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A FIELD PROGRAMME FOR EVALUATING DIRECT DRILLING TECHNOLOGY

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ABSTRACT

An on-farm field programme was established to test developments in equipment for direct drilling crops and pastures. The programme was initiated to give research workers access to crops grown under a range of climates, soil types, topography and management systems so that prototype equipment for direct drilling could be assessed under field conditions.

As the equipment became more reliable, the programme developed additional functions. A demand was created amongst farmers for direct drilling equipment, management techniques and consultancy. Technical and management problems were identified and expertise from other disciplines was required, for example pest management. The programme also undertook extension so that direct drilling could be promoted as a low risk management tool.

New and innovative management systems for direct drilling of both pastures and crops have been developed, applied and monitored on commercial properties. Examples are reported where different systems of pasture renewal were used and on-farm monitoring of pasture performance was established. Some problems associated with the acquisition of data on a commercial farm scale are discussed.

A model for development, testing and transfer of technology to the commercial sector was developed around the Field Testing Programme run by the Agricultural Machinery Research Centre at Massey University and the various pathways within this model are discussed.

INTRODUCTION

Since 1969 considerable research has been undertaken at the Agricultural Machinery Research Centre at Massey University into the design specifications of equipment for direct drilling of pastures and crops. Particular emphasis has been placed on studies of the micro-environment of the groove formed by the drill and its influence on seedling performance (Baker 1976; Choudhary and Baker 1980, 1981a, 1981b). Other aspects of machine design studied include the design of openers for handling crop residue (Baker *et al* 1979), the placement of fertilizer (Baker and Afzal 1986), wear characteristics of openers (Brown and Baker 1986), transfer and placement of seeds (Ritchie 1981, 1982; Campbell 1985), the interaction of fertilizer and herbicides (Barr 1981) and the interaction of drill types and pests (Follas 1981). These studies have complemented other research work on no-tillage (direct drilling) undertaken elsewhere (Jansen, 1981, Campbell, 1981, Dunbar, 1983, Hyde *et al*, 1983) although the programme was one of the few to concentrate on the interfaces of machines and soil and machine and plants.

The wide range of studies undertaken showed there was a need for a support programme which would provide field testing of the equipment developed, and provide a basis for research on the management factors associated with direct drilling such as pest control and the use of herbicides. Large areas of land having a range of soil types, topographies, crop types, climates and management systems are required to test field equipment and this was met by the field programme.

It soon became obvious that the most appropriate way of gaining reliable access to the range of conditions needed was to establish a programme under our own control. Such a move was clearly ambitious as few research organisations elsewhere ran similar programmes. Initially tractor, drill and operator were provided and the farmer or his advisor supplied many of the other inputs and made decisions on chemicals, fertilizer, pesticides and management. A charge for the operation was made to recover costs.

Soon after the programme was initiated it became clear that the success of any one crop was influenced as much by the inputs under the control of the farmers as by those over which we had full control. This was a factor that had been underrated by other groups and is still being underrated by some companies marketing agricultural chemicals, which are promoting direct drilling as a viable tool for farm management.

Thus, if direct drilling were to be sustainable and useful in gathering information and to be seen by farmers as a reliable management tool the Massey Direct Drilling Field Programme would need to have greater influence and control more of the inputs.

THE STRUCTURE

The administrative structure established for the Massey Direct Drilling Field Programme is summarized in Figure 1. It was essential that communication occurred between the staff involved in the research and development of the equipment and those involved in the operation of the machine(s) in the field. In practice key staff were involved in all three programmes, but it was also essential to establish a means by which staff from other departments within the University or from outside organisations wishing to become involved in the field trials could gain access to the field programme. Such people were often called upon for advice and troubleshooting.

THE OPERATIONS

The programme operates a 90 kW tractor, a 20 tonne truck and a 16 run prototype direct drill built at the Agricultural Machinery Research Centre and fitted with Bioblade openers. It employs a graduate full time who is responsible for the operation

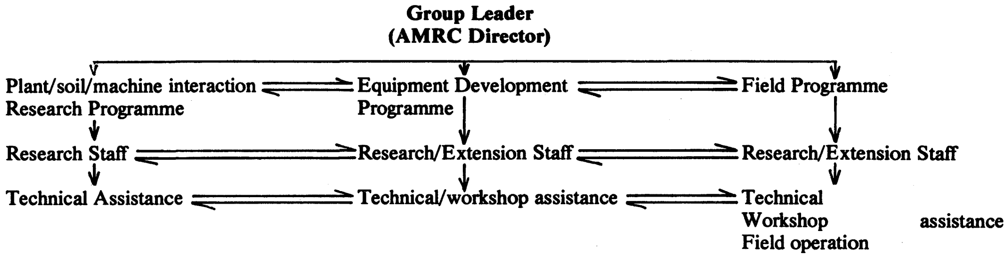


Figure 1. The administrative structure of the three programmes making up the direct drilling field programme at Massey University.

and maintenance of the equipment and for making modifications to the drill (in conjunction with staff from the Agricultural Machinery Research Centre) and for reporting the effectiveness of these modifications. The skills of this person in operating the machinery and reporting information, is a key component and he also has an important role in public relations and extension with the farmers involved.

The programme is supervised by a member of the professional staff of the Agricultural Machinery Research Centre who must make the initial contacts with farmers and representatives of the industry, provide on-farm consultancy on all aspects of crop establishment and management, ensure that the drilling operation is performed satisfactorily, make follow-up visits to assess crop performance, identify potential problems in plant health and advise on future management of the crop. He may also be required to liaise with other specialists to provide this information and is responsible for the financial management of the programme and its role in extension. The person supervising the programme must have a background in agricultural science, be familiar with aspects of crop husbandry, soil science and farm management as well as the technical and operational aspects of agricultural machinery and be capable of relating to farmers in groups as well as on a one-to-one basis.

Since 1976 the Massey Direct Drilling Field Programme has drilled crops on farms and research stations in Northland, Auckland, Waikato, Central Plateau, Hawkes Bay, Taranaki, Manawatu, Horowhenua, Wairarapa, South Canterbury, Central Otago and Southland.

A similar programme using a direct drill with Bioblade openers has been run for about seven years at Grafton by the New South Wales Department of Agriculture.

RESEARCH

The Field Programme provides research at a number of different levels. The design of the Bioblade No-till Opener resulted from a large number of laboratory and small plot research trials (Baker, 1976, Hughes and Baker, 1977, Baker *et al*, 1979 Afzal, 1981, Baker and Afzal, 1981, Baker and Mai, 1982, Choudhary *et al*, 1986). However as the programme progressed there was a need for more extensive testing of engineering concepts and of the design in general.

In one such project a graduate student studied the influence of surface coatings and construction materials on the rate of wear of opener blades (Brown, 1986). After preliminary trials in the laboratory, the most promising treatments were fitted to the drill for extensive field testing. As a result designs which were functionally cost-effective were identified.

In another project the effects of placement of fertilizer on crop performance was studied. During the normal course of drilling of a large number of paddocks on numerous farms, large plot trials were simply superimposed on the programme. Without the field drilling facility neither of these projects would have been possible on a field scale. The results of these experiments confirmed that designs for openers which had been identified earlier in the laboratory, were useful in the field (Choudhary *et al*, 1986).

A field programme such as ours has considerable potential for analysing different management systems. An example was the investigation of the cost-effectiveness of two systems for pasture renewal on two Taranaki dairy farms and one Manawatu hill country sheep farm (Ritchie, 1986). Because there are a number of different properties using the propramme for pasture renewal each autumn there is scope within this programme to increase the number of treatments (farms). However the resources required to monitor performance of the plants drilled on each of the farms currently limits the size of the programme.

In an attempt to overcome this problem two systems were implemented whereby farmers were involved in the monitoring procedure. In one case the farmer recorded pasture production on the basis of grazing days by stock units (S.U.G.D.). This method of assessment proved to be relatively simple to record and involved little of the farmer's time. Nevertheless the technique was open to criticism because variation in the severity of grazing and utilization of the pasture influenced the apparent pasture production. Conservation of pasture or feeding of hay or silage, and fertilizer application on resident and overdrilled pastures were also difficult to account for. Despite these problems this method of assessment has allowed the farmer to estimate the performance of the direct drilled introduced species relative to the plants already present on the farm with slightly more accuracy than that given by simple qualitative assessment.

In an attempt to increase the accuracy of monitoring pasture growth farmers were supplied with pasture meters. The collection of data was dependent upon the goodwill and interest of the farmers involved and it was important that the farmers were chosen carefully. Rising plate pasture meters were chosen because they are relatively robust, cheap and simple to operate, although other more accurate methods of pasture assessment could have been used (Thompson, 1986). Final results of the monitoring of pasture establishment using these probes are not yet available but some limitations have become apparent.

The number of calibration cuts that could be carried out on a site which was 200 km from the university was limited so data from the MAF research station at Normanby (30 km from the farms) were also used, but the two sets of data differed considerably and affected the calibration of the pasture meters.

Despite these problems, the performance of the direct drilled and resident pastures were compared. Absolute values for production data were not critical as the comparisons were between two totally different management systems.

DEVELOPMENT OF EQUIPMENT

The design of the bioblade opener involved considerable laboratory work and field testing. Once the biological requirements were determined and mechanical problems overcome, a set of bioblades were mounted on a commercial no-till drill. Many changes have been made to both opener and drill designs in the four different prototype drills that have been built.

The varied conditions provided by the field programme allowed those components of the drill which required modification to be identified: – Examples include: the fertiliser mechanism, press wheel and main disc bearings for the opener, path of seed through the opener, adjustment mechanism for depth of sowing and the design of the drag-arm. Few of these modifications could have been foreseen without field testing.

New Zealand, because of its range of soil and local climates, provides an ideal test-bed for equipment. The only field condition which could not be duplicated in New Zealand was drilling into sticky soils which have a high clay content. A special visit to New South Wales was arranged in which a single opener was tested on a special rig at the Livingston Farm (Moree) in a cooperative programme with Sydney Universtiy.

As the componentry on the existing direct drill developed, new technology was introduced to improve its performance in other areas. For example a hydraulic system designed at the Agricultural Machinery Research Centre was fitted to the drill during the summer of 1985/86 (Baker, 1987) and later patented internationally. The drill has covered 800 ha since then and the new system has been found to be unusually accurate, reliable and convenient. Minor modifications have been made to improve the life of the hydraulic rams which because of the nature of their action undergo an unusually high duty cycle in comparison with the normal functions of hydraulic rams.

Other devices to be tested on the drill in the near future will include equipment for electronic seed monitoring and a self-monitoring system for depth control.

TECHNOLOGY TRANSFER

Most farmers in New Zealand perceive direct drilling as a relatively high risk method of establishing pastures and crops. This may be due largely to the unreliable results gained in the 1960's and 1970's (Gillespie, 1986) arising through lack of suitable equipment or herbicides, misuse of equipment or herbicides and pesticides, and poor management (Baker, 1979). Consequently, when the Direct Drilling Field Programme was established at Massey University it had to overcome resistance to direct drilling and introduce new technology which was relatively expensive.

The programme was designed to demonstrate that direct drilling could be reliable if performed correctly, and to establish the credibility of the technology from Massey University when seeking funds. These objectives proved to be partially incompatible. In the early stages testing inevitably revealed mechanical defects in direct drilling which often led to the establishment of poor crops. Some farmers lost confidence in the technology, and with it, direct drilling in general but others understood that the programme was still developmental. To minimise the loss of credibility amongst farmers all trials could have been run on Massey farms, but this would have severely restricted the scale of operation and the speed at which improvements could be made.

Despite these shortcomings, it was assumed that with the involvement of the industry and the more rapid development of technology from the programme the technology would be adopted by the agricultural machinery industry and the field programme run by Massey University would become redundant.

Interestingly, this has not occured. The general economic downturn in agriculture has lead to a dramatic restructuring of the agricultural machinery industry. Economics are currently not conducive to the adoption and production of new technology. Even in times of buoyancy there have been few agricultural machinery companies willing to invest the large sums of money necessary to launch this type of high-technology onto markets in New Zealand and the rest of the world regardless of the cost-effectiveness of the technology and the enormous market for it (Barker, 1984). There is little true venture capital available for this type of operation in New Zealand and this has added to the restrictions. Nevertheless the success of the present field programme and the associated demand from farmers for low risk (high technology) direct drilling equipment must ultimately draw the attention of machinery manufacturers.

The next phase of the transfer could be to involve agricultural contractors in New Zealand. Currently there is more demand from farmers for drilling than there is for drills. Therefore if direct drilling is to become more widely accepted, farmers must have access to high-tech equipment that will provide reliable results in conditions that may be less than satisfactory. One of the more frequent problems encountered has been the persistence of some farmers to use direct drilling in "sacrificial paddocks" which have had their soil structure destroyed by mob stocking over winter. Interestingly as the reliability of the technique has increased more farmers have seen that direct drilling can have an important role in establishing pasture on better paddocks.

Agricultural contractors with high-tech drills and the expertise necessary to provide an effective and reliable service could be trained through the Massey Field Programme. Elders Pastoral Ltd and Waitakei Catchment Commission are currently exploring this option for direct drilling in the central North Island and South Canterbury/North Otago regions (Ritchie, 1985). The Massey Field Drilling Programme has been used in both areas in recent years to establish the credibility of direct drilling as a low-risk technology.

In both cases it was wisely foreseen that promotion of direct drilling for reasons of conservation was only viable if farmers could expect crop yields equal to those obtained from conventional tillage with no more biological risks. There are substantial data to show that in many soil conditions, high-tech direct drilling may promote seedling emergence with more assurance than tillage (Choudhary and Aban, 1986).

At both localities the demand for direct drilling may soon exceed the capacity of the Massey Field Programme to service it and suitable contractors will then be sought to take over our role. Previous attempts by Elders Pastoral to set up contractors to direct drill crops and pasture in the Taihape region have failed because the contractors have lacked the necessary high-tech equipment and the professional expertise which accompanies it. Conversely there is increasing acceptance of the Massey programme by farmers despite charges which are deliberately set above commercial rates so that unfair competition with local contractors does not occur. These charges also reflect the level of technology and expertise provided.

EXTENSION

Massey staff have been involved in discussions with individual farmers discussion groups and at field days. Most of the contact with farmers has been in association with demonstration areas set up on farmers' properties.

The programme has evolved into a full consultancy service for all inputs critical to the successful establishment of a direct drilled crop (including subsequent management). Consequently results have become more predictable and reliable and as a result the research and transfer of technology has developed still further. Other research staff from the university and adjacent research institutions have been associated with the field programme. Many of these scientists were initially asked to assist with specific problems that occurred with various crops such as disease, nutrition etc.

The overall effect has been to increase the collective experience and expertise available, which in turn has provided more reliable results from the drilling operations undertaken.

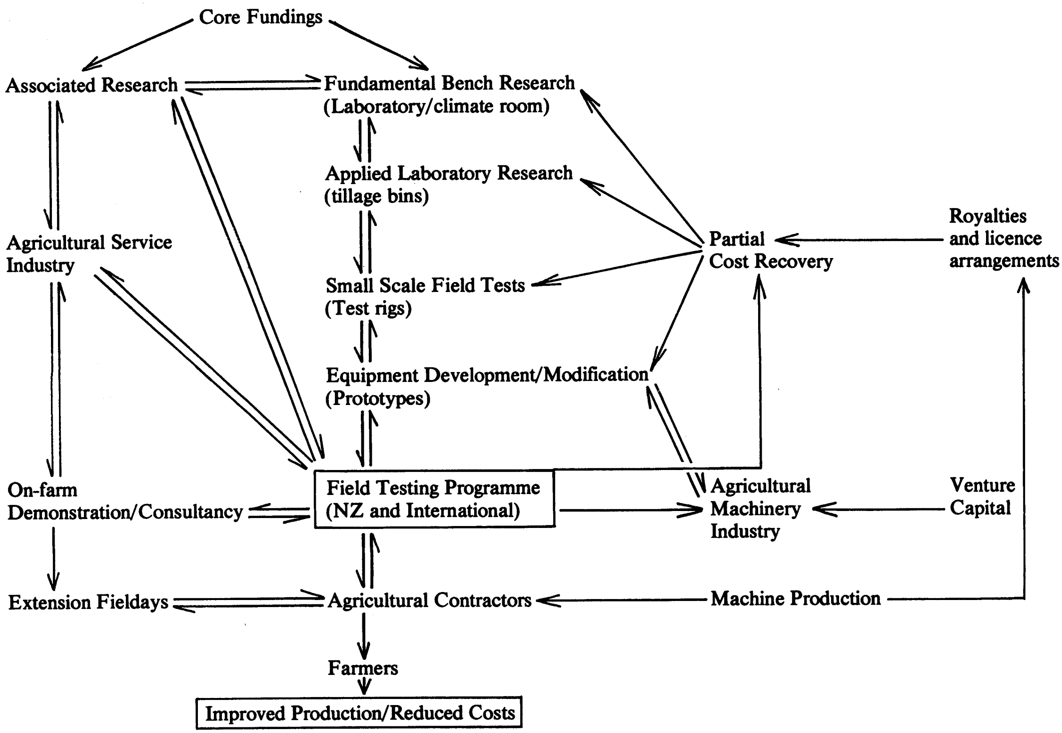
THE MODEL

A diagrammatic representation of the Massey Direct Drilling Field Programme model is shown in Figure 2. It illustrates the pathways which have been carefully maintained for interaction between fundamental research, equipment development, field testing, technology transfer and consultancy. This model is one of the few ways of clearly defining the development of basic concepts into marketable products in the field of agricultural technology. Other models, such as that used by the National Institute of Agricultural Engineering, in England, have also been successful in commercialising developments in equipment (R. Bell pers. comm. 1984).

However there are many institutions which have not maintained involvement with and control over their equipment as it was developed beyond an early prototype. In the United States, for example, further development of equipment has often been subjected to the commercial pressures of the farm machinery industry which has not always been conducive to thorough testing and rational evolution of the product to ensure that it meets the purposes originally intended (Baker, 1981).

The Massey Field Programme Model has provided a realistic and comprehensive test-bed for on-going development of equipment and associated management techniques for no-tillage

Figure 2. Massey University Agricultural Machinery Research Centre Field Test Programme Model



which has been achieved largely on a cost-recovery basis. The application of this model to other development projects within the Agricultural Machinery Research Centre is feasible and planned. This will help reduce the risk that firms may commercialise equipment that has not been adequately designed and field-tested.

The Direct Drilling Field Programme operated by the Massey University Agricultural Machinery Research Centre has a range of objectives. As its original objectives were to test equipment and identify problems and weaknesses in design, it inevitably had failures but these have been invaluable to the project in highlighting those areas where further research and development is required. Without the field testing programme these could not have been predicted. Not all failures were due to the equipment but many were due to other factors such as herbicides, insecticides and management practices which had to be modified. This period of analysis of failures was in conflict with another of the stated objectives of the programme, – the demonstation of direct drilling to farmers.

As the equipment was developed and the techniques became more reliable and the experience and expertise of the staff involved increased, the conflicts within the programme declined. In fact some of the current extension work undertaken has been to overcome the poor reputation of direct drilling developed during the 1970's and to improve the reputation of the Massey Direct Drilling Field Programme which was initiated against a background of limited staff experience and difficult machinery development problems.

The programme is essentially open-ended. Over a period of ten years it has had many functions and its role continues to change. In the current economic climate, the "user pays" philosophy may change the function of the programme further.

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