FINAL REPORT

OF

PROJECT NO FV41a

Design and testing of commerical prototype equipment for application of starter fertiliser

FINAL REPORT (Aug 1993)

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Design and testing of commercial prototype equipment for application of starter fertiliser

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Project completed	Sept 1993

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Relevance to growers and practical application

Application

Recent experiments at HRI Wellesbourne, aimed at using fertiliser more efficiently, have involved the injection from the seed drill, of liquid starter fertiliser 2-3 cm beneath the seed. The technique can increase yields or, more importantly, maintain yields with reduced fertiliser input, lead to an earlier harvest, and enable good yields to be obtained from less fertile soils. The experimental equipment, designed at HRI, has not been available to growers. The object of the project was to work with the drill manufacturers Stanhay-Webb to produce commercial equipment which would be available to growers.

Summary

Work at HRI Wellesbourne over a number of years led to the development of experimental drill-mounted equipment which injects starter fertiliser 2-3 cm beneath the seed. The objective of HDC project FV41a was to work with the British vegetable drill manufacturers Stanhay-Webb to produce a commercial prototype from the HRI design. The resulting commercial product is very similar to the experimental design except that a harder wearing steel is used for the injection coulter. Stanhay-Webb gave nine demonstrations to various growers and organisations, most of whom were impressed by the results. The equipment will appear on their 1994 price list.

Compared with conventional fertiliser applications, there are four potential benefits from using starter fertiliser in combination with broadcast fertiliser. These are:-

1. Better yields for the same total fertiliser application (starter plus broadcast), even on fertile soils.

2. Better yields when total fertiliser application is reduced.

3. Much better yields on low fertility soil.

4. Possibility of enhanced maturity and improved grading.

There has been in sufficient work to quantify the benefits of starter fertiliser in all situations but crops which have shown good responses include early carrots, salad and bulb onions, lettuce and parsnips. The most responsive soils appear to be light soils or those with a low fertility. The most effective fertiliser is ammonium phosphate or mixtures of ammonium and potassium phosphate. Compound fertilisers containing chloride or nitrate ions can reduce plant stands and should not be used.

Experimental Section

Introduction

The scientific studies which led to the development of starter fertiliser injection equipment at HRI began in the early 1980's when Costigan (1984) showed that, even on a fertile soil, placing fertiliser beneath the seed could increase the early growth of lettuce seedlings. However the experiments were carried out in pots, and there was no simple way to exploit these findings for field-sown crops. Clearly a method of injecting liquid fertiliser beneath the seed was required.

At about the same time studies were being carried out on the effects of different methods of seed bed preparation on the germination and establishment of early sown carrots and onions (Rowse and Goodman 1984, Rowse, Stone and Goodman 1985). It was observed that when wet weather follows drilling, most cultivation methods were satisfactory. However in drier conditions, the best germination was obtained from treatments involving shallow spring cultivations, to about the sowing depth. Similar findings by Flake and Brinkman (1979) and Hakansson and von Polgar (1984) have been attributed to the fact that undisturbed soil beneath the seed is better at conducting water to the seed than freshly disturbed soil. These findings illustrated the potential danger of a fertiliser injection coulter which would loosen the soil beneath the seed to an extent that would inhibit germination. Indeed several of the early prototypes did just this before an experimental design was obtained which performed satisfactorily under field conditions.

The objective of this project was for HRI to work with Stanhay-Webb, the major British vegetable drill manufacturer, to produce four pre-production prototypes based on the HRI design, in time for the 1993 season. This would enable trials and demonstrations to be carried out in different parts of the country, and ensure that a product was available to growers from Stanhay-Webb. The project was unusual in that no specific experiments were carried out. This short report will therefore describe the injection equipment (including early prototypes) and modifications made by Stanhay-Webb, and very briefly illustrate some of the results obtained in 1993. A full report on results over the last three years will be made in the final report of the associated project FV41- Drilled horticultural crops: starter fertiliser.

Materials and Methods

Injection coulters

The first prototype (fig 1) was fitted to a Stanhay S870 vegetable seed drill. In an attempt to minimise soil disturbance a Stanhay trash cutting front wheel (Part No 7700037, 3 in fig 1) was used to open the soil in front of the 3.5mm wide injection coulter.(2) Liquid fertiliser was injected below the depth of the seed coulter (4) through a 3.3mm OD stainless steel tube brazed to the trailing edge of the injection coulter (1).

Fertiliser injected with this coulter did increase seedling growth rates (Rowse *et al.* 1988) but water injected through the coulter tended to reduce growth compared with a conventional drill due presumably to soil disturbance beneath seed depth.

Apart from problems associated with soil disturbance, the extensive modifications to the drill shown in fig 1 would prevent the commercial manufacture of this design. It is more convenient to attach the injection coulter to the leading edge of the seed coulter as shown in fig 2. It is then a simple matter to convert a drill for fertiliser injection by simply changing the seed coulters. This design was tested but again its use tended to reduce emergence compared with the unmodified coulter.

The latest and most successful design is shown in fig 3. (See also photographs in appendix). It consists of a narrow raked-back knife coulter mounted forward of the drill unit front wheel at an angle of 30 degrees to the vertical.(Plates 1 & 2). The knife coulter was made from 6 mm mild steel but the lower portion which runs below seed depth was only 3.5 mm wide. Slots in the coulter enabled its depth to be adjusted. Usually the depth was set to between 1 and 2 cm below seed depth. Liquid fertiliser was pumped through a stainless steel tube silver soldered to the trailing edge of the coulter. Clearly in commercial use mild steel would wear too quickly so Stanhay-Webb have used a steel 080M15 which has been case hardened to 60 Rockwell C, to a depth of 1mm. It proved difficult to weld, braze or solder the stainless steel tube to this material so it was attached with epoxy cement. This has not been entirely satisfactory and some design changes may be required in the future.

The fertiliser pump

Early HRI experiments were carried out using a 12 volt electric windscreen washer pump. Since 1987 a much more versatile pumping system has been used based on six Watson-Marlow type 303 peristaltic pumps. (See plates 3,4 & 5 in appendix). In a peristaltic pump, liquid passes through an elastic tube which is constricted by a number of rollers. The rotating action of these rollers causes the constrictions to move along the tube, producing a flow of liquid along it.

This type of pump has many advantages for fertiliser injection compared with conventional PTO driven systems. It can be used when the tractor PTO is in use for another purpose such as powering the vacuum pump on the Stanhay Singulair drill. Unlike conventional systems, which use a manifold to divide the flow from a single PTO-driven pump, a separate pump is used on each injection line. Each pump can develop a pressure in excess of 1 bar and consequently there are virtually no problems with soil blocking the outlets on the injection knives. (This ability to develop pressure has enable the pumps to be used to band spray liquids such as the liquid soil conditioner "Soiltex"). When not rotating, the tube is always constricted by one of the rollers so that fertiliser does not siphon through the pump when the drill is not in work.

The pumps are ganged together on a common shaft (see photo) which is driven by a 6:1 ratio chain drive directly from one landwheel of the drill. The landwheel-drive means that the fertiliser starts to be pumped as the drill is lowered into work, and stops automatically as it is raised out of work. The pump speed is always directly proportional to the drill speed, so that over a limited range of drilling speeds, the amount of liquid applied per unit length of row is not affected by drilling speed. A range of different standard tube diameters can be used to produce different flow rates as shown below.

Tube bore (mm)	0.5	0.8	1.6	3.2	4.8	6.4	8.0
Pumping rate (ml/min)	6	14	54	200	440	720	1000
Application (ml/m row)	0.11	0.26	1.0	3.7	8.2	13.4	18.6

Intermediate rates can be obtained by using non standard tubing. For commercial application the two highest rates (13.4 and 18.6 ml/m row) are generally used but in experiments, the smaller tube sizes have been used to meter small amounts of liquid fertiliser. (Rowse *et al* 1988, Thompson *et al* 1988, 1990). Care must be taken when fitting new peristaltic tubes to the pumps that they are not stretched too tightly across the rollers as this can cause pumping rates to fall below those listed above.

Results

The object of FV41a was to develop a commercial prototype design from the HRI prototype. This has been achieved and Stanhay-Webb will be including starter fertiliser equipment in their 1994 price list. Stanhay-Webb carried out nine starter fertiliser demonstrations including ones for Kirton, Gleadthorpe, British Sugar, Nickersons Seeds, and a number of consultants. Most were impressed by the results. Stanhay-Webb have also been approached by a number of companies wishing to supply chemicals. It is important to note that all recent experiments at HRI have been carried out using ammonium phosphate or mixtures of ammonium phosphate and potassium phosphate. Compound fertilisers containing chloride or nitrate ions can reduce plant stands and should not be used.

This project is not concerned with the benefits from the use of the equipment, some of which have already been reported (Rowse & Stone 1991, Stone & Rowse 1992a, 1992b. A full report will be given in the final report of FV41. However the reader may be interested in some early observations on the data from the 1993 experiments in which the prototype equipment was used but which have yet to be fully analyzed statistically.

At Wellesbourne on a sandy loam soil, carrots onions and lettuce have shown good responses to starter fertiliser in previous years. For the 1993 experiment the responses of parsnip, red beet, calabrese and spinach were tested. Of these only parsnip showed a large response to starter fertiliser with 70% increase in yield at an early prepack growth stage. At Kirton and Arthur Rickwood onions and lettuce were used on a silt and organic soil respectively. At the time of writing the Kirton data is not available, but at Athur Rickwood bulb onions showed a small positive response of 15% at the salad stage, while the size of lettuce seedlings was nearly doubled.

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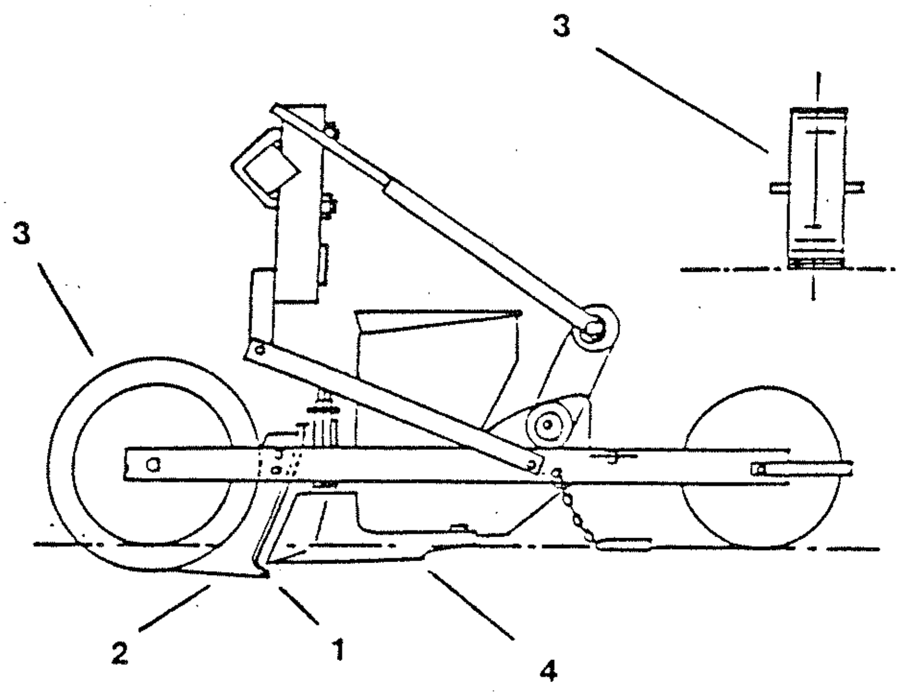

Fig 1. Early prototype injection coulter fitted to Stanhay S870 drill. 1 Fertiliser outlet, 2 injection coulter, 3 Stanhay trash-cutting front wheel, 4 seed coulter.

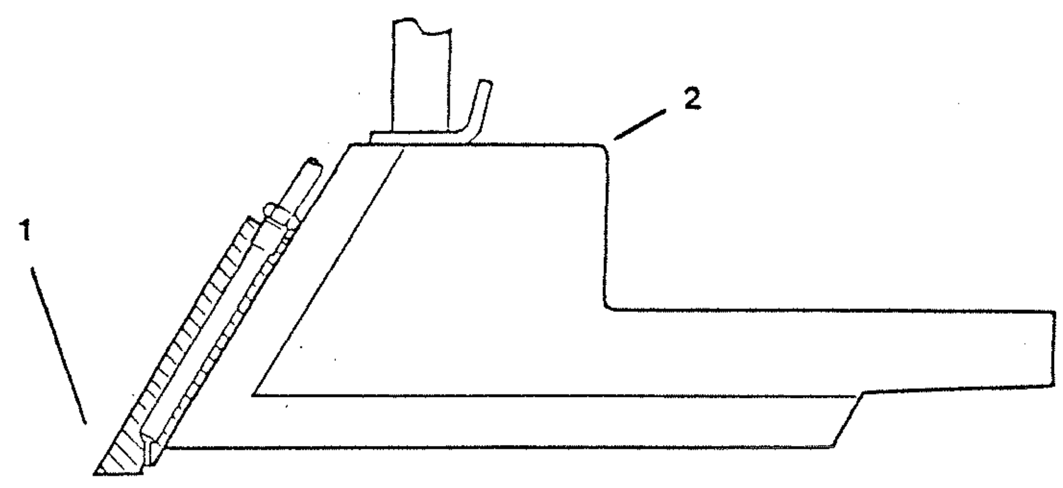

Fig 2. Later prototype injection coulter (1), mounted on leading edge of seed coulter (2).

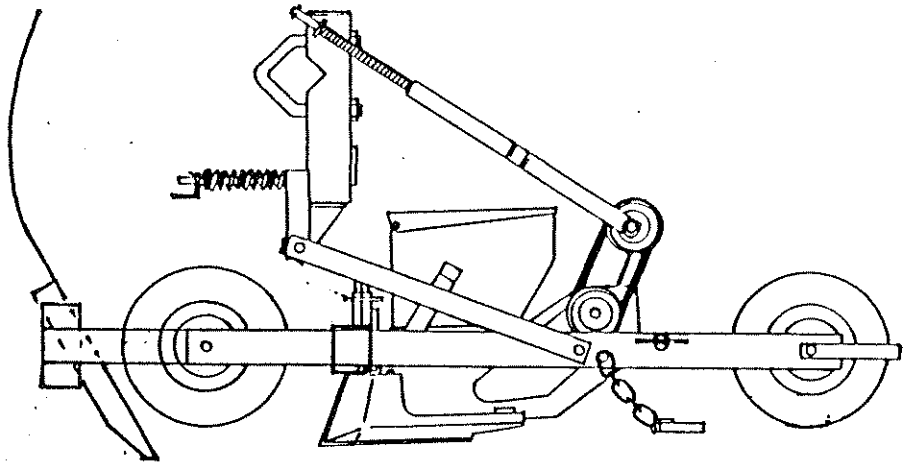

Fig 3. Stanhay S870 unit showing position of commercial prototype injection coulter.

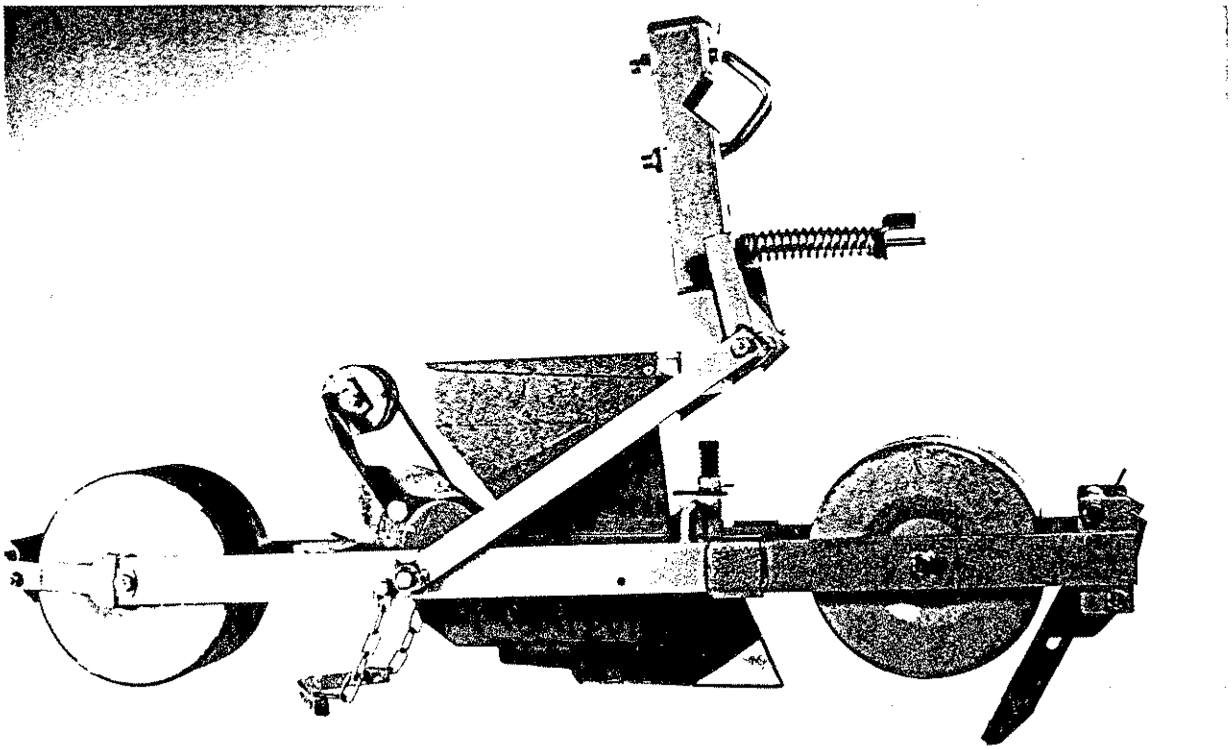

Plate 1. Stanhay S870 drill unit with HRI starter fertiliser injection coulter.

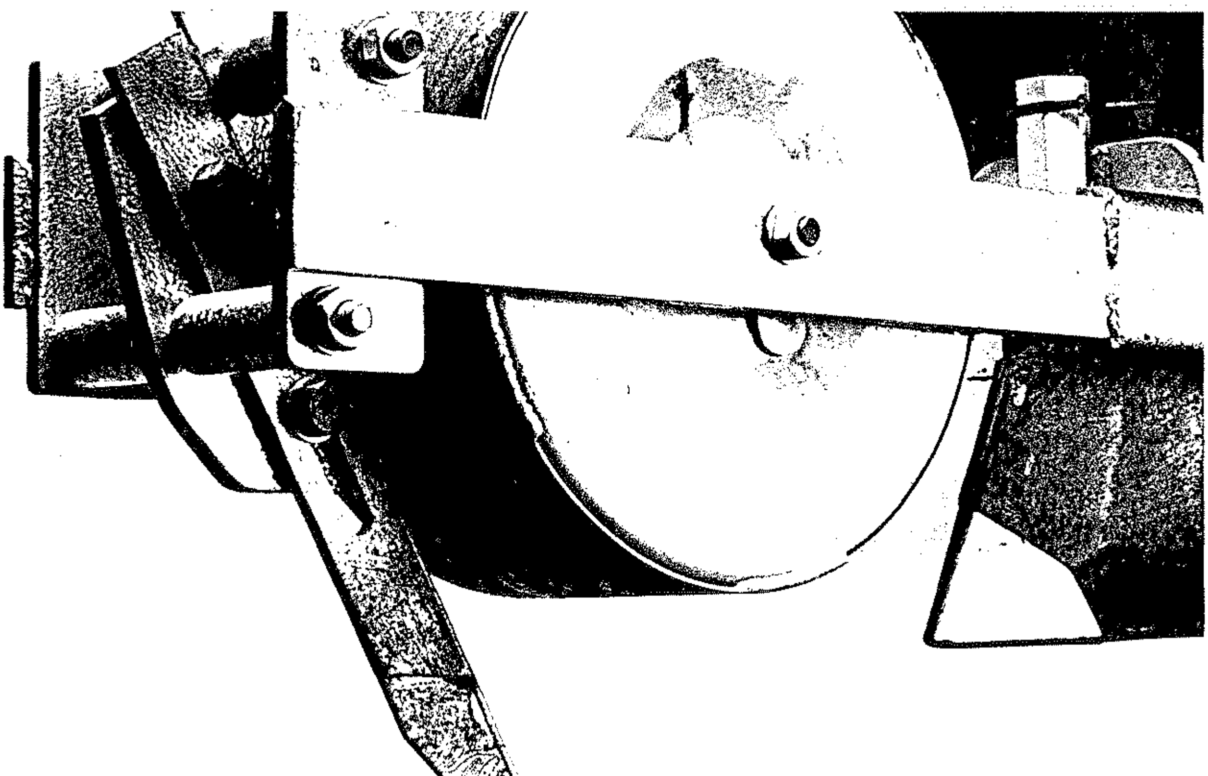

Plate 2. Detail of injection coulter.

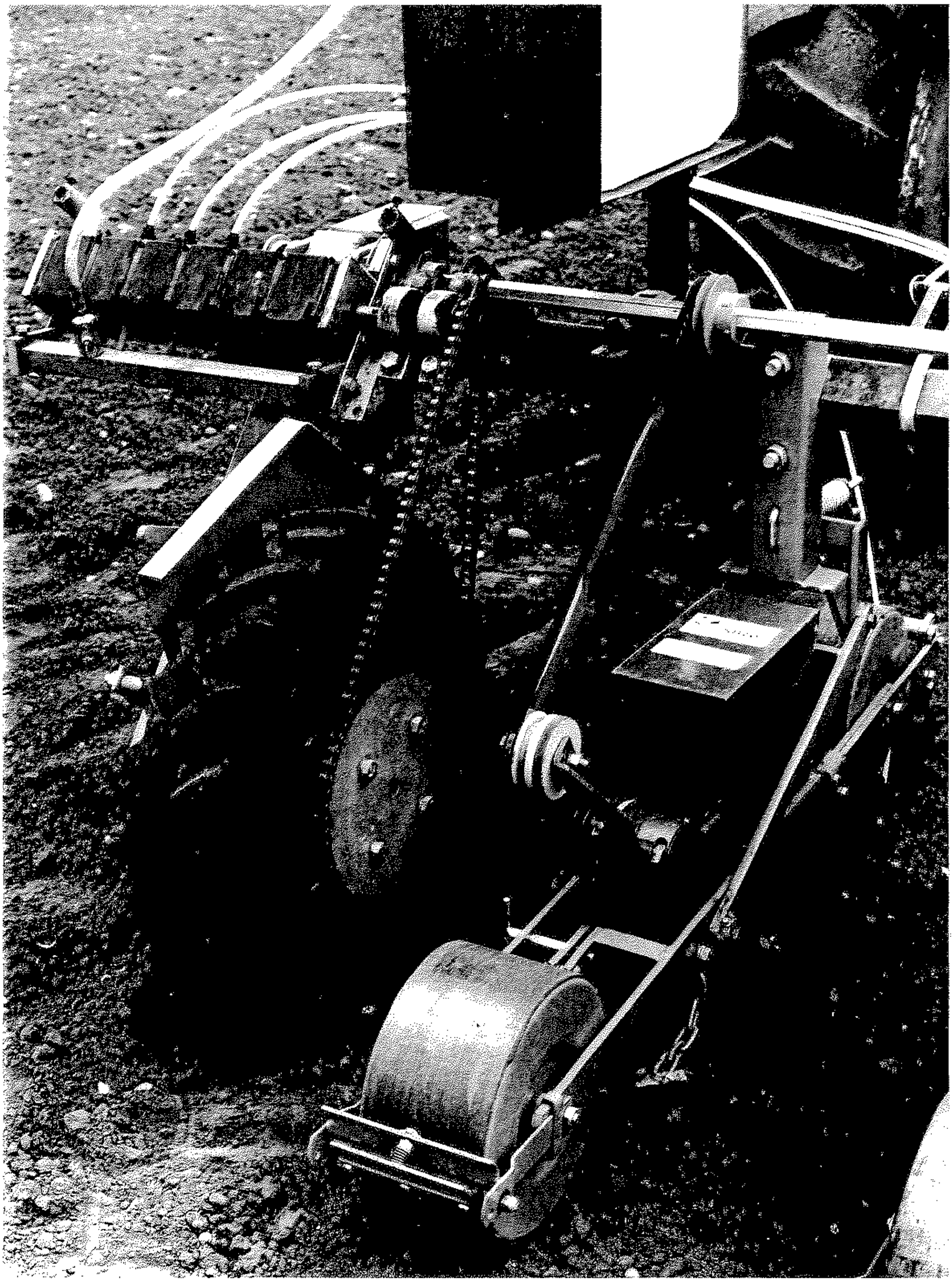

Plate 3. Bank of six peristaltic pumps mounted on drill.
Note the 6:1 direct chain drive from land wheel of drill.

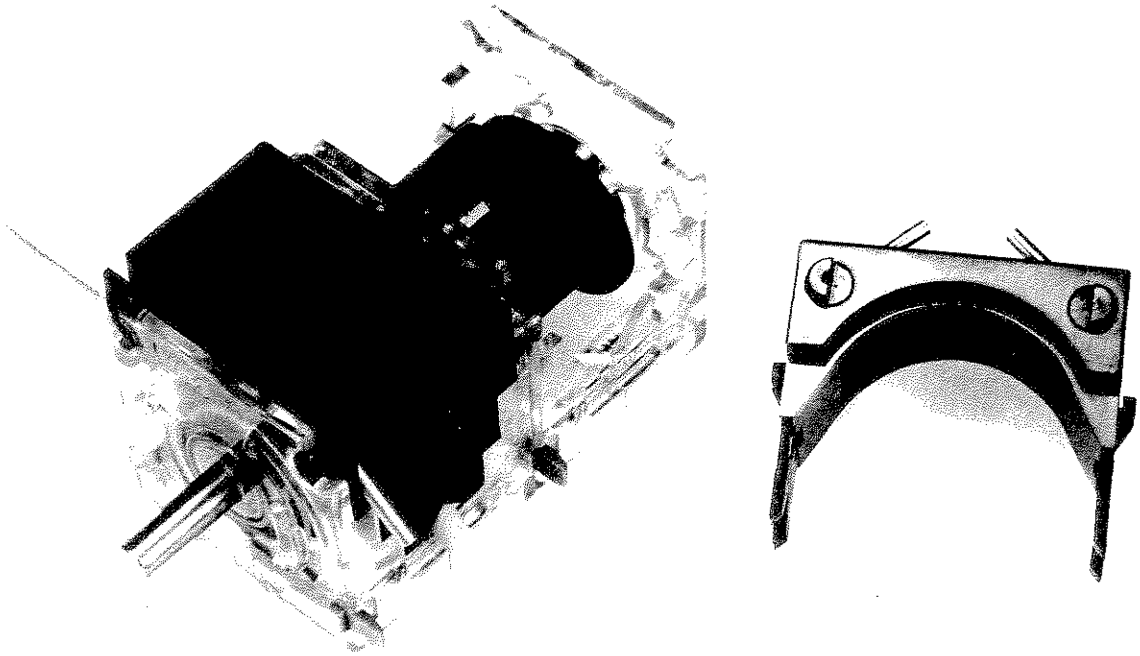

Plate 4. Detail of Watson-Marlow type 303 peristaltic pumps. Note one pump assembled with tube and the other with top removed to reveal rollers.

Plate 5. 3-row Stanhay S870 fitted with HRI injection equipment.

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Contract between HRI (hereinafter called the "Contractor") and the Horticultural Development Council (hereinafter called the "Council") for a research/development project.

PROPOSAL

1. TITLE OF PROJECT **Contract No: FV/41a**

DRILLED HORTICULTURAL CROPS: DESIGN AND TESTING OF COMMERCIAL PROTOTYPE EQUIPMENT FOR APPLICATION OF STARTER FERTILISER

2. BACKGROUND AND COMMERCIAL OBJECTIVE

Very encouraging results from the use of starter fertiliser were reported in HDC News No 13, indicating how good yields of vegetable crops might be obtained from soils of low nutrient status. Even on high fertility soil, useful responses were observed. These findings, together with previous work, have stimulated much interest among growers and researchers, and there have been many requests to borrow the HRI injection equipment.

The equipment developed at HRI Wellesbourne appears to have no commercially available alternative. The best responses to starter fertiliser are probably obtained from early-sown crops, and, at this time of the year, problems can arise when trying to share one piece of equipment between even two sites. Several sets of equipment are required to meet current demand for loans. A further problem is that the HRI equipment has only been designed for drilling small experiments, and would need some modification to enable it to be used on a commercial scale.

The initial objective of the proposal is for HRI to work closely with Stanhay-Webb, the major British manufacturer of vegetable seed drills, to produce and test, a number (probably 4) of pre-production prototypes based on the HRI design, which would be available for the 1993 season. This arrangement will provide sufficient units for trials to be carried out on different soils in different parts of the country. It will also ensure that eventually a product is available from Stanhay-Webb for growers wishing to use the technique. An objective for subsequent years is to coordinate trials carried out in different parts of the country to ensure that the technique is tested under a wide range of conditions, and to draw together the results.

3. POTENTIAL FINANCIAL BENEFIT TO THE INDUSTRY

It is likely that the technique will enable a reduction in the amount of fertilizer used, although the liquid starter fertilizer may be more expensive then the solid it replaces. The potential for producing larger and earlier crops has been well proven.

4. SCIENTIFIC/TECHNICAL TARGET OF THE WORK

The primary target is to have the four sets of prototype equipment ready for the Spring of 1993. Some technical development will probably be required in the following year.

5. CLOSELY RELATED WORK - COMPLETED OR IN PROGRESS

The current proposal is designed to supplement current proposals in HDC FV/41.

6. DESCRIPTION OF THE WORK

A meeting was held on 4 March with Stanhay-Webb who were enthusiastic. The technical development of the project is seen as three parts:-

1. Development of injection knife suspension system.
2. Development of pumping system.
3. Development of injection knife.

Stanhay-Webb expect to complete 1 & 2 and perhaps 3 ready for 1993. For experimental purposes the existing mild steel injection knife will be adequate. However for commercial drilling special materials will probably be necessary such as tungsten carbide or ceramic edging, or special plastics. Some technical development will be required during the Summer of 1993.

7. COMMENCEMENT DATE AND DURATION

Work will start in May 1992 and continue through the Summer so that the prototypes will be ready for Spring 1993. It is probable that some technical improvements will be required during 1993. It has been suggested that HRI coordinate the use of the drill on different sites and collect the results together. A proposal to fund this aspect of the work will be submitted to the field vegetables panel in the future.

8. STAFF RESPONSIBILITIES

Project Leader: Dr H R Rowse, HRI Wellesbourne.
Experiment Leader: Mr D A Stone, HRI Wellesbourne.

9. LOCATION

All initial work will be done either at HRI Wellesbourne or at a site convenient to, and selected by Stanhay-Webb. The siting of experiments in 1993 has yet to be decided, but interest has already been shown by ADAS in the Vale of Evesham, Kirton, Arthur Rickwood, Gleadthorpe, and several growers.