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SILSOE RESEARCH INSTITUTE

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THE DEVELOPMENT OF PROTOTYPE MOBILE SEED DRESSING APPLICATORS SUITABLE FOR AFRICAN COUNTRIES

UNIDO PROJECT NO: US/RAF/88/273

FINAL REPORT OF WORK CONDUCTED BY SILSOE RESEARCH INSTITUTE

P C H MILLER; J D POWER

September 1995

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THE DEVELOPMENT OF PROTOTYPE MOBILE SEED DRESSING APPLICATORS SUITABLE FOR AFRICAN COUNTRIES

P C H MILLER; J D POWER

Summary

1. Work by Silsoe Research Institute was directed at designing a pedal operated batch seed treatment unit with a maximum capacity of 10 kg per batch. The design was based on an existing unit as recommended by the Chief Technical Advisor to the project and the design and development study aimed at producing a mechanism which was relatively light and portable, could be fabricated without specialist tools and was sufficiently robust to operate in field conditions with a minimum of operator and environmental contamination. The main features of the design study were:

   (a) the use of a plough disc with added roughness elements to increase the friction between the disc rotor and the loaded seed batch;

   (b) a fabricated rotor housing and bearing support system for the disc which was driven from a pedalled crank via a vee-belt drive and free-wheel arrangement;

   (c) the use of a spinning disc for distributing the chemical within the treatment chamber with the disc directly connected to the main rotor and driven at the same speed from the same drive shaft;

   (d) an examination of the feasibility of using an air flow through the gap between the rotor and the stator such that the need for close tolerances could be relaxed - this was found not to be a practical approach.

2. Performance assessments were conducted involving:

   (a) in-country field trials in Zambia and Tanzania which aimed at assessing the operating characteristics of the design, the suitability and acceptability of the unit in realistic conditions, the ability to treat the required range of seed types and to assess the quality of seed treatment that could be achieved;

(b) developing tracer dye techniques for visually assessing the quality of treatment and for making measurements of chemical deposits on individual seeds using spectrophotometry techniques - facilities for making such observations were set up in the two African countries visited;

(c) subjecting defined batches of seed to given treatments such that they could then be used in field trials.

3. Results from the design and performance assessment study showed that the proposed unit was capable of achieving a good quality treatment (coefficients of variation of deposits on seeds of typically 25%) and, at the end of the work, was well suited to the proposed method of operation and the expected working conditions. Two experimental units constructed by Silsoe Research Institute as part of the project were left in Zambia and Tanzania (one in each country) on completion of the in-country trials work. Other key results from the study were:

(a) that operation of the main rotor formed from a plough disc at speeds of approximately 250 rev min^{-1} gave a good mixing action with a range of seed types and with a power consumption that could be provided by a pedalling input;

(b) that the liquid distribution disc could operate satisfactorily at rotational speeds down to 200 rev min^{-1} at flow rates in the order of 10 ml s^{-1};

(c) field trials with different batch sizes indicated that many operators maintained effective operation at the required rotational speeds for longer periods if the batches were less than 10 kg: this has implications for the future development of the unit since it would be easier to construct a smaller unit with a reduced maximum capacity particularly in respect of the close tolerances on the clearance between rotor and stator.

4. Staff at Silsoe Research Institute contributed to other work in the project associated with:

(a) the design and evaluation of other treater designs including a larger tractor operated unit the design of which was led by TEMDO in Tanzania;

(b) the training of African personnel associated with the project during visits to the UK.

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THE DEVELOPMENT OF PROTOTYPE MOBILE SEED DRESSING APPLICATORS SUITABLE FOR AFRICAN COUNTRIES

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1. Introduction

The use of effective seed treatment systems offers the potential to improve substantially the production of many grain crops grown in Africa from farm-saved seed. A correctly applied treatment will protect both the seed and the developing plant in the early stages of growth and hence reduce the need for subsequent pesticide use (Rennie, 1993). Elsworth (1993) estimates that losses of seed and food grains during post harvest storage may be as high as 40% in African countries.

This report summarises work conducted by Silsoe Research Institute as part of a UNIDO funded project (Ref No: US/RAF/88/273) which was undertaken during the period March 1993 to July 1994. Details of the work undertaken and the results obtained has been presented in two annual reports (Miller, Power and Wainwright (1993) and Miller and Power (1994)) presented to UNIDO. In addition to an overall review of the results obtained, the opportunity is taken in this report to re-examine:

(a) the measurements of air flow through the clearance gap between rotor and stator in the seed treatment unit which may have enabled the requirements for close tolerances to be relaxed;

(b) the design of the chemical distributing disc to prevent seed collecting on the disc when loading seed batches;

(c) some proposals relating to the closed handling of liquid formulations if these can be made available in regions where the equipment will be used.

2. Design of the seed treatment equipment

2.1 Rotor and rotor housing design

The experiment field work carried out in Zambia and Tanzania confirmed that the machine should be capable of treating a maximum of 10 kg seed batch and that this could be achieved by using a rotor with a diameter of 500 mm.

The rotor used was based on a 20 in (508 mm) diameter disc from an agricultural disc harrow (Beeversales Components Ltd in the UK) which was machined at the edge to the 500 mm diameter.

As previously reported (Miller and Power, 1994), the experiment examining the use of increased rotor/rotor housing clearances and an air flow through the clearance showed that this was not a feasible approach and that there was no alternative to using a small clearance between these two components. The design therefore aimed at maintaining a clearance of approximately 0.5 mm and it was found to be necessary to machine the edge of the plough disc to achieve this clearance.

Discussions with the Chief Technical Advisor to the project following the submission of the report describing work conducted by Silsoe Research Institute in the period August 1993 to July 1994 questioned the values of air flow computed from pressure measurements made in an experimental rig study described in this report (Miller and Power, 1994). This questioning was based on using the calculated volumetric flow rates (see Table 1 in Miller and Power, 1994) to calculate air velocities through the clearance gap between the rotor and stator. This clearance was assumed, as an over-estimate, to be 2.5 mm around the whole of the periphery of the rotor and this gave a mean air velocity in the order of 16 m s^{-1}. This is above the terminal velocity for many seed types (typically in the order of 10 m s^{-1}) and therefore should have prevented seed loss. However substantial seed loss was measured in experiments with rape seed having a mean diameter of 1.8 to 1.9 mm.

These calculations have been re-checked and revised values are now presented in Table 1. These are approximately 30% of the values originally presented but with the same pressure difference values and represent a mean air velocity, assuming a clearance gap of 2.5 mm, of 5.3 m s^{-1}. If the clearance were reduced to 1.25 mm, the air velocity would then be close to the terminal velocities of seeds but variations in clearance around the treatment drum may still result in substantial seed loss. The power required to generate the air flows shown in Table 1 were such that, when added to the rotor power, they could not be readily generated using the pedal drive system. The use of an air flow may have prevented the loss of some powdered chemical through the clearance gap but would give problems due to the power requirement and the risk of operator and environmental contamination with the powder laden air.

Laboratory rig work based on a modified "Rotostat" machine had shown that it was necessary to increase the surface roughness of the disc so that the seed toroid was fully formed in the treatment chamber (Liptrot, 1991). This was effectively achieved in the experimental design by spot welding eight 100.0 mm long, 10.0 mm wide and 1.0 mm thick ribs radially onto the disc surface at the outer radius.

Table 1 : Summary of results assessing the effect of an air flow across the rotor/rotor housing clearance

Seed Type	Rotor Speed, rev min^{-1}	Fan On	Measured Pressures mm of H_2O (see Figure 1)			Calculated Air Flow Rates		Measured Seed Leakage, %	Comments
			P1	P2	P3	kg min^{-1}	m^3 min^{-1} *		
No seed	Static	Yes	28	42	140	1.11	1.31	N/A	Full fan flow.
No seed	300	Yes	29	47	140	1.08	1.28	N/A	Full fan flow.
Wheat	300	No	--	--	--	--	--	< 1%	Seed jammed in gap. Some seed damage.
Wheat	300	Yes	37	73	139	0.91	1.08	< 1%	Much less tendency to jam. Some damaged grain in fan outlet.
Rape	300	No	--	--	--	--	--	59.8	99.5% of seed accounted for overall.
Rape	300	Yes	26	36	132	1.09	1.30	40.2	99.5% of seed accounted for overall.

* at a room temperature of 20°C and with measured humidity and atmospheric pressure conditions.

The main part of the rotor housing was based on a 25.0 mm thick steel annular ring to which a bearing assembly supported on three legs was welded prior to stress relieving and final machining. The seed treatment chamber was formed from a rolled steel sheet and fitted with a wooden lid. The whole assembly was supported on three legs as shown in Figure 1. This arrangement proved to be workable in African conditions, and the machine proved to be both rugged and portable. It is not envisaged that any departures from this design would be necessary unless dictated by local manufacturing considerations.

2.2 Pedal drive arrangement

A standard bicycle crank was connected to a drive pulley and a belt drive used to rotate the main rotor shaft (Miller and Power, 1994, Section 2.4c). The design speed for the rotor was between 240 and 300 rev min^{-1} and a 3:1 ratio was used in the final drive such that pedalling speeds would be in the range 80 to 100 rev min^{-1} (Åstrand and Rodahl, 1977). A free-wheel was built-in to the final shaft drive to improve the operation of the machine since there was no requirement to reverse the rotation of the rotor for emptying - the discharge door being designed to "plough" out the seed toroid. Following the modifications to the door design and adjustment of the belt run carried out in the Zambian field trials, the arrangement worked well and proved reliable under field trial conditions.

2.3 Chemical distribution disc

The spinning disc worked as expected when connected directly to the mixing rotor, presenting the chemical to the seed as a relatively coarse spray.

With batch sizes of up to 10 kg of seed, and a treatment cycle time of 30 seconds the treater gave consistently uniform distributions (Miller and Power, 1994, Section 2.5 Performance Assessments).

During the field trial work in Zambia and particularly in Tanzania (where seed batch sizes tended to be larger) it was noticed that with batch sizes approaching the 10 kg maximum loading there was a tendency for seed to fall onto the chemical disc during loading, or if the rotor was stopped with a full charge. It is recommended (Miller and Power, 1994, Section 6.2) that a shroud be used to protect the main part of the liquid spreading disc (see Figure 2). This would minimise the contact of seed with the disc surface. It would be important to leave a large enough clearance for any seed which did enter the disc to be discharged, as indicated in Figure 2.

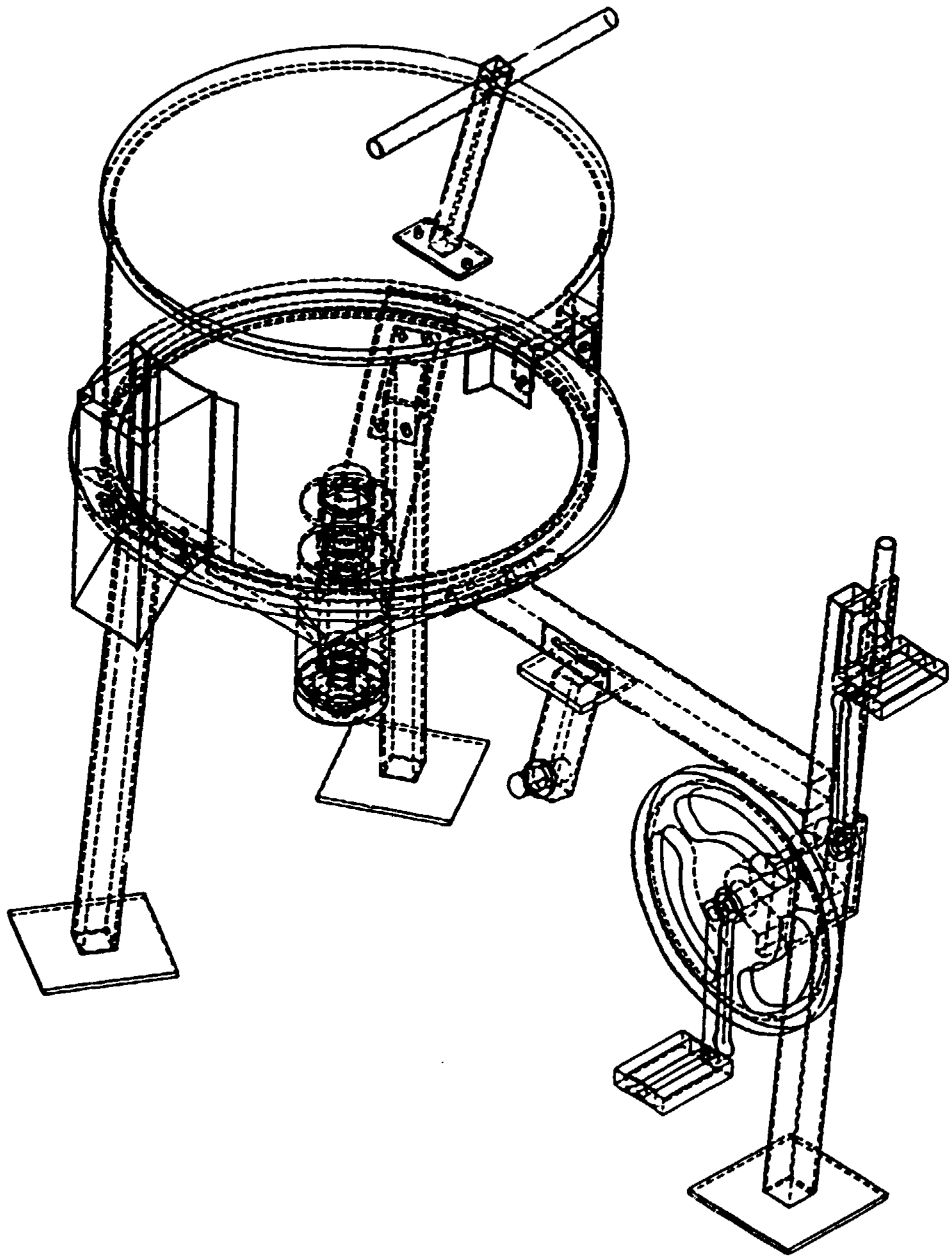

Figure 1 : General arrangement of the portable seed treatment unit design

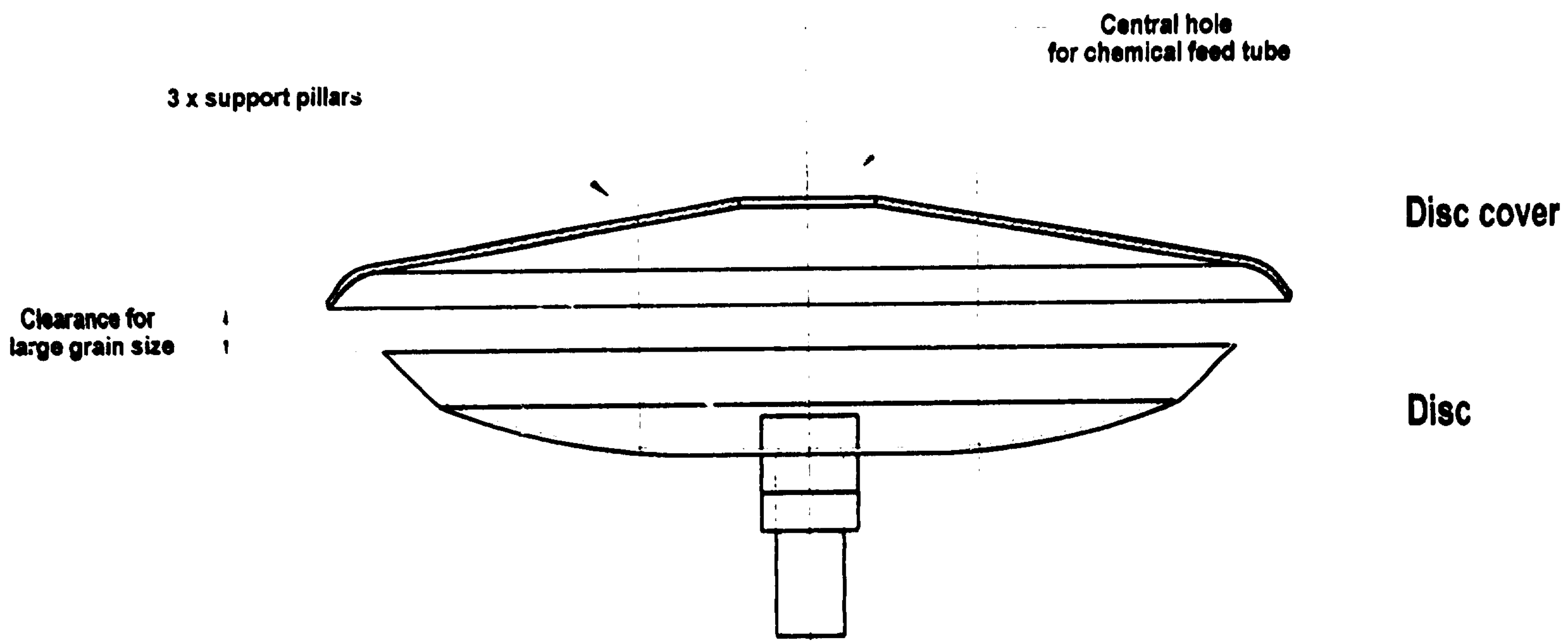

Figure 2 : Cover arrangement for the liquid spreading disc to minimise contact of seed with the disc surface

Handling the chemical formulation

The absence of a liquid chemical formulation had important implications for the potential operator, by-stander and environmental contamination with the system (Miller and Power, 1994, Section 6.3).

The use of a syringe to deliver the chemical to the seed treatment chamber worked well with the Fernisan 'D' slurry in Tanzania, but in Zambia the unstable nature of the Thirasam M suspension made it unworkable, and the slurry had to be introduced via an open funnel in the treater lid.

Provision of a liquid formulation would allow the use of a closed transfer/induction system which could be mounted on the treatment machine (Figure 3). This could be a simple hand operated pump, graduated to indicate loading. Provision for mounting the chemical shipping container on the machine could then be made. This would not be possible with unstable slurries, which require constant agitation.

3. Evaluation trials

3.1 In typical working environments

The design of the Silsoe pedal-driven seed treater proved suitable for use in African conditions. The field trial work in Zambia and Tanzania indicated that the value of seed treatment was understood, and that a machine of this type would be well received. The important considerations of cost and availability will have to be met, and any problems of local manufacture will need to be overcome without sacrificing critical tolerances. The simple design and operation of the pedal powered machine should ease the important dissemination phase. Figure 4 shows the Silsoe machine at Situmbeko, Zambia, where the cooperative of farmers were treating their own seed with Thirasan 'M'. The chemical was particularly difficult to keep in suspension, and this was being done by the Silsoe operative. If a liquid formulation had been available, the whole process could have been solely taken over by the local work force with a minimum of preliminary instruction.

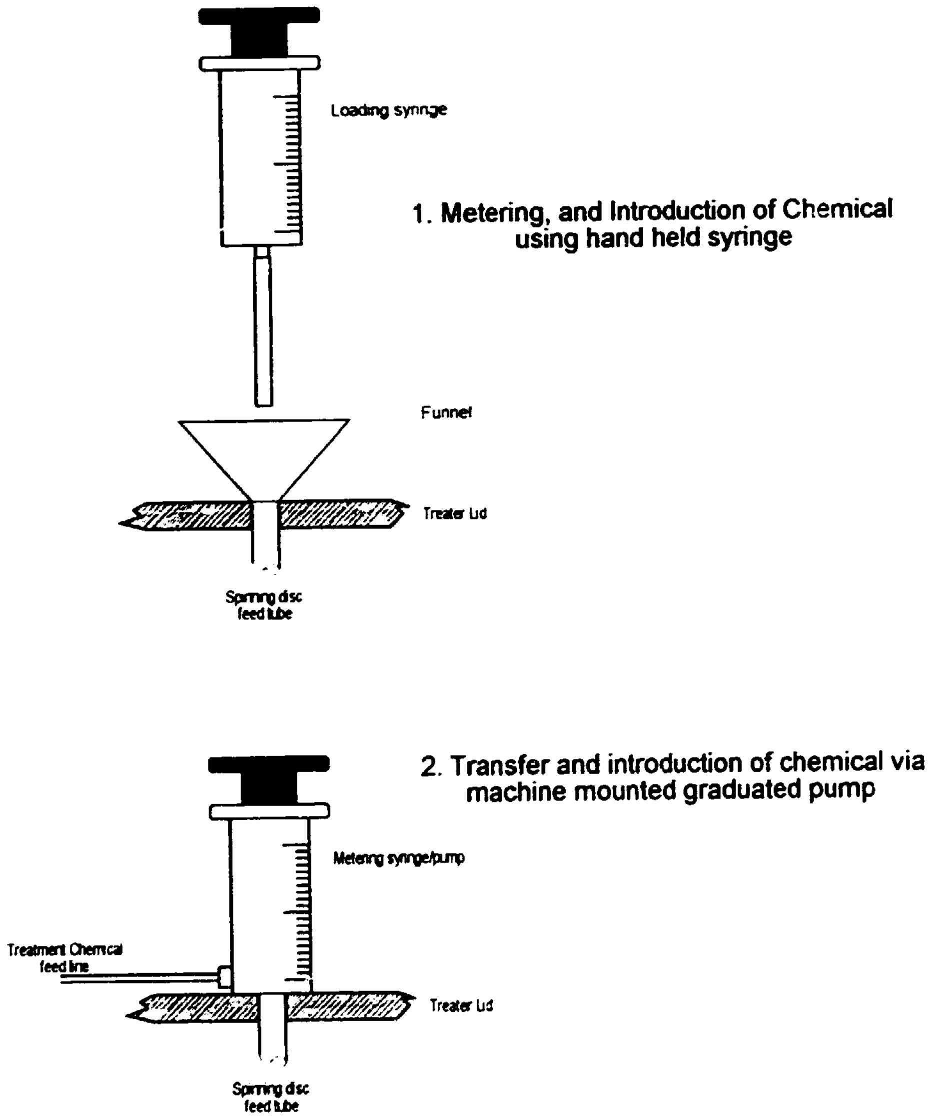

Figure 3 : Proposed design relating to closed handling of liquid formulations

Figure 4 : Seed treatment unit in operation in Situmbeko, Zambia during field evaluation trials

3.2 Measured performance and field trials

The performance of the treater was assessed with regard to uniformity of coverage, this was done visually, and using spectrophotometric techniques (Miller and Power, 1994, Section 2.5). The results show good levels of uniformity within the treated seed with coefficients of variation in the range 14.3 to 32.2%. A typical distribution of deposits is shown in Figure 5. The method of determining deposits on individual treated seeds was shown to be effective particularly for seeds of the size of UK produced cereals (wheat and barley) and maize and beans in Africa. Some problems were encountered with small seeds especially where the seed sample contained a level of dust which was also carried on the surface of individual seeds. Hence, although some data for the performance with sorghum was obtained from trials in Zambia, it is recommended that further work be conducted to examine the distribution of deposits on small seed types. The low volumes on individual seeds may give sampling problems at the single seed level that cannot be resolved by spectrophotometric methods using currently available dyes. Recent work at Silsoe Research Institute has aimed at identifying dyes that are soluble and have a good light absorbance characteristic such that the resolution of deposits on small seeds may then be possible.

The performance was also assessed during field trials with maize and sorghum in Zambia and with maize in Tanzania, these results compared favourably with the original measurements.

In trials conducted in the United Kingdom with wheat seed using the unit fitted with the ribbed plough disc rotor to apply water-based tracer dye treatments, assessments were made of the germination both before and after treatment. There were no statistically significant differences in any of the seed batches tested but there was some trend towards higher germinations with the treated seed batches. This may be related to the effects of surface abrasion or surface moisture content (unlikely since the added water is a very small percentage) together with dormancy effects and is worthy of further study. Such a study was outside the scope of the current project.

4. Concluding remarks

Much of the work on the collaborative project undertaken by Silsoe Research Institute was conducted during the period March 1993 to August 1994. Details of the work and the results obtained have been reported to UNIDO in two annual reports. This report has briefly reviewed the results of the study and has used the opportunity to re-examine some of the features resulting from the work.

It is concluded that the final design produced for a pedal-driven seed treatment unit provides a good basis for commencing the commercial full-scale development of the treatment of farm saved seed. Developments are likely as the concept is further developed and it is hoped that in the first instance, these would relate to the provision of liquid formulations of the treatment chemical enabling improved handling and an identification of the size(s) of unit most suited to the range of operating conditions.

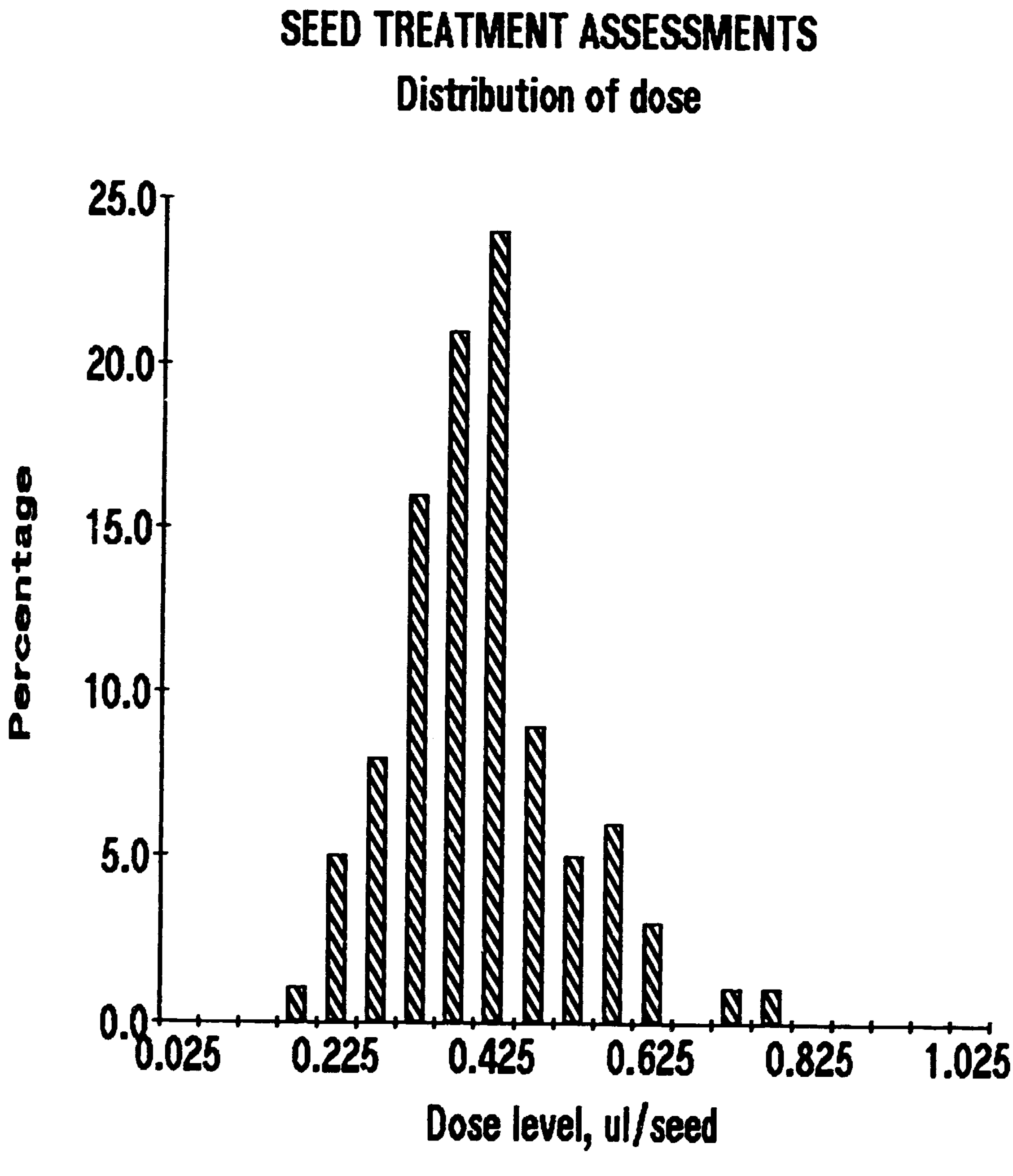

Figure 5 : The distribution of dose on treated wheat seed. Tracer dye applied at 10 ml kg^{-1}; 20 s mixing time, 250 rev min^{-1} with the plough disc rotor. Target dose = 0.57 μl/seed. 1 hour soak time.

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