PRESIDENTIAL ADDRESS

DEVELOPMENTS IN AGRONOMY

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SUMMARY

1. Plant breeding has resulted in a very large increase in the national average maize yields over the past 30 years. This increase, together with the recent steady increase in barley yields, has resulted from the introduction of new overseas varieties. The recent New Zealand breeding program for maize should contribute to increased yields in the near future. With wheat and oats it is estimated that plant breeding has recently given yield increases of about 20 kg/ha/an. of grain. Because of the rate of genetic improvement in maize yields appears to be ten times that in other cereals, it is suggested that a major effort should be made to exploit further genetic improvement in wheat, barley and oats.

2. The contribution of crop husbandry techniques to increases in average crop yields is very difficult to estimate, but for wheat. oats and barley appears to be about 20 kg/ha/an. This rate of improvement is probably much less than that achievable with a more active research and extension program.

3. An expansion of basic research in cropping and pasture systems is being made at the Universities, the Department of Agriculture and at the Plant Physiology and the Crop Research Divisions of D.S.I.R. This should lead to a greater appreciation of the potential of irrigation, fertilisers, existing genotypes and varieties, to achieve optimum production.

INTRODUCTION

Agronomy has been defined in the dictionary as the rural economy. This is a much wider interpretation than that used by most agricultural scientists who generally think of agronomy as that field of science pertaining to the growing of plants. Agronomy can thus be taken to include pastures, crops, plant breeding, cultivation, fertilisers, soils, and even aspects of economics. The two main topics I will attempt to review on the New Zealand scene, are the results from, and plans for, crop breeding methods and crop production techniques. As a basis, I will first attempt a simple analysis of the long-term trends in the yields of cereal crops in New Zealand.

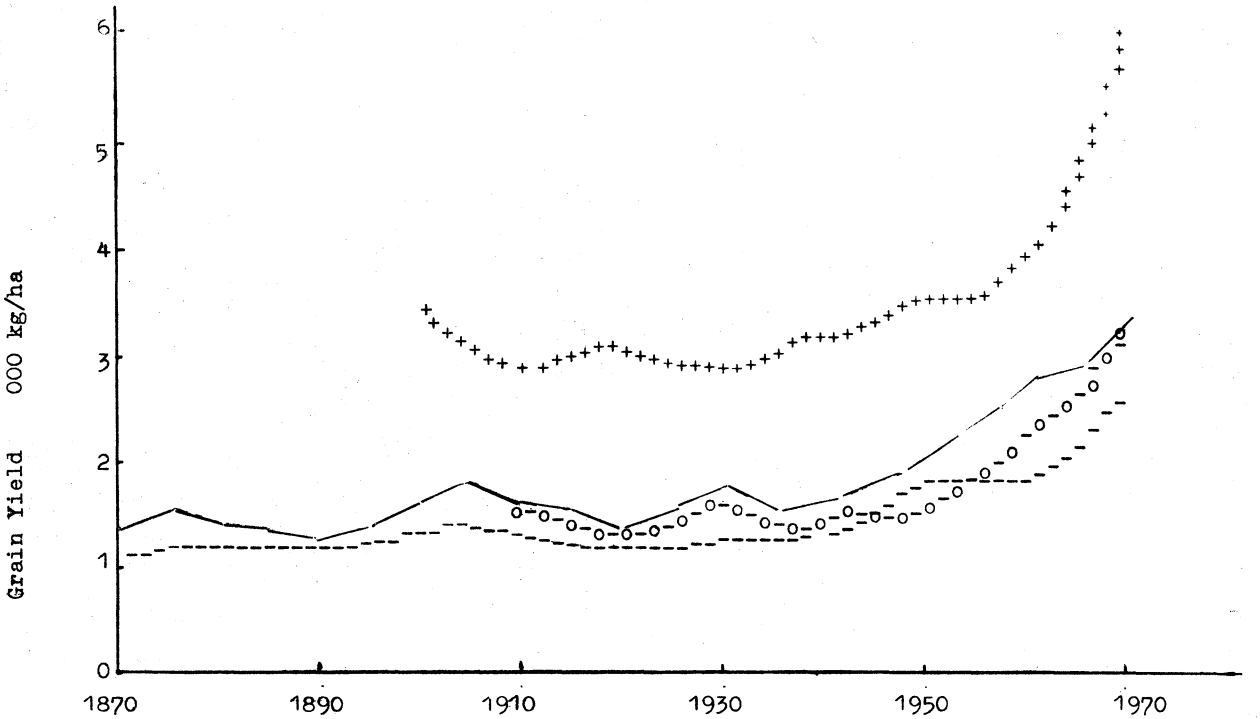

Fig. 1. Five year average grain yields of wheat—— ; oats ---; barley 0-0-0 and maize + + + in New Zealand 1870-1970.

Trends in Cereal Yields in New Zealand

When the 5 yearly running average yields of wheat, oats, barley and maize for the period 1905 to 1970 were graphed, Fig. 1, there appeared to be two distinct cycles in yields covering the periods 1905 to 1930 and 1930 to 1955. In these cycles the yields of cereal grain declined to low levels during the 1915 to 1920 periods and again during the 1930 to 1935 period, but they then rose to a relatively steady level of productivity, around 1700 kg/ha for oats, 1900 kg/ha for barley, 2200 kg/ha for wheat and 3300 kg/ha for maize. The low level for the first cycle seemed to correspond to the First World War period, while in the second, it corresponded with the depression. These low levels of production may have resulted from the crops being grown on lighter land or under lower rainfall, but there certainly do not appear to be any readily identifiable yield benefit from either improved varieties or crop husbandry methods up to 1955. For all cereal crops, however, the rise in average yields over a period 1955 to 1970 has been quite dramatic.

It is very likely that this rise was largely a result of improved crop husbandry (better soil fertility and harvesting methods) and the use of new higher yielding varieties of cereals.

I think it is useful to attempt to identify the relative contribution of each of the two components - plant breeding and crop husbandry, and I suggest that an estimate for each can be obtained by comparing the average yields of oats and wheat over a long period. For the period 1870-1955 the yields of oats and wheat are almost exactly parallel to each other and during this period there were probably no new varieties released with very marked increased yielding ability. From 1955 to 1960, however, there were no new oat varieties released, but two new higher yielding wheats Aotea and Arawa became widely grown. In this period the average yield of oats remained around 2200 kg/ha but average wheat yields increased from 2650/ kg/ha to 3000 kg/ha. This difference thus enables an estimate of the value of the new wheat varieties. The release of two new higher yielding oat varieties since 1960, however, resulted in the graph of oat yields to again parallel that of the wheat yields. On the basis of these comparisons and in the absence of well planned long-term studies on the yield potential of new and old cereal varieties, it is suggested that the differing slope of the wheat, oats, and barley average yields over the 1955 to 1970 period can be used to estimate the relative contribution of plant breeding and crop husbandry to average yield improvement in N.Z. The total improvement for each cereal (barley, wheat, oats and maize) over the period 1945 to 1965 was about 1100 kg in 20 years, i.e. 55 kg/ha/an. The comparison

between wheat and oat yields together with a study of the rate of wheat improvement between 1935 and 1955 when no varieties with higher yields than the existing varieties were released, indicates that the rate of yield gain by crop husbandry methods and other factors was between 10 and 35 kg/ha/an. The rate of genetic improvement from the new wheat varieties released in 1955 and 1956 appeared to be between 15 and 30 kg/ha/an. The new overseas bred barley (and maize) varieties being grown in New Zealand since the Second World War seem also to have given average increases in yield similar to that of the wheat.

It is thus proposed that the genetic and husbandry contributions to yield increases over the past 20 years are of the order of 22 kg/ha/an. The genetic improvement has been achieved in oats and wheat by having our own breeding program, but in the case of barley and maize, we have benefited entirely from overseas bred varieties. The N.Z. breeding programs for genetic improvement in barley and maize are only 10 and 3 years old respectively, thus we cannot expect to make a significant improvement in average yields for at least another four years.

Although we should realise the difficulties in attempting to generalise too much from data on average crops yields, it is tempting to speculate on the significance of the most recent dramatic rise in average yields of maize in New Zealand, and it would certainly be a serious omission if no comment were made.

As has already been pointed out the close parallel between maize, wheat and oat yields over the period 1905-1960, suggests very similar rates of genetic and husbandry improvement for all cereals during that period. The sharp rise in maize yields from 4,000 kg/ha to 6600 kg/ha between 1960 and 1970 however, would seem to be largely due to very large genetic gain from the use of the Wisconsin hybrid varieties which were introduced and developed by the N.Z. Department of Agriculture. It is suggested that the average level of genetic improvement in maize has changed from about 20 lb/ac/annum (the wheat, barley and oat level) to about 200 lb/ac/annum. If this is substantiated by yields in later years then it would suggest that a higher priority should be given to plant breeding programs to exploit hybrid vigour in other crops.

I suggest that at the present time greater emphasis should be placed on investigating the potential for N.Z. Agriculture in growing large quantities of hybrid seed for export. At present our plant breeding program includes the development of hybrid varieties of onions, tomatoes, maize, and sweet corn. I propose that a serious study should be made of the prospects for N.Z.

in breeding and growing hybrid wheat varieties for export as hybrid seed. This would certainly be in line with the generally accepted idea that N.Z. must make the maximum use of its small area of reliable, highly productive land to produce high value crops for export.

There are two defects in conventional pure line plant breeding of self fertilised cereal crops that need closer examination to assess their significance. There is firstly the possibility that the high level of uniformity within a pure line and secondly the availability of only a few varieties may enable either a rapid loss of resistance to diseases and pests subsequent by the variety being released, or the rapid spread of disease between crops. There is some evidence also that although new varieties may offer large genetic gains in yield potential during their early stages of evaluation, these may be gradually lost as the variety becomes more widely grown. The evidence on this aspect is certainly conclusive in relation to the disease resistance based on major genes, e.g., the resistance to powdery mildew in the Cross 7/61 and Hilgendorf 61 wheat varieties which was almost totally lost within three years of these varieties being released. There is some evidence also for a gradual change in the pathogenicity of insects and fungi in relation to multiple gene resistance in pure line varieties and a consequent loss in yield ability. This loss in performance or "yield slip" in relation to the environment is very difficult to measure and evaluate, but a much greater effort should be made to evaluate it in the near future.

Another cause of loss of yield similar to the above, is that associated with the greater severity of diseases and pests when a high proportion of the cropping area contains very few varieties. Although there may be obvious advantages to merchants and processors in having only a few varieties of a particular crop, e.g., there were only three main wheat varieties in N.Z. compared with 30 varieties in Kenya (a country with the same acreage). There are obvious disadvantages in higher disease losses when these few widely grown varieties are attacked by pests or disease.

Whether you classify the advantage of growing a wide range of varieties as being a plant breeding or a crop husbandry benefit is not important; the main thing is that this relative benefit should also be evaluated in some way, and if worthwhile it should be obtained by either developing multi-line varieties, or by developing and having released a greater range of new varieties of the present cereals.

Crop Husbandry Studies

The long term cereal yield indicated that the past benefits from improvements in crop husbandry have been at least equal to that achieved by the usual plant breeding methods. For the future it is expected that even greater contributions will be made by increased use of irrigation and fertiliser, particularly in Canterbury. Thus, the amount of research effort on crop husbandry should be increased greatly at the University, D.S.I.R. and Department of Agriculture. At the present time however, there appears to be an awareness of this need and an intense interest in crop husbandry research. An outline of the main problems under study, or needing study, is as follows:-

Lincoln College

Studies have been conducted on the physiology of growth in wheat with the aim of finding what factors are limiting the yield potential of New Zealand varieties. Under a new D.S.I.R. research contract the relative importance of plant population, soil nitrogen and water on cereal yields will be studied.

Massey University

A proposal submitted for a D.S.I.R. research contract, aims at studying the adaptation of new cereal varieties to various environmental factors in relation to yield and quality of grain.

Plant Physiology Division D.S.I.R.

The relative efficiency of different photosynthetic systems for plant growth is being studied, together with the possibility of synthesising new types of forage plants better able to grow under conditions requiring different photosynthetic systems. Basic studies are also being made on the efficiency of utilisation of energy by different crop and pasture plants in different rotation.

Crop Research Division D.S.I.R.

An expanding program of husbandry studies on lucerne is being carried out. The first studies being completed have looked at factors limiting seed yields and seedling establishment. Further studies on the significance of disease and insect resistance are being started.

Basic studies are being undertaken to find the genetic limits to crop yields under optimum soil moisture and fertiliser application in Canterbury, under intensive cropping systems. Other studies on systems to produce maximum economic yields of grain are also being planned. Husbandry studies are also proceeding on the evaluation of new crops which will be required for new local and export markets.

Department of Agriculture

An intensive program of research on the technology of irrigation in relation to crop and pasture production is being developed, and proposals have been made for this to integrate with the Crop Research and Lincoln College projects. The long term studies on the fertiliser requirements of various crops and pastures on different soil types are being continued.

Soil Research

A review of agronomy would not be complete without reference to the most basic component - the soil. Improvements in crop husbandry techniques are largely transmitted to the crop via the soil - hence soil fertility studies are vital for maximum progress in Agronomy. The agronomic aspects of soil research do extend quite widely from soil structure and fertility to housing, highways and effluent disposal. Although soil physical characteristics which affect crop yields may not yet be readily amenable to adjustment, basic studies on their relationship to cropping should be continued. Similarly the increasing complexity of decision making in relation to the conflicting needs of agriculture, housing, highways and recreation demand an expansion of effort by soil scientists to assist the science of agronomy. Effluent disposal is also becoming recognised as belonging more logically within the ability of the soil agronomist rather than the engineer and an increasing effort should be made for effective methods of dealing with organic waste products resulting from the increased processing of our agricultural products.

CONCLUSION

Basically, New Zealand has very limited agricultural resources and these contribute a very high proportion of the gross national product - basic to our standard of living. New Zealand is making and must continue to make immediate and drastic changes in farming patterns and cropping systems. In the past our cropping patterns have been largely small scale and simply. There is only a limited scope for amalgamation and large scale production. Much greater emphasis must be placed on producing higher value products either by raising quality or by developing new products.

Far more research will have to be carried out to develop the improved technology for producing the more expensive crops.

Greater emphasis will have to be placed on the following topics:-

1. Breeding hybrid crop varieties

2. Breeding high quality processing crops

3. Husbandry of new crops e.g., peppermint, edible dry beans, and drug crops.

4. Irrigation and fertiliser requirements for crops and pasture

5. Development of intensive cropping and pasture systems.

Although there have been rapid genetic advances in productivity with poultry and pig research, it appears that genetic improvement in sheep and cattle will be much slower. It is suggested that the major increase in production of meat and dairy produce for export will result from major advances in producing animal feed supply through improved cropping and pasture systems.