreaks have long been used to modify the microclimate with the objective of increasing crop production. Traditionally windbreaks have consisted of parallel belts of trees, planted perpendicular to the direction of the most harmful wind, to shelter crops and prevent soil erosion. Usually shelter belts are designed for a single paddock or farm. There are parts of the country where the potential of "mesh" or "network" systems of shelter belts designed for extensive areas should be examined.

Another form of shelter, not seen in this country, is that of the sown windbreaks (Rosenberg, 1977). This is an annual windbreak which consists of tall crops interplanted systematically into fields of shorter crops, e.g. maize in soybeans or sugar beet, and tall wheatgrass used to shelter small grains. Spacing between windbreaks is usually some 8-12 times the difference in height between the two crops. The windbreak porosity should be about 50% which is equivalent to two rows of maize. Perhaps there are areas of New Zealand where this type of windbreak could be used.

Climatological information to assist farm management decisions:

Henry Nix (1977) describes as the ultimate goal of crop research ..... "the ability to predict the behaviour of any crop production system at any location under any technology and any set of weather conditions. If we could do all this then we could tell the farmer what to grow, when to grow it and his probability of achieving certain nominated yields".

Nix goes on to argue that our goal is to develop models of crop production systems which will allow us to predict the consequences of any specified management strategy on any specific crop for any area.

We need to lay aside the traditional techniques of statistical agronomy if we are to make progress in understanding the functional relationships between climate and a given crop production system.

There are several ways in which we can use climatological data to advise the farmer at present. In the USA there are a number of private firms providing farmers with irrigation schedules using both climatological data and on-site inspection to make recommendations. The farmers pay up to $6-12/ha for this information. A similar service could be provided in this country for those farmers who find it pays to schedule water application carefully.

Climatological information can be provided for the farmer on a probability basis so that he can assess the risks associated with following a particular course of action, e.g. estimates of the number of spring workdays; average length of growing season for a particular crop for his district probability of soil being suitable for direct drilling of crops and pastures; probability of having dry periods of a nominated length for certain farm operations.

Management can reduce the effects of climatic variability on production:

The New Zealand farmer is accustomed to seasonal variation in climate and farms accordingly. If he is to cope with this variability and at the same time to increase production a great deal of management skill and flexibility is required. Where appropriate he is able to carry out drainage and/or irrigation to provide optimal soil water conditions for his crops. He can diversify the crops which he chooses to grow and thereby minimise his risks. Where desirable he can plant shelter belts. He must select those cultivars for planting that are best adapted to his district and which will not place him at too high a risk from climatic variability.

Climatic variability has a dominant effect on feed supplied for animal production and crops for **in situ** feeding and conservation have a very important part to play in cushioning these effects of climate on farm output. There will be increasing use of crops as animal feed in the future as a complement to pastures.

The Agronomy Society has a keen interest in the brassica crops as well as grain crops. The brassica crops provide a means of conserving some stockfeed **in situ.** This is a short-term conservation in that crops are sown with a predictable period of climate-induced feed shortage in mind and must be used within a month or so of the target date.

This Society has a growing interest in the production of crops which can be conserved as silage. Quality silage reserves go some way toward enabling the animal producer to become less dependent on the weather for his immediate supply of feed. The farmer is able to establish a feed reserve which can be used when the climate seasonally swings against pasture production. These reserves are particularly valuable when stock numbers are being increased. A farmer will usually plan to increase stock numbers on the basis of performance during the preceding 2-3 years, but he has no crystal-ball to tell him what the climate is going to be in the next three years. Thus there is a place for high producing forage crops as an insurance feed supply to be used when stock numbers are being built up. The reserve provides the safety factor against climate swings and enables a farmer to continue production at the higher level.

In summary I wish to leave you with the thought that there should be greater dialogue between the climatologists and the agronomists. This can be encouraged through the development and use of crop production models.

Our climate will continue to change in the future – that is a certainty. The challenge we face as agronomists is to develop the technology which will lessen the effects of climatic swings on farm production. May I again quote from Bryson:

But I must make it most emphatic
that the climate is not static,
that the change is here to stay
(until it goes the other way)!

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