ADVANCES IN MAIZE PRODUCTION THROUGH AGRONOMIC RESEARCH 1967-75

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INTRODUCTION

Maize production for grain and to a lesser extent as an animal forage has a long history in New Zealand. Thompson (1922) records the introduction of maize by Governer King into the Bay of Islands in 1793. By 1900, 5 000ha were grown for grain with an average yield of 2.8 t/ha. In 1967 the area grown had declined to 3 000 ha but the average yield had increased to 6.0 t/ha. The major area of production was Poverty Bay. To-day 27 000 ha are grown for grain with an average yield of 8.2 t/ha with yields of up to 14.0 t/ha being achieved. Of the total area grown only 10 000 ha are in the Poverty Bay region with 15 000 ha in the South Auckland and Waikato regions. The rise in the area grown in these latter regions followed the decline in the profit from traditional dairy and sheep production. Increased interest is also being shown in use of maize as green feed or silage either in place of or supplementary to pasture.

The upsurge in the area of maize grown and the level of yield have accompanied increased agronomic studies which have questioned the traditional techniques used for maize production in the 1960's In this paper it is the object to outline the basis for the changes in the production techniques arising from the agronomic studies made over the past eight years and, further, to question whether the present techniques will continue to give the highest yield at the lowest cost.

HYBRID SELECTION

By 1967 it had been established for the Gisborne region that hybrids of 110-120 day relative maturity (RM) gave the highest grain yield (Graham, 1967). Production was based, mainly, on hybrids of Wisconsin origin. Maize was cribbed dried and the moisture content of the grain at harvest was not critical in respect to the cost of drying. In the new areas of production direct heading and artificial drying were immediately adopted and it was found desirable to harvest about mid May at a grain moisture content of 24%. To achieve this target hybrids of 110 RM needed to be sown no later, on average, than mid November (Cumberland **et al.** 1970). From 1968 hybrids, ranging in RM from 80-120 days, were tested throughout prospective new maize growing areas from Auckland to Marlborough (Cumberland **et al.** 1971). In all areas, the full season hybrids of 110-115 days RM, gave the highest grain yields though the hybrids of lower RM rating had lower grain moistures for a given harvest date.

Although Cumberland and Farrell (1971) pointed out that the lower drying cost for early maturing hybrids could offset the yield advantage of full season hybrids, early maturing hybrids, because of their lower yield have not gained general acceptance. The change to earlier planting at that time which lowered the grain moisture content for a May harvest, further favoured the use of full season hybrids. There is, however, a need for early maturing hybrids, capable of 90-95% of the yield of the full season hybrids, to allow for harvest to be commenced earlier. In the main the yield capacity of the current, full season, hybrids is similar. Discussion on the improvement in yield through further hybrid development is outside the scope of this paper but continued improvement is to be expected from overseas breeding programmes. Lodging is an important factor in hybrid acceptability and, similarly with yield, difference between current hybrid appears to be attributable to locality, season and management rather than hybrid (Cumberland **et al.** 1971). Fullerton (1973) reported that tolerance to stalk rots (Gibberella and Fusarium Spp.) amongst the current hybrids was good but resistance to Northern leaf blight and eyespot diseases was poor. The author attributed the high incidence of lodging in some crops to the invasion of stalk rots after premature senescence following Northern leaf blight attack. Improvement in resistance to Northern leaf blight in present and future hybrids would appear to be essential.

For silage production, as for grain, the full season hybrids give the highest yields (Cumberland **et al.** 1971, Blackmore and Mitchell, unpublished data). Further increases in total dry matter yield for silage could come about by using hybrids of greater relative maturity which would not reach full grain development until late April or by selecting hybrids for total yield rather than grain yield.

Whether the more expensive F_1 hybrid seed is required for silage production is questionable. Brown (unpublished data) has shown the F_2 hybrid to be as equally productive though lower in grain yield. The importance of a high grain content in high dry matter silage is at present being investigated.

SOWING DATE

Initially it was suggested that maize should not be sown before November 1 in the Waikato and South Auckland regions. Subsequent trial work has shown early sowing, in October, to have two major advantages.

Firstly it advances the date of harvest or gives lower grain moisture for a given harvest date. A 115 day hybrid, sown in Waikato in early October, can be expected to reach 26% grain moisture by March 31 or by May 1 from a November 1 sowing. Further delay in sowing increasingly delays harvest as the rate of grain drying declines (McCormick 1974).

Secondly, with delay in sowing after mid October, in both the Waikato and South Auckland regions, the yields of grain and total dry matter, on average, decline (McCormick, 1971, 1974, Farrell, 1975). The effect, which is primarily due to the lack of adequate soil moisture during the grain filling period, is similar for both early and full season hybrids (Farrell, 1975). In areas with a reliable summer rainfall or with soil of high water holding capacity, delay in sowing should not have so great an effect on yield. However there is some evidence to show that even where moisture is adequate grain yields from early sowing are nevertheless higher (McCormick, 1974).

The earliest practical date for sowing clearly varies with locality and soil type, but given that the risk of frost after emergence is low, the level of soil temperature at 5 cm, is probably the best indicator of sowing date. Aldrich and Long (1965) from USA studies point out that maize can be sown at soil temerature as low as 10°C provided the temperature is rising. In Waikato and South Auckland regions soil temperatures average 12°C by October 1 and under such conditions maize will emerge in 12-14 days germinating equally as well as from later sowing dates at higher soil temperatures (McCormick, 1974). Soils too wet to plant early such as peats, will usually have associated low soil temeratures.

PLANT POPULATION

Current practice in Gisborne in 1967 was to sow in 90 cm rows with a harvest population of about 48,000 p.p. ha. (Graham, 1967).

From a series of plant population trials Douglas **et al.** (1971) reported that where moisture was favourable grain yield increases ranging from 21-37% were obtained with populations up to 90 000 p.p.ha. in 76 cm rows. Under drier conditions, maximum grain yeilds were obtained with only 60 000 p.p. ha. It was significant that yields were not reduced with populations as high as 110 000 p.p. ha. The absence of a sharp decline in grain yield with population in excess of optimum for the conditions was considered to allow reasonably high populations to be recommended to take advantage of good seasons without jeopardizing grain yield in dry seasons. Later work, with full season hybrids and populations up to 200 000 p.p. ha. equi distantly spaced (Douglas and Dyson, 1972 and Dyson and Douglas, 1975) showed that grain yields within 10% of maximum were obtained with populations in the range 75-110 000 p.p. ha. Douglas **et al.** (1971) reported a similar response in grain yield, amongst hybrids of different relative maturity, to increasing plant population. However Edmeads (1972) estimated the 80 day hybrid KC3 required 155 000 p.p. ha to give maximum yield compared to 90 000 p.p. ha for the 110 day W575 because of its smaller plant size and leaf area. The necessity to adjust plant population, to compensate for differences in per plant leaf area, in order to maximise yield was evident also in sowing date work (McCormick, 1974). Early sown PX610, with a smaller leaf area, required 90 000 p.p. ha to give equal yield to late sown PX610 at 60 000 p.p. ha. Early maturing hybrids, at higher plant population, may be more competitive in yield with full season hybrids at standard populations and further study on plant population is needed both in relation to sowing and hybrid maturity.

Currently maize is sown in 76 cm rows but with herbicides available for complete weed control closer row spacing is possible. Grain yield increases up to 15% have been recorded for the same population of plants in 38 compared to 76 cm rows (Douglas **et al.** 1971, McCormick, 1974). However, at present machinery to plant maize at 38 cm is uncommon though harvesting of maize in 38 cm rows with a standard header is considered practical.

Silage yields

Douglas and Dyson (1972) showed that with adequate moisture available total plant dry matter yield continued to increase up to populations of 200 000 p.p. ha. However the proportion of grain declined and, as it is understood at present, the feed value of the crop. Investigation into the relationship between feed value and maize plant population is at present in progress.

FERTILISERS

The expansion of maize growing since 1967 brought into production predominantly land which was previously in permanent pasture. Fertiliser studies have been concerned, therefore, with the requirement of continuous maize produced in the period 1-5 years after pasture rather than 5-10 years. Work in the latter field is at present in progress. Fertiliser trials have been restricted mainly to the requirements for nitrogen, phosphorus and potassium although a small number of trials have included magnesium and lime. Widespread work by the Ministry of Agriculture and Fisheries has shown a negligible requirement of maize for fertiliser following well managed pasture (Cumberland and Douglas 1970, Cumberland **et al.** 1970, Douglas **et al.** 1972a). In successive years of cropping nitrogen is the most important deficiency with much less phosphorus required and, from the result of about 30 trials, no potassium.

One reason for this state of affairs is, undoubtedly, the build-up of soil fertility under well fertilised pasture. This was illustrated by Sears (1960) and later demonstrated by Sears **et al.** (1965) when they showed maize, kale and potato crops required less nitrogen immediately following pasture than in subsequent crops. Later work (McCormick and MacKay 1973, Sinclair and Douglas 1974) has shown that maize pasture rotations lessen the fertiliser nitrogen input required for the crop.

The dominance of nitrogen as the limiting nutrient to maize production has led Cumberland **et al.** (1970) to state that the widespread use of compound fertilisers is wasteful. More recent unpublished work by Douglas and Sinclair, has shown there is no difference between the fertiliser response from compounds and fertiliser mixtures applied with the same constituents. The amount of fertiliser required in any situation and the timing of its application be it pre-plant, at planting or post planting is complex and closely tied to the individual conditions. There is however some trial evidence which shows that adequate nitrogen can be applied to a crop at planting rather than side dressed later (Douglas **et al.** 1972). But in situations where heavy rainfall occurs soon after planting a later side dressing of nitrogen may be advantageous. In relation to energy conservation the application of fertiliser only at planting is desirable but further work is required to see if this is generally feasible.

There is a need to know more about the basic nutrient supplying power of individual soils so that soil tests, particularly for nitrogen, can be developed for cropping situations and rotations can be devised which give reasonably quick restoration of fertility.

WEED CONTROL

Advances in weed control, through herbicide development, have possibly been the most important factor in the expansion of maize growing and rise in average grain yield. In Gisborne in 1967 inter-row cultivation, either alone or in conjunction with post emergence 2,4-D application, as described by McKee (1955) was the major method of weed control.

In the new areas of production inter-row cultivation was abandoned in favour of herbicides. Cumberland **et al.** (1970a) demonstrated the importance of weed control per se., the ability to achieve this with herbicides alone and the depressive effect inter-row cultivation could have on maize yields. The use of the triazine, Atrazine, shown by Patterson (1961) to be more effective than 2,4-D in post-emergence, broad-leaved weed control, was adopted and is still in use as an effective pre-plant, pre and post emergent herbicide for broad-leaved weed control. Other soil residual herbicides for pre-emergent and pre-plant control of both annual broad-leaved and grass weeds have since been developed. The effectiveness of herbicides has been improved by adjusting the application rate to the level of soil organic matter and soil incorporating herbicides to overcome the problem of insufficient soil moisture to activate the chemical (Matthews, 1974). Soil residues affecting proceeding crops or pasture have presented problems in some areas. However studies on herbicide persistence have shown that at normal rates of application the herbicides remain in phytoxic amounts after the crop in only a few soil types (Rahman **et al.**, 1975). Though problems still remain in the control of perennial broad-leaved and grass weeds and with annual spp. on high organic matter soils where other than post-emergence herbicides are ineffective, by the correct use of herbicides it is possible to achieve weed free crops from the time of sowing.

INSECTS

Given (1973) has described the insect pests of maize. They fall mainly into two categories. Those which affect plant population by destroying seedlings and those which affect grain development after flowering. In the first group there are such pests as soldier fly, Argentine stem weevil, white fringed weevil, black beetle, cutworm and wireworm. In the second are armyworm and tomato fruitworm.

For both groups screening of chemicals has been undertaken to obtain suitable and economic methods of control. A discussion of such chemicals and their application is somewhat outside the scope of this paper.

Maize sown after pasture, infected with the various soil-borne insects mentioned previously, is particularly vulnerable to attack. The importance of good clean cultivation needs to be stressed to prevent insects tranferring from one host to another as can occur with Argentine stem weevil (Kain and Barker 1966).

CULTIVATION

The basic method of pre-plant cultivation for grain maize has not changed. The importance of thorough pre-plant cultivation for the control of weeds, stressed McKee (1955), though less critical with herbicides, is still pertinent. For maize following pasture the importance of a thorough breakdown of turf for insect control has been emphasised (Kain and Barker, 1966; Hewitt, 1969 and Cumberland, 1973). However, Mackay and Rowe (1973) have shown that with pre-desiccation of the sward a seed-bed can be produced in one week without reduction in final yield.

Matthews (1972) puts forward many excellent economic and ecological reasons why, with the availability of selection chemicals for weed control in maize, cultivation sould be abandoned all together. Williams **et al.** (1971) have shown that both maize for green feed and silage can be successfully produced without cultivation and savings made in pasture production because of the shorter interval needed for crop production. The production of maize for grain has not been so successful (McCormick and Mackay, 1973) because of the inability of the machinery at present available to precision plant maize in uncultivated ground. The authors considered that had equal plant population been obtained in cultivated and uncultivated ground yields would have been equal. Herbicides to control paspalum and other rhozom grasses in pasture plus good insect control without cultivation are necessary. Such herbicides should soon be available (Matthews, 1972, Scherp and Sarfaty, 1975). Machinery to precision plant into uncultivated ground is required but for high density silage maize precision planting is probably not needed.

CONCLUSION

Current maize technology is capable of producing yields of 13 to 16 t/ha of grain and 21-26 t/ha of forage dry matter. Major areas of concern in agronomic research are:

1. The assessment and prediction of the levels of fertiliser needed for continuous cropping for grain or forage.
2. The importance of crop rotation to maintain high maize yields with good weed, disease and insect control and minimal fertiliser inputs.
3. The importance of feed value of maize forage compared to yield per se.
4. The practicability of reduced or minimum tillage for forage and grain production.

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