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DESIGN AND EVALUATION OF A JAB PLANTER

JEFF SMITHERS[1], LOUIS LAGRANGE[1], BRUCE FRASER[1], DEVON NEETHLING[1], ALAN HILL[1]

[1]School of Bioresources Engineering, University of KwaZulu-Natal, South Africa, smithers@ukzn.ac.za

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ABSTRACT Final year Bioresources Engineering students at the University of KwaZulu-Natal, South Africa, have designed, constructed and evaluated a manually operated jab planter to operate under no-till conditions. The planter consists of a frame and handle, seed hopper, a precision seed metering mechanism, a seed delivery tube and a ground opening device. The planter was evaluated by comparing the performance when planting using a conventional hoe or using the no-till jab planter. This paper contains a summary of the design requirements and performance of the jab planter.

Keywords: Jab planter, Conservation tillage, South Africa.

INTRODUCTION The use of conservation tillage in agricultural production has many benefits including better utilisation of rainfall as consequence of reduced evaporation and improved infiltration, reduced soil compaction, improved soil structure and weed control, and reduced energy input with reduced or no tillage. Some of the challenges when planting through the organic matter left on the surface include penetration and consistency in depth of planting, particularly when planting manually.

According to Baudron *et al*. (2007), a small scale conservation tillage planter is needed for use in rural areas of Southern Africa. There is also a need to increase productivity in rural farming through education on better farming techniques (Nts'Ekhe, 1993). This is particularly relevant in South Africa where there is currently a large focus on small scale farmers by government.

Small scale agriculture is widely practiced in Southern Africa and the majority of the work carried out on these small scale agricultural projects is carried out manually, with the aid of hand tools such as hoes. In order to increase productivity it is necessary to expand the range of hand tools used by labourers on these projects. Jab planters are one possible tool which can be adopted to improve efficiency. Currently, many small scale farmers do not practice conservation agriculture because of restricted access to no-till planters (Baudron *et al.*, 2007).

Manually operated jab planters for both tilled and no-till conditions have been in use for a long time, with many commercially models available. The effectiveness of these planters is uncertain, especially in conditions where organic matter is present. Available jab planters also experience difficulty in achieving both sufficient penetration and reliable and consistent seed deposition, especially in compacted soils (Hansen, 2008). In addition, problems related to size differences when using ungraded seeds are common, as the seeds can be crushed very easily when using steel dispensers. Single seed dispensers are efficient when dealing with uniform well graded seed, but in rural areas this is not generally the case as seed sizes for the same crop are known to vary greatly (Dupriez and De Leener, 1988).

According to Fraser and Neethling (2008), the available jab planters are expensive, ranging from US $100-$150, excluding shipping costs. This price is uneconomical for small scale subsistence farmers in Southern Africa.

This paper is based on a final year Bioresources Engineering Design Project undertaken by Fraser and Neethling (2008) in the School of Bioresources Engineering and Environmental Hydrology at the University of KwaZulu-Natal (UKZN), South Africa. The objective of the design project was to design, build and test a manually operated prototype jab planter that can operate in no-till conditions and which is able to plant through a layer of organic matter. The envisaged impact of the planter is to help increase productivity in small scale agriculture by reducing labour requirements and improving the consistency in depth of planting.

DESIGN REQUIREMENTS The design requirements included ergonomics, maintenance, planting, cost and technical requirements.

Ergonomics In order to facilitate both transport and ease of use, the weight of the device should be limited to approximately 7 kg and a single person, including women who generally perform the field work, should be able to operate the planter. A depth control device is required to ensure consistency in depth of planting. Both left handed and right handed operators should be able to use the device and the device should be ergonomically suitable for the average operator's height and hand size.

Maintenance The planter must be as simple as possible to operate, and should not require constant maintenance to keep it in good working order. Any maintenance should not be complicated or specialised in nature, and the tools required to carry out any servicing should be readily available in rural areas. Servicing, for example to grease moving parts and sharpen blades, should not need to be performed more frequently than once per hectare of planting. As far as possible, readily available, off the shelf parts should be utilized.

Planting The rate of planting should be faster then present manual planting techniques, which were estimated by Baudron *et al.* (2007) to be approximately 56 hours per hectare in Southern Africa for a single worker. The planter should be able to operate in clayey soils and in wet conditions. The planter must be robust and able to withstand being used in no-till areas and not be damaged if accidentally dropped. Importantly, the planter must be safe to operate.

Cost The cost of the planter should be affordable to small scale farmers and the initial feasibility and costing study estimated the cost to be R 500 per planter (approximately US $ 70 at current exchange rates).

Technical Requirements The planter should be able to plant various size and shaped seeds, ranging from a 15 mm diameter pumpkin seed to a 4 mm diameter soya bean seed. The life span of the device should exceed 5 years or 50 hectare. The planter must be able to operate in varying conditions and should be able to operate in soil hardness up to 50 $N.cm^{-2}$. The planter should be able to operate in areas with organic matter on the surface of the soil, such as plant residue and stalks from the previous year's crop. However, if the planter cannot penetrate some organic matter, the matter can be moved by the operator so that the seed may be planted at a specific point in the field. The planter should be small enough to operate between rows of existing crops in the field, to allow intercropping and multi-cropping. The seed hopper should be able to accommodate 2500 Grade 4 Maize Seeds, which will allow 0.25 hectares of planting with a plant density of 10000 maize plants per hectare. The planter must be able to plant at predetermined depths ranging from 10 to 50 mm.

FEASIBILITY STUDY The feasibility study conducted by Fraser and Neethling (2008) assumed that labour costs were for free and that the seed and fertiliser cost were approximately R 2 500 per hectare. With these costs, yields of above 1 750 kg per hectare are required to make a profit and to repay the capital cost (R 500) in less than 5 years if 25% of the profits are used to repay the capital outlay.

OVERVIEW OF THE DESIGN AND CONSTRUCTION The components of the jab planter included the structural frame, as shown in Figure 1, a replaceable bit, the seed release and deposition mechanism, a depth control plate for setting the planting depth, pressure plates to release the seed and an automatic precision seed hopper metering mechanism and associated components. Once the theoretical design of these components had been completed, the design was constructed resulting in the jab planter shown in Figure 2. Fraser and Neethling (2008) estimated the cost of the materials used in the construction to be R 340 per planter.

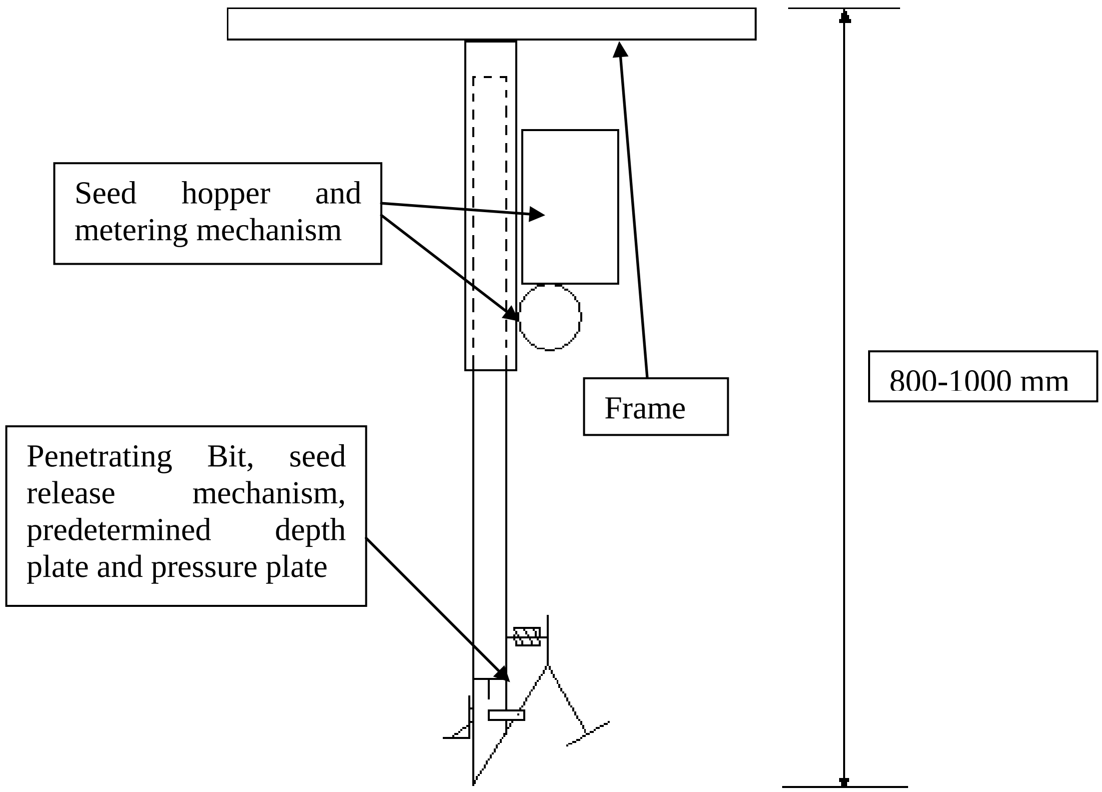

Figure 1. Sketch of the jab planter and all its components (Fraser and Neethling, 2008)

Figure 2. Completed jab planter (Fraser and Neethling, 2008)

EVALUATION OF THE JAB PLANTER The performance of the jab planter was evaluated both in the laboratory and by workers in the field.

Laboratory Testing The efficiency of the seed metering device was evaluated by recording the number of times a single kernel was released (Singles), no kernel was released (Blanks), two kernels released (Doubles) and kernels damaged during metering (Breaks), as a percentage of the total number of runs. Both commercial quality graded seed, purchased from a seed supplier, and ungraded seed, removed from a maize cob by the design team, were used in the tests. The results from the tests are shown in Figures 3 and 4.

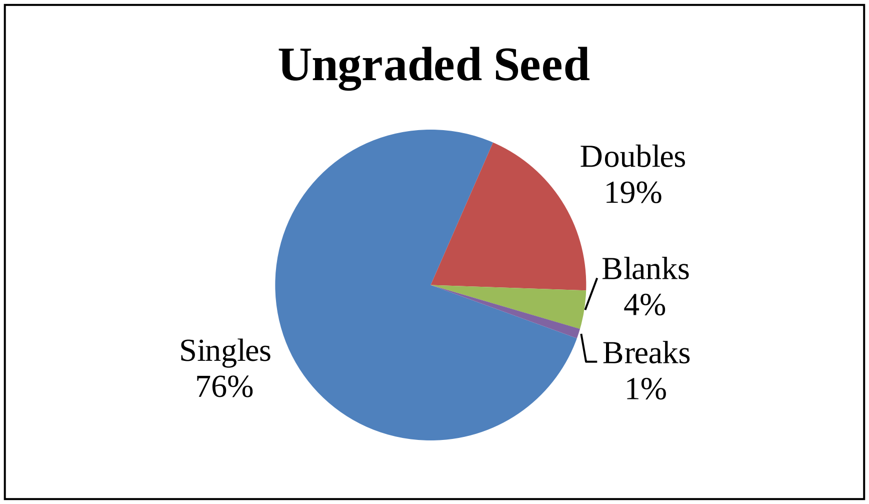

Figure 3. Seed metering efficiency with ungraded seed (Fraser and Neethling, 2008)

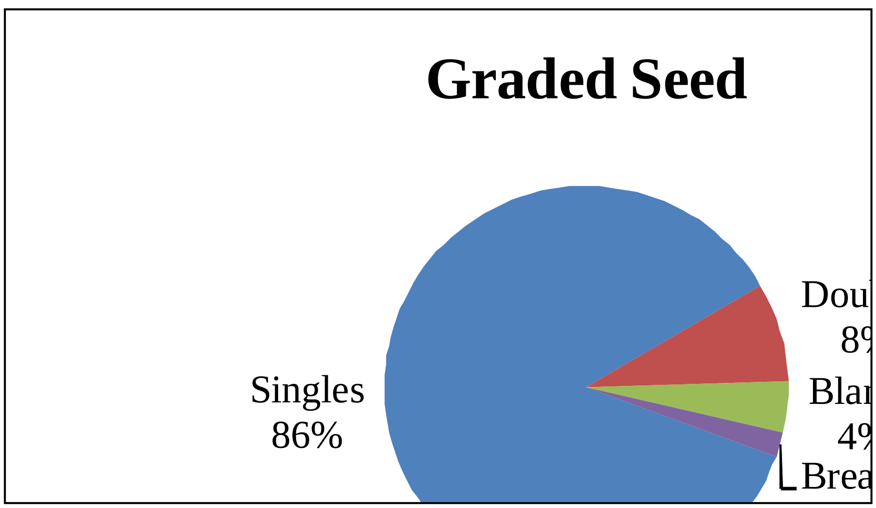

Figure 4. Seed metering efficiency with graded commercial seed (Fraser and Neethling, 2008)

The testing showed the efficiency of accurately metering ungraded seed to be 76 %, whilst graded seed to be 10 % higher at 86 %. This was expected as the ungraded seed was collected from a cob of maize from the field and there was a large variation in the distribution of seed size and shape, such as flats and rounds. With this large variation in seed size and shape, more double seed runs were experienced with the ungraded seeds as more than one seed would frequently fit into the seed metering hole.

It was postulated that the occurrence of a double run is better than a blank run, as seed is still being delivered into the soil. Blank runs occurred on average 4 % of the time for both the graded and ungraded seed. This is a relatively low percentage considering the low cost and simplicity of the seed metering device. When planting, the operator can hear the seed entering the seed delivery tube. Thus when a blank run occurs, the operator will be able to hear that a seed has not been delivered and can perform another run.

Field Testing Field tests were performed at the university research farm in September 2008. The soil at the test field had a 60 % clay content soil and was in a no-tilled condition. The tests were conducted on a 50 m long strip of land. Six different operators were used to measure the amount of energy required for the operation, the time taken to plant a specific area, and the average depth of planting. In order to make a comparison between the two methods of planting, the same operators were tested using both the jab planter and conventional planting using a hoe. The average of all the operators was determined and the results are shown in Figure 5.

As shown in Figure 5, the results indicate that the same area can be planted in a third of the time using a jab planter compared to a conventional hoe. Fraser and Neethling (2008) attributed this to the mechanical metering system and the sharp penetrating bit of the jab planter. As shown in Figure 5, the average heart rate of workers using the jab planter was slightly less then when operating the conventional hoe. This result was surprising as it was thought that using the jab planter would require more effort as it is substantially heavier then a conventional hoe. As a consequence of the above, on average approximately 30% more calories were expended when planting using a conventional hoe compared to the jab planter. With a desired planting depth of 40 mm, the average depth of seed was found to be 48.5 mm for the conventional hoe and 40.5 mm for the jab planter. It is also evident from the standard error bars shown in Figure 5, that the variation in performance between operators are similar for conventional hoe planting and planting using a jab planter.

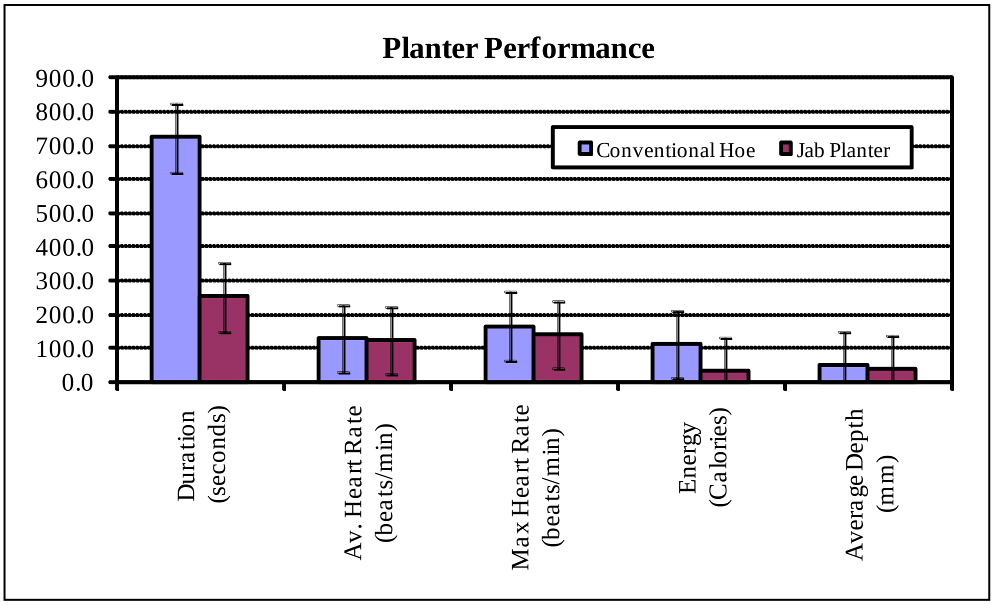

Figure 5. Comparison of the average performance of 6 operators planting using a conventional hoe and the jab planter (I-bars = standard error)

CONCLUSIONS The design, construction and evaluation of a manually operated jab planter was successfully undertaken by two final year Bioresources Engineering students at UKZN. Design requirements for the jab planter included ergonomics, maintenance, planting, cost and technical aspects. The resulting jab planter can be operated by a single operator with relative ease and requires approximately 30 % of the time to plant a given area compared to conventional planting using a hoe. The planter is able to precision meter seed 76 – 86 % of the time, depending on the grade and quality of the seed. The planter is also able to operate in no-till conditions with a layer of organic matter and requires less energy input by the operator compared to conventional planting using a hoe. In addition, the planter was found to be relatively safe to operate, as safety was a major concern in the design of the planter.

The reduced energy expended by the operator when using the jab planter, and the reduced time required to plant a given area, are major benefits of using the jab planter as labour is becoming more and more scarce in rural areas in South Africa, due to factors such as HIV-Aids amongst potential workers and migration of people from rural to urban areas.

It is thus postulated that commercial production of the jab planter could have a large impact on the small scale farming community in Southern Africa. The project has shown that the use of jab planting in no-till conditions is possible with a small, lightweight, hand held device that is affordable to small scale farmers in Southern Africa.

Most of the design criteria were met and evaluated. However, no long term durability tests have been performed on the planter to date and this is an aspect that needs to be investigated. Furthermore, it is recommended that the metering mechanism be re-designed to improve the efficiency of metering of seeds, particularly with ungraded seeds.

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