

## Design Development and Performance Evaluation of Two-Row Corn Seed Planter

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### ABSTRACT

*One of the main requirements for small-scale cultivators is that they can be used in small plots of land and have simple design and technology. However, many planting tools on the market today are not suitable for narrow land conditions. Therefore, this study aims to design and develop a corn seed planter that can be operated in narrow areas and can improve seed planting efficiency and accurate seed placement. The research parameters observed were the distance between plants, the depth of the planting holes, the number of seeds per planting hole, and the efficiency of using the tool. The results of the research show that the planting tools that have been designed and developed are very easy and practical to operate by farmers on narrow land. The distance between plants varies between 21.3 – 24.2 cm. The depth of the planting hole ranges from 5.4 – 7.1 cm. The distribution of the number of holes filled with 0 seeds was 3.00%, filled with 1 seed was 90.38%, and filled with 2 seeds was 6.62%. Planter efficiency data is 85.61%. This data shows that this cultivator meets the minimum standards for the manually operated cultivator category.*

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## 1. INTRODUCTION

Farmers in Indonesia generally use a planting stick to plant corn seeds (Tokora, 2021). This tool is made of wood which is used to make planting holes (Budiman, 2016). Corn kernels are inserted into the hole manually (Adetola & Akinmade, 2020). The distance between plants is only estimated by farmers (Djoyowasito *et al.*, 2017). This method is less efficient because it requires a lot of time and labor (Iskandar *et al.*, 2017).

Planting corn seeds can be done better by using equipment that suits land conditions (Ansar *et al.*, 2020). Corn seed planting equipment can be designed based on farmer needs and land conditions (Hajad *et al.*, 2021). Indicators of success in designing a corn seed planting tool are the farmer's comfort in using the tool, the tool's ability to increase efficiency and reduce labor (Ghaderpour *et al.*, 2018).

Planting corn seeds is generally done by inserting the seeds into the planting hole at a certain depth (Gill *et al.*, 2014). If done manually, the planting holes are sometimes filled with unequal numbers of seeds, and the distance between plants is irregular (Alhassan *et al.*, 2018). As a result, the distance between plants is not the same (Zhang *et al.*, 2019).

Various types of planting tool designs have been developed by previous researchers and have advantages and disadvantages when operated. Brune *et al.* (2018) have designed a corn seed planter with 94% efficiency, but it cannot be used on narrow land. Yang *et al.* (2015) have developed a seed planting device with 73.4% efficiency and three times faster than manual planting methods. Kumar *et al.* (2013) have developed a planter with an average field capacity of between 0.28 to 0.31 ha/h at an average speed of 2.27 km/h.

Currently, there are many research results that discuss corn seed planting tools designed to make it easier for farmers when planting corn seeds (Oduma *et al.*, 2014). However, the planter still has a field working capacity that does not match its actual capacity. Apart from that, the filling of seeds in each hole is not the same and the distance between plants is irregular (Ansar *et al.*, 2021).

The planting method using manual planting sticks can result in decreased land productivity because the distance between plants is irregular (Syafa'at & Subantoro, 2017). Land productivity can be increased by optimally arranging the distance between plants (Djiemon *et al.*, 2019). However, too many plant populations can also interfere with the interception of sunlight for photosynthesis (Yuliana *et al.*, 2020). Thus, it is necessary to design a corn seed planting tool that can regulate the distance between plants. Based on this argument, this research aims to design and develop a corn seed planting tool to be operated manually in narrow areas.

## 2. MATERIALS AND METHODS

### 2.1. Materials and Tools

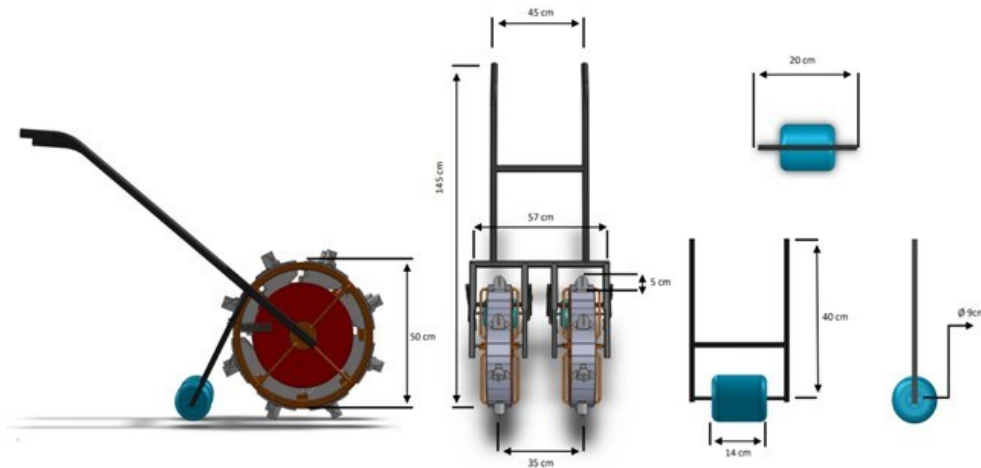
The materials used to make a two-row corn seed planter were cast iron, steel plate, bolts and nuts of various sizes, chains, gears and acrylic. The design of the equipment should be simple so that it is easy to produce with the existing local technology. The supporting materials needed were welding wire, putty, sandpaper, and paint. The test samples were corn seeds of the Bisi variety with a harvest age of  $\pm 125$  days which had been shelled in dry condition. The production equipment included an electric cutting machine, electric welding machine, drilling machine, hacksaw machine, wrench, compass, and protractor. Meanwhile, the research measuring equipment is a digital tachometer, digital scales, stopwatch, measuring tape, and roll meter.

### 2.2. Design Stages

The research was carried out in several stages. First, identify the performance of the tool before development, formulate design ideas based on the identification results, analyze the components of the tool to be developed, create design drawings for the planting tool, assemble the tool, and test the performance of each component of the planter tool that has been developed.

The construction design of a prototype of a two-row corn seed planter was presented in Figure 1. The furrow opener was made of durable V-shaped steel to increase the accuracy of seed placement. The planter hopper was designed with a seed capacity of 2.5 kg and was made of light and durable acrylic. Seed metering devices

were designed with a variety of seed size that can be changed in a very short time. Panter handles were made from galvanized cylindrical pipes which can be adjusted to suit the worker's body size. The drive wheels were made of plastic polyvinylchloride (PVC) and were both coupled to the drive shaft.



**Figure 1.** Design of a two-row corn seed planter

### 2.3. Observation Procedure

Testing of the two-row corn seed planter was carried out in a rice field measuring 550 x 350 cm. The land is dry and only cultivated using a hoe. Tool testing was carried out 5 times in different plots. The performance parameters measured were the distance between plants, the depth of the planting hole, the number of seeds per planting hole, and the efficiency of the tool. Actual field capacity (KLA), theoretical field capacity (KLT), and equipment efficiency (EA) are calculated using the following equation (Hermawan, 2011):

$$AFC = \frac{L_l}{W_t} \quad (1)$$

$$TFC = 0.36 (V.jt) \quad (2)$$

$$Eff = \frac{KLA}{KLT} \times 100 \quad (3)$$

where  $AFC$  = actual field capacity (ha/h),  $TFC$  = theoretical field capacity (ha/h),  $L_l$  = planted area (ha),  $W_t$  = total time used for planting (h),  $V$  = equipment forward speed (m/s),  $jt$  = planting space (cm), 36 = conversion factor ( $\text{cm}^2/\text{sec} = 0.36 \text{ ha/h}$ ), and  $Eff$  = equipment efficiency (%).

### 2.4. Data Analysis

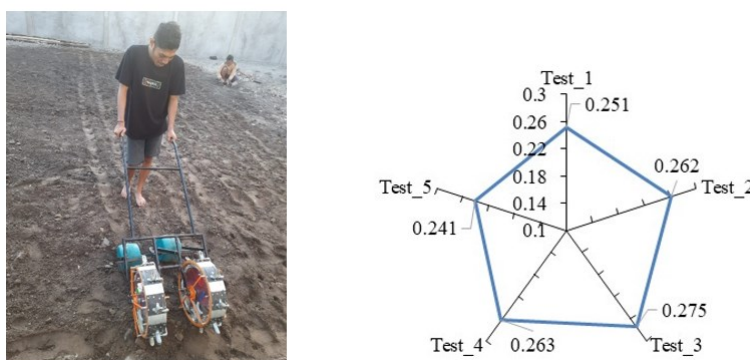
The required data included the planting space, depth of planting holes, number of seeds per hole, number of empty and uncovered holes, theoretical and actual field capacity, and equipment efficiency. Data was presented in the form of tables and graphs to determine the relationship between design parameters and the tool performance (Ansar et al., 2020).

### 3. RESULTS AND DISCUSSION

#### 3.1. Performance Test

Testing the performance of the corn seed planter is presented in Figure 2a. The figure shows that the process of operating the designed planter is very easy and practical. When pushed, the lever is able to open the seed allocation valve, so that the seeds can fall into the planting hole based on the recommended distance between plants, namely 20 x 35 cm. This distance between plants is considered optimal for increasing land productivity based on the results of previous research (Ansar *et al.*, 2020). Wirawan *et al.* (2018) also argue that spacing between plants is one of the factors for optimizing land use productivity.

The results of observations of actual field capacity are presented in Figure 2b. The results of observations show that actual field capacity varies between 0.241 - 0.275 ha/h. This is thought to be because the operator's thrust speed is not constant. The smallest actual field capacity is 0.241 ha/h and the largest is 0.275 ha/h. The average field capacity was found to be 0.258 ha/h.



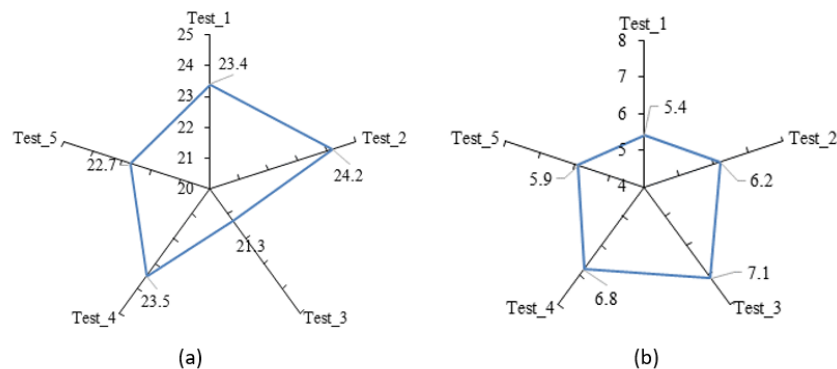
**Figure 2.** (a) Performance testing of the designed two-row corn seed planter in field; (b) Field capacity (ha/h) of the equipment

#### 3.2. Plant Space

The results of measuring the distance between plants are presented in Figure 3b. In this picture it can be seen that the lowest distance between plants is 21.3 cm and the highest is 24.2 cm. The results of these measurements show that the distance between plants varies. This happens because the ground surface is uneven, so it always changes as the wheel rotates. This variation in planting distance is still in accordance with the planting distance recommended by previous researchers (Oduma *et al.*, 2014).

Several factors influence land productivity, one of which is the distance between plants. In general, low land productivity is caused by non-optimal spacing between plants. Distances between plants that are too close together can result in the leaves of other plants shading each other, resulting in stunted plant growth. Apart from that, competition between plants for nutrients is also very large.

The growth of corn plants can be maximized by adjusting the distance between plants. Setting the distance between plants can minimize intra- and inter-species competition in populations. An excessive number of plants on limited land can reduce competition for plant growth factors, such as nutrients, water, solar radiation and growth space (Prastyo *et al.*, 2017).



**Figure 3.** Results of performance testing of the designed two-row corn seed planter: (a) Plant spacing (cm), (b) Planting depth

Spacing between plants that is too wide can improve the growth of individual plant roots, but provides an opportunity for weeds to grow in the plant gaps. Corn plants accompanied by weed growth can be detrimental because there is competition in the use of nutrients, water, light and growing space. Spacing between plants, apart from reducing the number of plant populations, also reduces the use of sunlight and plant nutrients, because some of the solar radiation only falls on the soil surface and nutrients can be lost as a result of evaporation. [Nariratih et al. \(2013\)](#) also reported that spacing plants that are too close together can disrupt growth, but if they are too far apart can reduce the number of plants per unit area.

### 3.3. Planting Depth

The results of measuring the depth of the planting hole are presented in Figure 3b. This image shows that there are deep planting holes, but there are also shallow ones. This varying depth of planting holes is caused by the uneven texture and condition of the land because the soil processing process was not carried out perfectly. The planting process occurs after the planting hole is formed and then the corn seeds fall directly into the planting hole. The depth of the planting holes produced in this study ranged from 5.4 – 7.1 cm.

The ideal depth of the planting hole according to research results ([Sitorus, 2015](#)) is 3 - 5 cm because it can produce perfect seed growth capacity. Planting seeds that are too deep can cause poor growth. The depth of the planting hole resulting from this research exceeds the standard ideal depth of planting holes. This is caused by the spout of the planter being too tapered and sharp, resulting in a hole that is too deep. Improving this planting tool can be done by designing a slightly blunt punch snout.

The research results of [Lanya et al. \(2020\)](#) also reported that the shallow depth of the planting hole can cause the seeds to not be firmly planted because the roots are not deep enough. The heavy load because the seed coat is lifted to the surface of the soil can cause the seeds to fall easily when exposed to water.

The depth of the seed planting hole affects the growth and development of plant roots. It is very important to pay attention to the depth of seed planting so that the germination process, which is the beginning of seed growth and development, can take place well. In addition, planting seeds too deep can cause the seeds to work harder to reach the soil surface and will use up energy to produce leaves and stems ([Amalia et al., 2020](#)).

### 3.4. Distribution of the Number of Seeds per Planting Hole

The results of observations of the distribution of the number of seeds per planting hole are presented in Table 1. In this table it can be seen that the distribution of the number of seeds per hole varies. The distribution of the number of holes filled with 0 seeds was 3.00%, 90.38% filled with 1 seed, and 6.62% filled with 2 seeds. The number of seeds expected per planting hole is only 1 seed. In fact, the seed rationing disc has been designed by shifting the rotor casing to adjust the diameter of the corn kernels, but sometimes the seed rationing process is not as desired. This variation in the number of seeds per planting hole is thought to be caused by the non-uniform shape and diameter of the corn seeds. Another factor is that there is no agitator implement, so there is a buildup of seeds on the metering device which is influenced by the weight of the seeds and the earth's gravitational force.

**Table 1.** Distribution of the number of seeds per planting hole

Number of seed	Distribution of number of seeds per hole (%)					Average
	1	2	3	4	5	
0	2.86	2.62	3.57	4.05	1.90	3.00
1	89.05	89.76	90.95	89.76	92.38	90.38
2	8.10	7.62	5.48	6.19	5.71	6.62

The seed allocation component is the most important part of this planting tool because it functions as a divider for the seeds to fall regularly into the planting hole. This component is driven by the rotational power of the wheel by rotating the planting unit's axis, so that the seeds can fall based on the earth's gravitational force. The performance of the seed removal tool has worked well because it is able to place seeds in the soil with an average of one seed per hole, although there are still holes with two seeds. More than one seed in one hole can cause competition for sunlight. On the other hand, if many planting holes are empty, then the plant population is not optimal so that production per area will be low. Likewise, the number of seeds in each planting hole must also be considered when cultivating corn. An excessive number of seeds per planting hole cannot provide optimal results. In order for the growth and development of corn plants to be optimal with high production, the number of hollow seeds must be properly regulated to maintain the balance of food nutrients in the soil. The greater the number of seeds in the planting hole, the nutritional requirements also increase.

### 3.5. Field Efficiency

The results of testing in the field obtained data on actual field capacity (AFC), theoretical field capacity (TFC), and efficiency (Eff) as shown in Table 2. The average AFC value was 0.27 ha/hour, while the average TFC value was the average is 0.31 ha/hour, so that the efficiency of the planting equipment is obtained on average at 85.61%. This data shows that the efficiency of this planter has met the minimum standards for the manually operated planter category, as previously reported by researchers. The efficiency value obtained from this research is higher when compared with the results of research ([Djoyowasito et al., 2017](#)) regarding performance tests and design of a single-tube system corn seed planting machine which only produced an efficiency of 82%.

**Table 2.** Data on the efficiency of using a two-row corn seed planter

Plot	AFC (ha/jam)	TFC (ha/ jam)	Efficiency (%)
1	0,27	0,31	87,10
2	0,26	0,31	83,87
3	0,27	0,32	84,38
4	0,28	0,33	84,85
5	0,29	0,33	87,88
<b>Average</b>	<b>0,27</b>	<b>0,32</b>	<b>85,61</b>
<b>Deviation Standard</b>	<b>0,010</b>	<b>0,009</b>	<b>1,580</b>

Based on the data in Table 2, it can be seen that the efficiency value of using the two-row corn seed planting tool is greatly influenced by the pushing speed and soil texture. The higher the pushing speed, the higher the efficiency of tool use. A similar thing has been reported by (Yazgi, 2016) that short planting times can provide higher efficiency. The maximum recommended forward speed limit for this tool is 2.33 km/h based on previous research. If it's too fast, sometimes the corn seeds won't embed properly.

The land area used to test the capacity of the tool is 550 x 350 cm. The distance between plants has been determined based on the results of preliminary research, namely 20 x 35 cm. To obtain accurate and precise test results, field tests are carried out in rice fields to produce more accurate data. The location for this field test was a rainfed rice field which was dry at the time the test was carried out. The testing process starts from placing corn seeds in the seed storage tank to observing the number of seeds that come out and are embedded in the hole.

Field test results show that when the tool crosses hard and rocky soil textures, the planting mouth cannot open a soil groove that matches the desired hole depth. This happens because the weight of the tool is less than optimal and the groove opening tip is not sharp enough. Even though the land conditions used to test this planting tool were uneven, planting holes were still formed. The same thing has been reported by (Sianipar & Fatoni, 2019) that the hard soil texture conditions sometimes make it difficult to form planting holes, so that the distance between plants is sometimes not the desired distance. Furthermore (Cay et al., 2018) said that the distance between plants in each plot can vary due to the influence of the uneven ground surface. Thus, as far as possible, till the soil as thoroughly as possible before planting.

#### 4. CONCLUSION

The components of the two-row corn seed planter that have been designed can be used to plant corn seeds, although there are still several shortcomings and limitations. These shortcomings can be taken into consideration for the development of subsequent tools. The lowest distance between plants is 21.3 cm and the highest is 24.2 cm. The depth of the planting hole ranges from 3.0 – 7.1 cm. The distribution of the number of holes filled with 0 seeds was 3.00%, 90.38% filled with 1 seed, and 6.62% filled with 2 seeds. The average efficiency of planting equipment is 85.61%. The efficiency value of tool use depends on the worker's pushing speed. High thrust speeds can also result in high tool usage efficiency. The efficiency value can increase if this planting tool is used on land with a soft soil texture and a flat surface. Fast planting and less tiring work are important benefits for farmers from using this tool.



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