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TOWARDS THE DEVELOPMENT OF A SEED INJECTION MECHANISM FOR USE IN MINIMUM TILLAGE PLANTING

By

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ABSTRACT

Some advantages of minimum tillage compared to conventional tillage systems are given. An evaluation of current minimum tillage planters is then made identifying two major problems namely the handling of trash, which detracts from making a continuous furrow of uniform depth, and unnecessary power consumption when making this continuous furrow in spaced planting of seeds.

Then the design, manufacture and development of a rig type of a seed injector for use in precision-drilling of a typical tropical seed is presented. It is proposed to inject the seed using a rotary sleeve valve in a planter which is tractor drawn.

Preliminary field testing of the mechanism was carried out showing the feasibility of the mechanism subject to further work in accordance with some recommendations which are presented.

1. INTRODUCTION

The purpose of tillage could be summarized as removal of unwanted vegetation, trash burial and the production of desirable conditions for crop growth. Different cultivation systems can have a devastating effect on the environment in the long run by promoting soil erosion (by wind and water), loss of aggregate structural stability leading to surface capping and affecting rainfall infiltration. Additionally, tillage is a very expensive operation usually requiring several tools and passes to achieve a desired tilth. Bose and Patel (1965) reported that about 30% of the power in agriculture is expended on

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tillage, with 15% on primary tillage alone. Thus it could be economically worthwhile to reduce the number of tools and passes if this can be done without affecting crop yields.

The minimum tillage system is attractive to both temperate and tropical countries, but more so to the latter when compared to conventional tillage, for the following reasons:-

- reduced soil erosion by wind and water (Dickey et al, 1985).

- reduced water loss due to the no-tilled soil having a higher water retention capacity in the root zone (IITA, 1983).

- increased infiltration as capping is minimized in minimum tillage

- reduced investment in farm power and machinery (Kahle, 1985).

- better timeliness of planting and adequacy of weed control (Chaudhary, 1983). Timeliness of planting is a very important consideration (Bunting, 1968) which is often over looked.

- no-tillage crop residues resulted in higher concentrations of C,N,P. and exchangeable Ca and K compared to ploughed plots under Nigerian conditions. There was also a stratification of pH in the 0-500mm layer (Chaudhary, 1983) and no phototoxin effects. The no-tillage soil was found to have a high organic matter content and better soil structure after 24 consecutive crops (IITA, 1983).

- With good drainage, nutrient availability and adequate pest control, minimum tillage yields are comparable or slightly greater than in conventional tillage (Griffith et AL, 1977).

To this end it should be pointed out that although most of the cultural operations necessary for the successful operation of a particular minimum tillage system can be carried out effectively, most of the advantages of minimum tillage have not yet been fully realised so far because of the complexity of design of planters that will perform well in the kind of conditions to be encountered in minimum tillage, especially the handling of trash. Hence the conception of this project.

2. REVIEW OF CURRENT MINIMUM TILLAGE PLANTERS

Current minimum tillage planters can be categorized into two basic types, namely the rolling injection type and conventional planters modified for minimum tillage.

2.1 The Rolling Injection Planters

These consist of a rolling ground-contacting wheel to the periphery of which are attached one or a number of seed injectors in the form of beaks which can be opened and closed by a lever or cam arrangement. These injectors receive the seed from the open below which there is a seed metering mechanism driven from the rolling wheel.

There are various problems associated with the operation of these planters, which include, among others,

- they are not heavy enough to penetrate hard soil,
- a narrow range of seed spacings,
- clogging of injectors in moist cohesive soils, to mention a few.

2.2. Conventional Planters Adapted for Minimum Tillage

Modification of the conventional planters has in the main involved the incorporation of the trash handling coulters, and eliminations of furrow openers and seed covered by the special soil openers and seed coulters, while on some designs pneumatic injection of the seed is used, e.g. the A-blade coulter (Mac Intyre et al, 1986).

The main operational problem of these planters is the general incompatibility between depth control functions and residue tolerance (Morrison and Gerik, 1985). Additionally these planters:

- are not adapted to spaced planting of typical tropical crops such as maize, beans, peanuts, etc.
- are large, heavy and expensive.
- have soil opener penetration problems under hard soil conditions.

3. THE DESIGN OF THE SEED INJECTOR

3.1 Problem Definition

In views of what has already been discussed, a novel direct drilling mechanism of the injection type was designed, manufactured and tested. It was intended that the injector should fulfill, among others, the following main objectives:

- simplicity and ease of manufacture
- adaptation to precision drilling of various seeds
- minimum seed damage
- ability to plant through surface vegetation or trash.

3.2 Some Design Considerations

Since different crops have different agronomic requirements, it is very difficult, if not impossible to realize a planter design that will handle all seeds and spacings. One possible approach to ease the decision making as to the level of technology to be incorporated into the design is to differentiate between the planting methods used for various seeds, namely broadcasting, hill dropping, ordinary drilling, and precision-drilling. It then becomes feasible to design a planter for precision-drilling a range of seed shapes, sizes and spacings, and this approach does away with the concept of a universal planter (Mutoizi, 1986).

3.3. The Basic Design of the Injector

A design of the injector is proposed whereby trash and soil penetration will be achieved by a positive action which converts the rotary motion of the ground drive into linear, reciprocating motion of the injector.

During the course of its reciprocating motion the injector will receive the seed preferably at its topmost position and deliver it at its bottom-most position. To facilitate this with minimum seed damage a rotary sleeve valve mechanism is used. Moreover, the sleeve valve eliminates the use of beaks which inevitably clog when operating in moist cohesive soils.

It is also proposed to reduce the draught of the injector tine by rocking the injector assembly such that during the soil engaging stroke the injector travels in a direction opposite that of the planter (see 4.0).

In line with the desired objectives, adjustability of within-the-row spacing and depth of planting can be achieved by varying the forward travel speed and the radial distance of the peg on the disc that operates the rocker and injector.

3.4. A note on Calculations

A kinematic calculation was carried out based on precision-drilling maize seed with 50 cm spacing and 40 mm depth of planting. The selected forward travel speed on which calculations were based was 2 m.p.h. or 0.9m/s since present-day drilling speeds are in the range 0.9-1.8m/s (Bufton, 1977).

One important feature of these calculations was to try and arrange that the tine peripheral speed at seed injection (position B-B, fig.2) be less than the forward travel speed of the mechanism (0.9m/s) so that the tine would have a net velocity (i.e. relative to the soil, assumed stationary) in the direction of travel of the mechanism (to the right). If this net velocity could be correctly chosen, then hopefully a gap would be formed between the soil and the tine into which the seed would be released. Additionally, at the rake angle of 90° a net tine velocity relative to the soil is likely to impart a certain level of compaction to the surrounding soil which is desirable for good soil-seed contact (Spoor, 1969).

Fig.1 shows the expected theoretical soil excavation profile.

4.0 DETAILED DESCRIPTION OF CONSTRUCTION AND FUNCTIONING (See Figs. 2)

Counter rotation of the landwheel (1) and the disc (2) is achieved using the crossed Vee-belt (3). The peg (4) engages the plunger assembly (5) in the position 'A-A' so that as the planter travels along, the injector tine (or plunger) penetrates the trash and soil against the action of extension springs (6). During penetration the injector assembly is rocked by the rocker assembly (7) in such a way that the injector moves in a direction opposite that of the planter for reasons already cited in sub-chapter 3.3. The injector receives the seed when it is in a position relative to the rocker such as indicated by 'A-a' and releases it in the position 'B-B' after which the extension springs retract the injector assembly back to the relative position 'A-A'. During one complete rotation of the disc, the sleeve valve bush (8) is rotated by a fixed pin (9) in the rocker engaging a helical slot in the bush such that the seed passage in the injector (10) is aligned with the inlet port on the rocker in the relative position 'A-A' while in position 'B-B' the bush has already been rotated so as to align the seed passage with the seed release port in the brass sleeve (8).

The support frame assembly (11) is made of Mild Steel Rolled Hollow Section for rigidity. The frame also provides for easy fitting of the components and adjustability of belt tension. The planter is drawn using a parallel linkage attachment (Kepner et al., 1982) from a tool bar suspended on a three-point linkage.

5.0 TESTING

5.1. Testing Procedures

The ultimate criterion for evaluating a complete planting operation is the pure stand obtained in the field, which depends on seed viability and vigour as well as environmental factors, all beyond the control of the planter (Kepner et al., 1982). As the mechanism was not operating in conjunction with a seed metering mechanism as yet, evaluation of the pure stand would have been unrealistic if not impossible. Nevertheless some performance tests were carried out whereby assessments were mainly visual, accompanied with some measurements where necessary. It was thus intended to assess the following:-

- Soil excavation and seed placement, of interest here being the creation of a gap between the injector and the soil into which the seed would be free to emerge.

- Operation on a mulch cover, to assess the penetration behaviour and trash blockage.

- Clogging.

- Power saving. The draught was measured using an extended octagonal ring transducer (Godwin, 1975; Godwin, 1982). A lab calibration of the ring transducer was carried out using a strain gauge amplifier, a UV recorder and set of weights. In the field three different travel speeds, 1, 1.5 and 2 m.p.h. were used. It was intended to use these speeds since the common drilling speeds noted in section 3.4 are for planters using furrow openers. Since in the design of the injector there is need for synchronization between the seed metering unit and the injector rotatory sleeve valve, speeds in the range 0.9-1.8m/s result into less time available for the seed to be delivered, say by gravity drop, from the metering unit to the sleeve valve, if the injector is to deliver a seed each cycle. Thus lower speeds were selected. The mechanism was then operated in two modes at each speed, namely while jabbing and while locked in the vertical position, in order to have an idea about the saving in power that could be achieved by intermittent action of the injector compared to making a continuous furrow. The average draught at each speed was measured using a digital plainmeter. These tests were carried out on a clay loam soil that was specially prepared by Cambridge rolling and levelling prior to testing.

5.2. Discussion of Results

- Soil Excavation and Seed Placement: Despite allowing the soil time to dry it was so sticky at the time of testing that it was not possible to assess the designed gap between the soil an the injector. There being no seed metering unit, and attempt was made to hand-feed the mechanism with maize seed but it was not possible to deliver any seeds into the soil due to the soil being so sticky as to quickly plug the seed deliver port.

- Operation on Mulch: It was observed that with a fair amount of barley straw ca. 20 mm thick the injector could easily penetrate but there was some dragging along of the barley straw due to belt and wheelslip which changed the designed synchronous speed relationship between the injector mechanism and the ground.

- Clogging: The injector was found not to execute the full stroke because of clogging of the lower end of the helical groove in the brass sleeve (i.e. the groove accommodating the pin which rotates the sleeve to align ports at the topmost and bottom-most positions of the injector). Apparently there was no clogging between the brass sleeve and the rocker.

- Power Saving: A convenient sampling time of 6 sec. was used for determination of average draught at the different speeds in both modes-locked and jabbing. Two sets of results, in dry and wet conditions, were obtained as follows:-

AVERAGE DRAUGHT, N				
	Locked		Jabbing	
Speed (m.p.h.)	Dry	Wet	Dry	Wet
1	558	278	495	235
1.5	622	313	472	223
2	478	-	-	230

PERCENTAGE SAVING IN POWER		
Speed (m.p.h.)	Dry	Wet
1	11%	18%
1.5	24%	29%
2	-	-

Due to the time and weather constraints the average draught of the jabbing mode in dry conditions at 2 m.p.h. could not be obtained as the photographic paper for the UV recorder ran out. Likewise the average draught of the locked injector in wet conditions at 2 m.p.h. could not be measured because of breakdown of the strain gauge amplifier. But nevertheless, the results seem to show that the saving in power increases as the speed of travel increases, suggesting the mechanism might be suitable for operation at high planting speeds, subject to there being enough time per cycle to deliver the seed from the metering unit to the injector sleeve valve.

6.0 CONCLUSION AND RECOMMENDATIONS

The limited testing conducted confirmed the feasibility of the mechanism if improvements can be carried out, as follows:-

- the ground clearance has to be increased to avoid trash blockage.
- the injector tine should be sharp and as narrow as possible for penetration and operating around obstacles such as maize stumps from the previous crop.
- the creation of a gap between the soil and the injector into which the seed can be released should be investigated using a coarse non-sticky soil in dry and friable conditions.
- timing might be improved by using a cogged belt or chain drive but at the expense of complicating the design a bit since counter-rotation of the lang-wheel and disc are desirable. Only one wheel might suffice to drive the mechanism for a number of injector units.

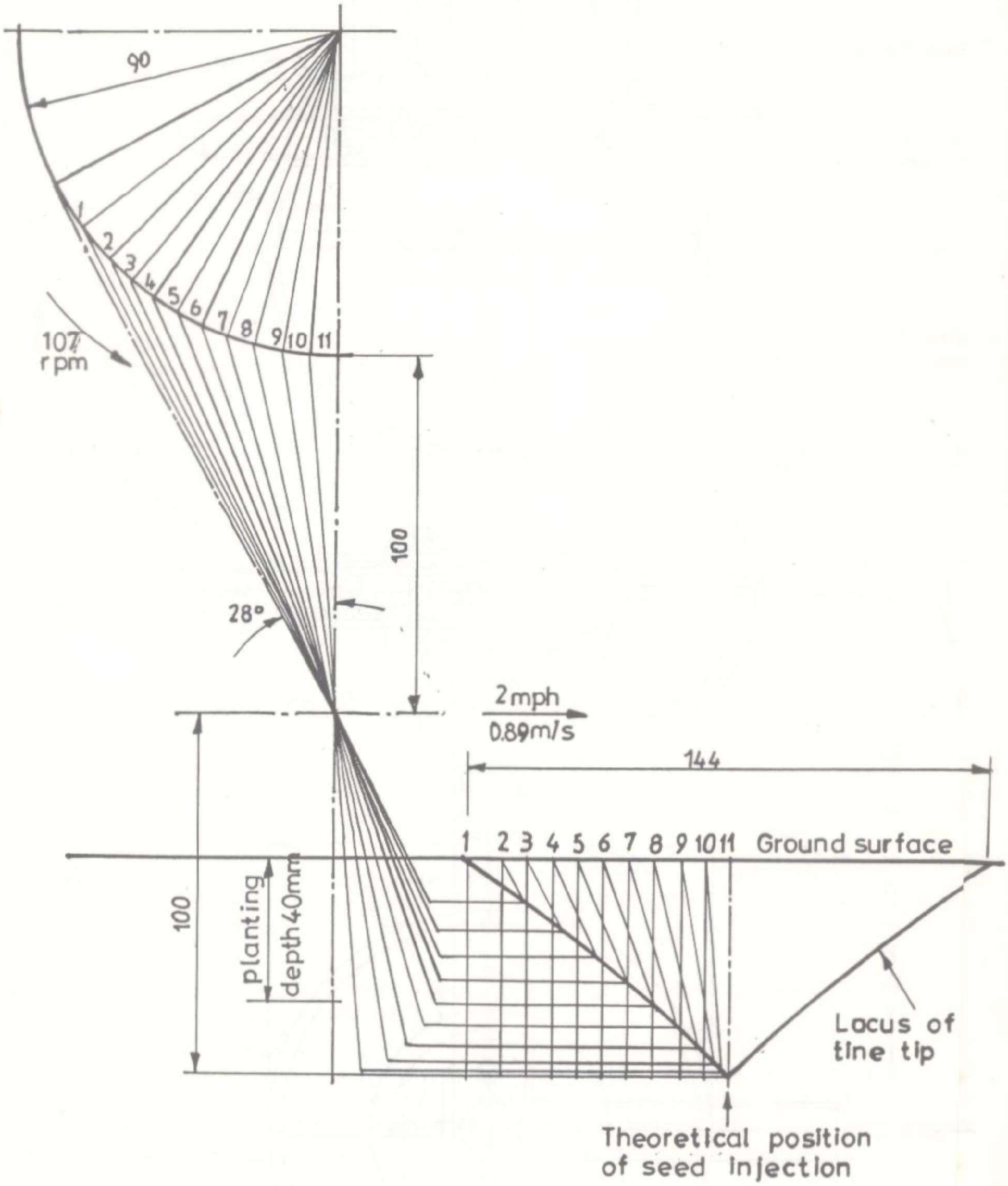

Fig. 1: Soil Excavation profile (theoretical) in elevation.

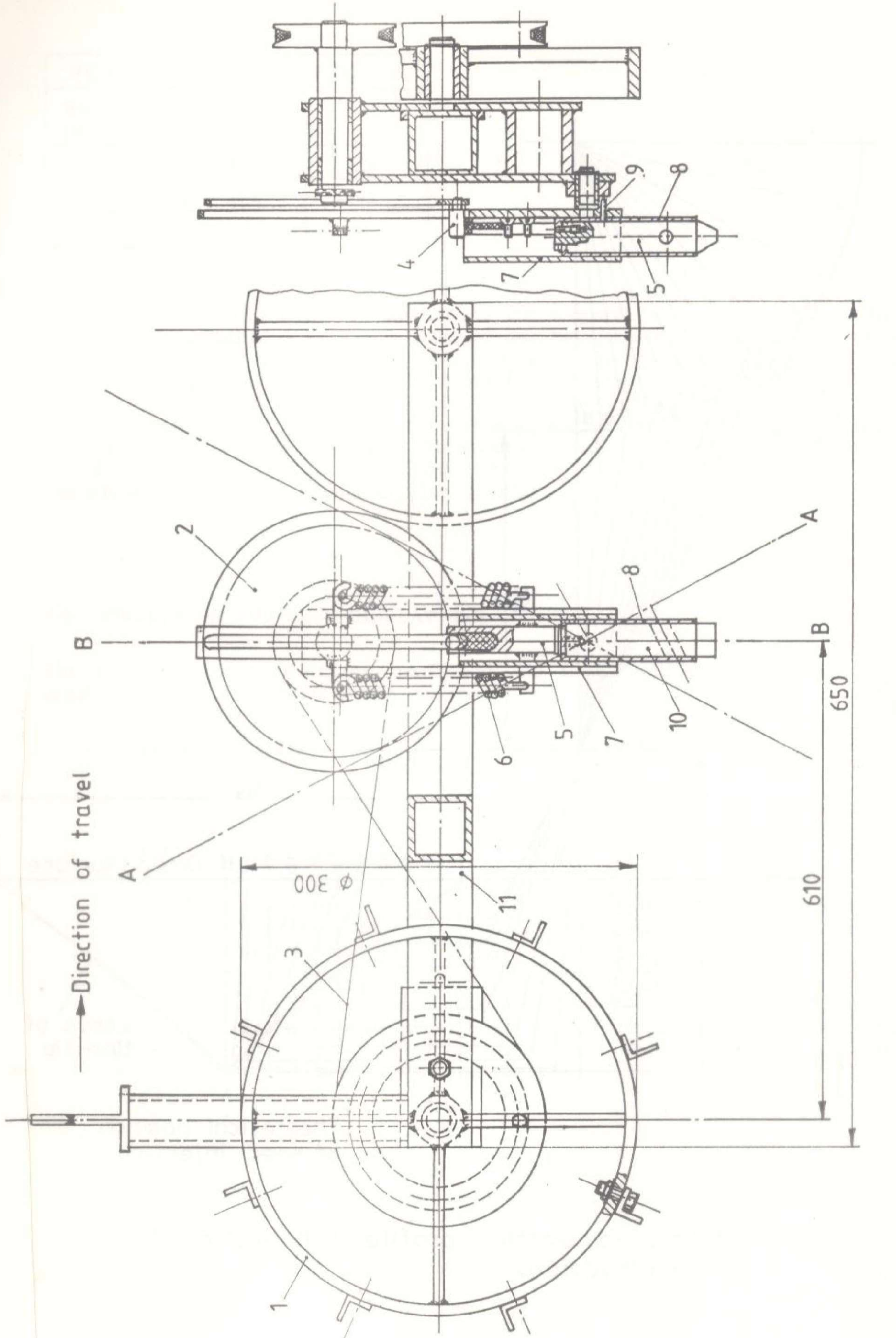

FIG. 2

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