DEVELOPMENT OF A HAND PLANTER
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Abstract
A prototype Simple hand Planter was designed constructed and tested for performance. It was
designed to plant two seeds of Maize (Zeamays) per drop. It is a simple machine made mainly of
wood with few metal components. Some properties of maize seeds such as size and angle of
repose which were used to design the seed cell and hopper respectively were determined locally.
After the construction, test results showed that the planter has a metering efficiency and accuracy
of 96% and 58% respectively. It has a field capacity of 0.5ha/hr as against 22hr per hectare if
one person is to work.

Keywords: Development, planter, hand, maize

Introduction
The growth of a new crop starts with the
planting of a seed or transplanting of seedlings. The placement of seed in the soil is done
in many ways. Traditionally, this is done by
the use of cutlasses, hoes, and matches etc.
With the advancement in science and
technology, different machines have been
developed for planting and many other
agricultural production activities.
This has revolutionised agricultural production
leading to large hectarage being planted within
a short period of time.

The earliest type of row crop planter was a
wooden Keg with holes around its centre to
allow seeds to drop. In 1839 Rockwell was
granted patent on a device for planting corn. In
about 1892, the Dorley Brothers developed an
drop planter for cotton seed planting. The
check row planter was patented by F.M. Robin
in 1857. (Smith and Wilkes,1979)’Also the
cell drop and picker wheel planting mechanism
was developed in the 1880’s.

In 1890, the single Kernel cumulative drop
planter was developed by Missouri and Kan
who were both primitive farmers. The hill
drop attachment did not come into use until
1920’s. The tri-cycle tractor came in 1922, and
tractor mounted planter appeared in the farm,
and the precision planter for vegetable was
developed in 1944. Since then, many
companies have developed and produced
different types of seed planting machines.

At the local level, a lot of attempts have been
made at developing seed planting machines;
notable among them are the jab planter and
injector planter developed by the International
Institute of Tropical Agriculture (IITA) Ibadan
in 1978Attempts were made at using these
planters with little success as they are no
longer being used by farmers.

To therefore reduce drudgery and to increase
the local farmer’s hectarage, efforts at
developing simple hand tools must continue
and that gave rise to the development of this
particular hand planter.

Methods of planting
There are three different ways of seed
placement in the soil namely:

1. **Broadcasting**: This refers to the
random scattering of seeds over
broken soil and covering them with
some type of rake or harrow. This was
very common until the 1840. The first
patent was granted Eliakun in 1799,
but William T. Rennock was the first
to manufacture grain drills.

2. **Drill Seeding**: Smith and Wilkes
(1980) defined drill seeding as the
random dropping and covering of seed
to give definite row, but no definite
distances between seeds.

3. **Precision Planting**: This is the
placement of seed or group of seeds in
definite distance between seeds and
between rows.
Methodology

Description of the machine

The planter consists of the following basic components.

i. **Hopper**: This helps to hold or store the seed before planting and during planting operation. This may be trapezoidal, rectangular or oval in shape and can be made up of wood, sheet metal or plastics or a combination of materials such as fibre glass.

ii. **Seed metering Device**: This part of the planter is used to meter or deliver the seed to the seed tube at the required time at the required interval. There are many designs of this component to suit the different seed sized and shapes.

iii. **Seed tubes**: This component is the channel that seed into the opened furrow. This may be the collapsible or rigid type. The one for this machine is the rigid type made of plastic tube.

iv. **Furrow opener**: This small component that opens the soil for the seeds to drop into furrow openers are usually either of the hoe type or disc type. The disc type is preferred the disc ants or roll over it without becoming clogged.

v. **Furrow Coverer**: The Component covers the dropped by bringing soil over the seed.

vi. **Press wheel**: The press wheel forms the soil over the seed for quick germination.

Design considerations and analysis

Agronomic parameters

Agronomic factors considered during the design of the maize planter include intercrop spacing between maize plants which was given as 25-30 cm, inter-row spacing of 75 cm.

**Determination of parameters**

To design a functional planting machine, it is necessary to establish through the calculations of certain design parameters. The following properties of maize seed were locally determined for the design of the seed slide and hopper respectively are seed size and Angle of Repose.

**Size**: The size of the seed is described by its length, width and thickness and these are necessary for the design of the seed cell. (Fig. 1) The digital Venier caliper was used to measure the sizes of fifty (50) seeds of maize to obtain an average size of the seed. Readings are recorded in Appendix A.

![Diagram of Seed Size](image)

\[ a = \text{length} \]
\[ b = \text{maximum width} \]
\[ c = \text{thickness} \]

**Fig. 1 Determination of Seed Size**
ii Angle of repose: Angle of repose together and angle of internal friction are frictional properties of granular materials such as grains and seeds which are important to the design of equipment for solid flow structures for storage (Moshenin 1980). Angle of repose is the angle formed with the horizontal at which the material will stand when piled. This is important in the design of hoppers which determines the flowability of grains in it.

Determination:

1. A circular plate of diameter 260mm was filled to an over-flowing level with the maize sample and then allowed to settle.
2. Two meter rules, one placed inclined at a point around the circumference of the plate: (AC). The other rule was placed tangentially on top of the heap as shown in Fig 2.
3. The protector was used to measured the angle 0 which is the heap made with the horizontal.
4. Ten samples were taken and readings recorded in Appendix G.

\[ \text{Fig.2 Determination of Angle of Repose (Heap of Maize Grains)} \]

Determination of density
Density (\( \rho \)) = \( \frac{\text{mass}}{\text{volume}} \) \hspace{1cm} (5)

Mass = 720 kg
Volume =

Bulk density of maize seed \((\rho_b)\) = \( \frac{\text{mass of seed}}{\text{volume of seed}} \)

\[ \begin{align*}
\text{= } 720 & \quad \text{x} \quad 1000 \\
1000/10-3 & \quad 1000 \\
\text{= } 720 \text{g/m}^2
\end{align*} \]

Analysis of reading
The mean, standard deviation, variance and standard error for the length width and thickness of each maize seed were calculated from the frequency distribution table (Appendixes B-E) with the aim of determining the means and standard deviation of the size of seed using the following equations

i) Mean (-\( \bar{x} \)) = \( \frac{\sum f \times x}{\sum f} \) \hspace{1cm} \text{-------------------------}(1)

Where

\[ \sum f \times x = \text{Summation of the products of frequencies} \]
\[ \sum f = \text{Summation of frequencies} \]

ii) Variance \((S^2)\) = \( \frac{\sum f \times x^2 - \frac{\sum f \times x}{\sum f}}{n-1} \) \hspace{1cm} \text{-----------------------------}(2)

Where \( n = \text{total no of seeds measured} \)

(iii) Standard Deviation \((S)\) = \( \sqrt{S^2} \) \hspace{1cm} \text{-----------------------------}(3)
Standard Error (SE) = \frac{s}{\sqrt{n}} \hspace{1cm} \text{(4)}

Table 1. Result of Seed Properties

<table>
<thead>
<tr>
<th>S/no</th>
<th>Mean (mm)</th>
<th>Standard deviation</th>
<th>Seed dimension (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Length</td>
<td>11.76</td>
<td>1.08</td>
<td>11.76 + 1.08</td>
</tr>
<tr>
<td>Width</td>
<td>9.90</td>
<td>0.513</td>
<td>9.90 + 0.513</td>
</tr>
<tr>
<td>Thickness</td>
<td>4.64</td>
<td>0.527</td>
<td>4.64 + 0.527</td>
</tr>
<tr>
<td>Weight</td>
<td>0.426</td>
<td>0.090</td>
<td>0.46 + 0.090</td>
</tr>
<tr>
<td>Angle of Repose</td>
<td>30</td>
<td>0.950</td>
<td>30 + 0.950</td>
</tr>
<tr>
<td>(Degrees)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Component design

**Hopper:** According to Bosai et al. (1978), grain hoppers have the following shape designs. Trapezoidal, hexahedral or combined the trapezoidal shape was selected for the diagram.

![Hopper Diagram](image)

The hopper is square shaped with the top measuring 24x24 cm, while the base is 6x6 cm. The sides are slanted at an angle to the base equal to the angle of friction $\beta$ of the sowing material (Maize) which was found to be 300 degrees.

### Determination of Volume of Hopper

The volume (M3) of a hopper is determined per hectare by the formula:

$$ V_c = \frac{L_g Q_H B}{10^4 \eta_c q_H} $$

(Bosai et al. 1978) \hspace{1cm} \text{(6)}

Where:
- $L_g$ is the run length m
- $Q_H$ is the seed rate Kg/ha
- $B$ is the sowing width
- $\eta_c$ is the coefficient of fullness of the hopper which is equal to 0.9
- $q_H$ is the volume weight

Hopper length $L_c$ is given as

$$ L_c = a (n_c + 1) $$

Where:
- $a$ is the row width
- $N_c$ is the number of boots.

Cross sectional area of the hopper is determined by

$$ F_c = \frac{V_c}{L_c} $$

\hspace{1cm} \text{(8)}

The following data were obtained:
- $L_g = 100$ m
- $Q_H = 40$ kg
- $n_c = 0.9$
- $q_H = 6$
- $B = 1$ m

Volume $V_c = \frac{L_g Q_H B}{10^4 \eta_c q_H}$

\hspace{1cm} \text{(9)}

$$ V_c = \frac{100 \times 400 \times 1}{10^4 \times 0.9 \times 2} = \frac{50000}{45000} $$

$$ V_c = 2.73 \approx 3$ m$^3$

For one hopper ($V_b$), the calculate volume ($V_c$) is to be divided by five which is the number of hoppers used for calculation:

$$ V_b = \frac{V_c}{5} = \frac{3}{5} = 0.6 $m^3$$
Seed metering mechanism
The metering mechanism is made of two pieces of wood, the smaller piece used to adjust the seed cell slides inside the main piece. The thickness of the slide is about 15mm to accommodate two seeds of maize at the same time.

Testing

Laboratory test
The planter was designed to plant two (2) seeds of maize per stand. The planter was tested in the laboratory for metering accuracy.

Procedure
The machine was held by the hands and it was operated one hundred times at different spots on the floor in the lab. The number of seeds discharge by the metering plate during the operation was counted and recorded as shown on table

<table>
<thead>
<tr>
<th>No of seeds discharge</th>
<th>No of Times</th>
<th>No Seed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>1st</td>
<td>100</td>
<td>5</td>
</tr>
<tr>
<td>2nd</td>
<td>100</td>
<td>3</td>
</tr>
<tr>
<td>3rd</td>
<td>300</td>
<td>13</td>
</tr>
</tbody>
</table>

Metering efficiency (ME) can be calculated from the following expression.

\[ ME = \frac{\text{Total number of stand}}{\text{Total number}} - \frac{\text{No of stand with no seed}}{100} \times 1 \]

For the 3 operations (ME) = \( \frac{300-13}{30} \times 100 \times \frac{1}{1} = 96\% \)

Average of discharge with 2 seeds = \( \frac{59+52+58}{3} = 58 \)

Metering accuracy (MA) can be calculated from the following expression

\[ MA = \frac{\text{number of discharge with 2 seed}}{\text{Total number of times operated}} \times 100\% \]

\[ MA = \frac{58}{100} \times 100\% = 58\% \]

Field test
A small piece of land of length 50m long with 5 ridges was used for the test. The hopper of the planter was filled to capacity with the maize seed. The depth gauge was set to about 4cm.
Table 3 Results of field Test

<table>
<thead>
<tr>
<th>Ridge</th>
<th>No of Stands</th>
<th>Planter 0.seed</th>
<th>1 Seed</th>
<th>2 Seed</th>
<th>3 Seed</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>100</td>
<td>2</td>
<td>14</td>
<td>56</td>
<td>16</td>
</tr>
<tr>
<td>2</td>
<td>100</td>
<td>4</td>
<td>21</td>
<td>58</td>
<td>18</td>
</tr>
<tr>
<td>3</td>
<td>100</td>
<td>3</td>
<td>23</td>
<td>53</td>
<td>20</td>
</tr>
<tr>
<td>4</td>
<td>100</td>
<td>4</td>
<td>20</td>
<td>54</td>
<td>19</td>
</tr>
<tr>
<td>5</td>
<td>100</td>
<td>4</td>
<td>24</td>
<td>55</td>
<td>20</td>
</tr>
<tr>
<td>Total</td>
<td>500</td>
<td>17</td>
<td>11427693</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Metering Efficiency is calculated as follows

\[
(ME) = \frac{\text{Total number of stands} - \text{No of stands with no seed}}{\text{Total number of standard}} = \frac{500 - 17}{500} \times 100 = 96.6\%
\]

Discuasion

The number of seeds expected to be planted per hole by the planter is two (2) for maize incidence of one seed per hole means that the cells are not filled. When more than 2 seeds are metered, that indicates the presence of small sized seeds. Thus may be thinned after germination or the seeds are graded before planting. None – uniformity of seed was observed to be the major factor that influences the metering accuracy of the planter.

The metering efficiencies of 96% and 97% for laboratory and field test respectively show that the planter is good; but the metering accuracy of 58% and 55% for laboratory and field test need to be improved upon by proper grading of seeds and adjustment of the seed cell.

It was also observed that it has a field capacity of 0.5ha/hr as against 22 hours per hectare when one person is used to plant manually.

Conclusion

The development of the Hand planter was carried out with the aim of achieving efficient and precise maize planting on the farm. The laboratory and filed tests of the planter show that it can be used effectively for planting maize. With the performance obtained it can be said that the objective of work has been achieved. Thus, this will go a long way in encouraging farmers to increase their hectarage.

References


