



Engineering of Ergonomic and Affordable Rice Planting Tool for Effort to Meet the Energy Scarcity of Agriculture

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Abstract. The aim of this research to develop a simple rice seedling transplanter with a crank system for two lines, the manufacturing costs are cheap and affordable, ergonomic, lighter and easy maintenance. Agricultural activities are mostly found in rural areas and many land conditions are divided into small plots, making it difficult to implement mechanized machinery, especially planting machines of the field rice seedlings, this causes farmers to be reluctant to use these machines in addition to expensive prices. Expectations of the results of this study can motivate farmers to implement rice seedlings planting tools that begin with simple technology and can overcome the scarcity of planters so as to support the food security program. The design approach is based on a functional design and structural design. The stages of designing this machine include problem identification, formulation and refinement of ideas, selection of draft concepts, analysis and creation of working drawings, manufacturing of prototype tools, testing and refinement of prototype tools. Field testing showed that this rice seedling planter had a working capacity of 0.03ha/hour, at road speed of 0.5km/hour.

1. Introductions

Transplanter of rice seedlings is a technological innovation of planting machines to move seedlings on rice plants. This tool has the advantage of being able to accelerate the planting time of rice seedlings and overcome the scarcity of labor planting rice seedlings in certain areas. In rice cultivation, one of the activities that absorbs labor is the planting of rice seedlings. Budiman [6] explains that the activity requires a workforce of around 25-30% of the total workforce needs of rice cultivation. At this time farmers in the implementation of rice farming still plant rice seedlings manually with human labor. Problems regarding the scarcity of rice planting labor began to occur in several rice production centers, although the entire area of rice fields could be planted but not on time. This was due to the limited number of planting workers. Such a situation is certainly very alarming for the government in increasing food security.

The scarcity of labor conditions, especially in rice cultivation activities, often causes the planting schedule to retreat and not simultaneously, thus affecting the rice cropping index, pest disturbance which ultimately affects rice production. Therefore, since the last few years, rice transplanter machines have been introduced and developed. Agricultural activities are mostly found in rural areas and many land conditions are divided into small plots, making it difficult to implement mechanized machinery, especially planting machines of the field rice seedlings, this causes farmers to be reluctant to use these machines in addition to expensive prices.

The aim of this research to develop a simple rice seedling device with a crank system for two lines, the manufacturing costs are cheap and affordable, ergonomic, lighter and easy maintenance.

Expectations of the results of this study can motivate farmers to implement rice seedlings planting tools that begin with simple technology and can overcome the scarcity of planters so as to support the food security program.

The benefits of this research activity in terms of technology are improving the efficiency of planting rice seedlings moving system, increasing the work capacity of transplanting wetland rice seedlings compared to conventional planting systems, and spurring the development of appropriate tool design that refers to local potential and capabilities. Benefits social benefits are growing application technology for planting rice seedlings of moving system, motivating farmers to face the reduction of agricultural power, advancing agriculture, especially planting rice seedlings, paddy seedlings of moving systems is more ergonomic and affordable prices, and opening business opportunities for planting rice seedlings that more interesting.

2. Literatur View

Budiman [6] explains that planting of paddy seedlings in Indonesia is still done manually and absorbs planting power, time and relative production costs of 25-30 hok/ha or 200-240hours/ha or 25-30% of total power for rice cultivation or 100-120hok/ha. Whereas the scarcity of planting power has occurred everywhere, including in rice production centers in Java. As a result, many irrigated rice fields experience delays in planting time, although efforts have been made to raise planting costs by Rp. 750,000-850,000/ha, which is quite expensive. To overcome the scarcity of planting power, it is necessary to engineer a prototype of a manual rice seedling device and use rice seedlings resulting from wet or conventional nurseries. The planting tool as an alternative to providing manual rice seed planting equipment for farmers who do not use dry nurseries.

Anonymous [2] explains that the development of rice planting systems before 1965, almost all of them used the transplanting system technology using rice seedlings from fields with ages of 30-40 days. Anonymous [3] explains that While the development of the transplanting system in Japan began with the use of the rice seedling plant with the propulsion to plant it pulled by a tractor or tractor mounted and using the seedlings from dry seedlings or seedlings-type where the seedlings are placed in the nursery box or mat-type seedlings and until now there has been a growing tool for planting rice seedlings with propulsion for planting and being pulled and rotated by self-propelled transplanters.

Siregar [12] explains that while the development of the technology of planting rice seedlings in Indonesia is constrained by the farmers generally workers as farm laborers, do not have arable land. Therefore, since 1983 a simple, easy and inexpensive model of rice seedlings planting or manual tansplanter has been developed. Criteria for rice seedlings that can be planted by using rice seedlings: young age 15-21 days after seedling, has 3-4 leaves and seed height from the ground surface to the longest leaf tip about 17-22 cm, with a depth of planting ranging from 2.5 to 7.5 cm.

Siregar [12] also explain that to evaluate the performance of the planting tool, it can be done based on the design parameters of the design of the rice seedling planting tools, including the number of empty hills, missing hills, floating hills, broken hills, seedlings collapsed, number of plants per clump, number of population per unit area, uniformity of number of embedded seedlings per uniform or uniformity of plants per hill, row space, planting depth and work capacity.

Ravikumar [10] has designed and developed rice growers to help farmers because of the reduction in labor, costs and time. This tool consists of the main framework configuration, hopper, planter stalks and floats. This tool is very simple and lightweight to be more ergonomic because it reduces energy use. Bhowmik [5] has also attempted to develop manual rice-growing planters. the use of rice seed planting machines for the farming community is still complicated and expensive the working capacity of this tool can reach 0.2 ha/day, by working 8 hours a day. Estimated cost of making this rice transplanter is Rs 7000 and is easy to operate.

Sing [11] explained that traditional rice cultivation with human power is less efficient because of its low work capacity, less regular planting distance, besides being less ergonomic because when planting a bent body position that can cause serious back pain. The working method of the transplanter tool that is made is when the tool moves forward the wheel will rotate, then move the chain that carries the rice seedlings and is planted by the fins placed on the wheel. This tool still needs improvement so that its performance is more optimal.

Pradhan [9] explained that the use of rice transplants ergonomically helped the use of human power. In this article heart rate was examined because of the influence of transplanter use for 2 lines, 3 lines, and 4 lines. Heart rate use 4-line transplanter was 137.4 beats/minute, use transplanter 3 lines were 130.8 beats/minute and 127.7 beats/minute for 2 lines transplanter. Oxygen consumption rate is 1.10 l/min for transplanter 4 lines, followed by 1.02 l/min for transplanter 3 lines and 0.9 l/minute for transplanter 2 lines.

Aimin [1] obtained a patent for a rice seedling plant manually, no CN201230460Y patent. This rice transplanter manual consists of a frame, the floating plate, the slider, and seedlings groove components. The purpose of this invention is the existence of a simple, low cost, good quality rice seed planter, suitable for small plot.

Bangren [4] also obtained a patent for a rice seedling planter, no CN101317509B. The mechanism of this tool consists of four planters, which consist of the upper crank, the planter arm, which is equipped with a rocker arm and clamping rod. Manual rice seed planting tools generally have the same principle, there are arms to pick up seeds and plant them.

Gao [7] specifically researched the stem of the planter, obtained patent No. CN201222865Y. The present invention is to perfect the disadvantages of the prior art and to provide an arm that has better performance, reduces the use of lubricants, and increases product durability, so that its operation is more stable. The planter has an important role in the transplanter to take and immerse the rice seedlings.

3. Methodology

The design approach for designing this rice planting tools is done through several stages, among others; Literature review and field, basic data collection and analysis, Design and testing. Stages of making this machine design refers to the methods compiled by Pahl [8] which is described in the book Engineering Design, which includes problem identification, formulation and completion of ideas, selection of draft concepts, analysis and drawing of work drawings. The tests include structural and functional testing at the Laboratory. After doing the field test; adaptation test, functional, and verification. Then for the improvement made the modifications and re-testing.

4. Prototype model

The rice seedlings planting tool uses human propulsion, which is designed to be integrated so that it does not take up too much space, simple, lighter, and ergonomic. The design criteria that exist in the design are it is used to plant rice seedlings, this machine can take rice seedlings and plant rice seedlings, has a light and simple construction, has a size of 165cm(long), 96cm(wide), 55cm(high), number of rows 2 rows, and human driving force. The model of rice seedlings planter is shown in figure 1.

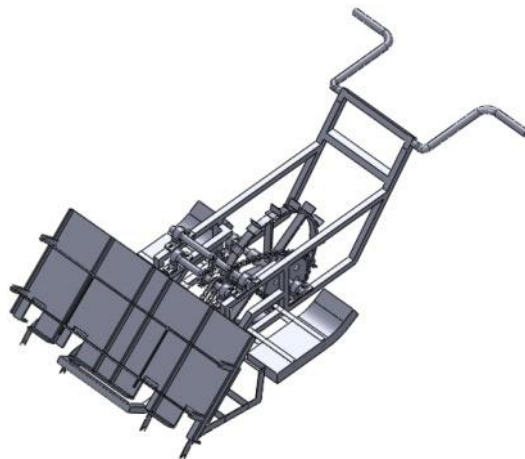


Figure 1. The model of rice seedlings transplanter

Planting rice seedlings or rice transplanter functions to plant rice seedlings in rice fields. Operation of this tool by being pulled by the driver. The framework of the rice seedling planter tool is made of iron box size 2.5 cm×2.5 cm with iron pipe 2.54cm in diameter. 15-day old rice seedlings are placed on the storage reservoir. Then the power of the driving wheel is used to rotate the axle through the wheel, the shaft is connected to the main gear, then the main gear is connected by using the second gear chain where the second gear shaft also turns the direction of the gear in reverse. rotation in the third gear shaft, so that the second and third gear shaft rotations are opposite, then the third gear is connected using a chain to the driving gear of the planter stem so that the stem of the planter can move to grab the rice seed in the hopper and plug it into the paddy field. Tool making scheme can be seen in figure 2.

The working principle of this transplanter device is that the rice seedlings are placed in the rice seedlings storage reservoir, the rice seedlings flow down because of the slope of the seedlings collection tank and the force of gravity. At the bottom of the reservoir there is a hole and the regulator of the amount of folw of rice seedlings. The rice seedlings in the hole are taken by the planting arm and immersed in the sludge. The movement of the planter arm comes from the wheel rotation. The amount of rotation of the planter arm is regulated by the comparison of the gear on the shaft of planter arm and the gear of the wheel shaft.

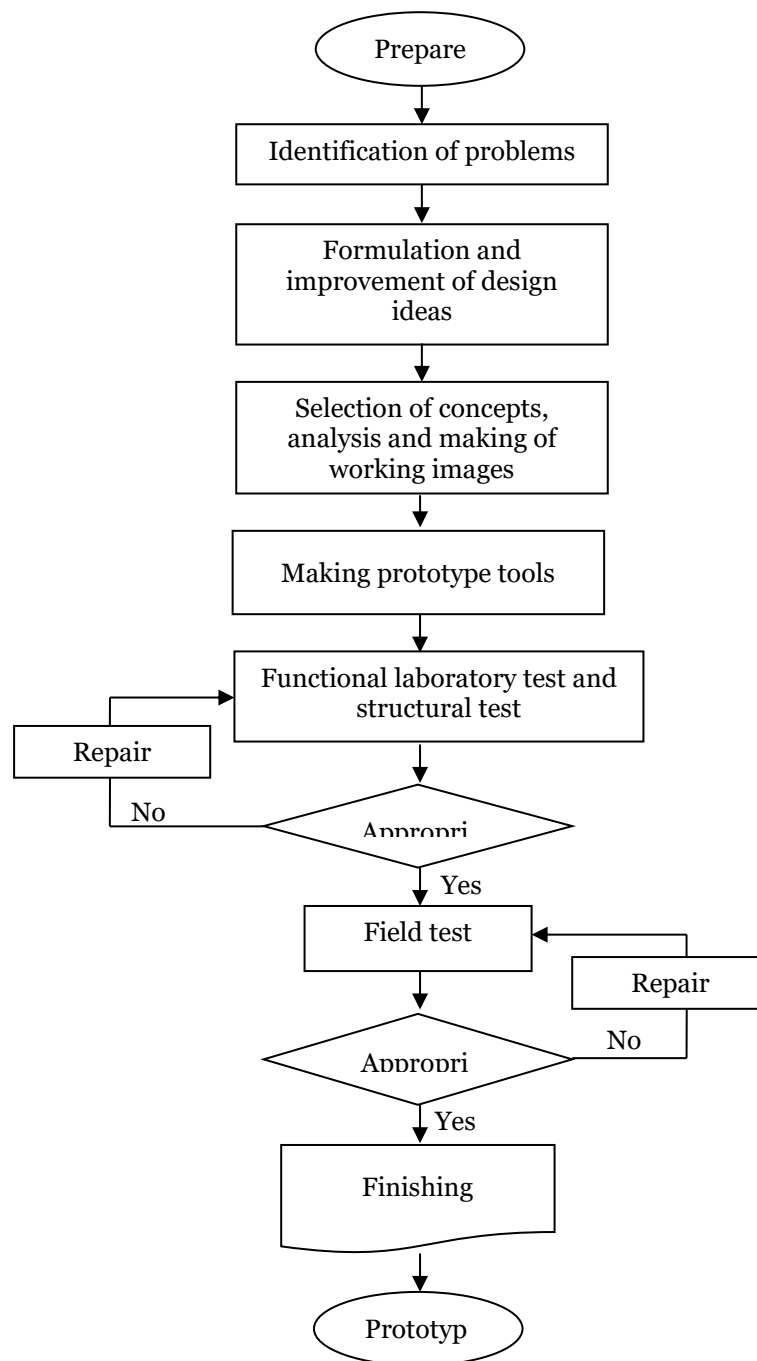


Figure 2. Scheme of making field rice transplanter

5. Result and discussion

This tool is more efficient because it has a working capacity of 0.03 ha/hour compared to traditional planting with hands that have a working capacity of 0.006 ha/hour. Besides this tool is more ergonomic because the operation is enough to be pulled by hand, while traditional methods, rice seeds are planted one by one while bending down causing fatigue and lumbago. This transplanter needs development so that the design of the tool is simple and lighter.

The testing was carried out in two stages, namely laboratory test and field test. Tool design testing includes structural tests and functional tests. Broadly speaking, the results of the testing of the rice seedling planter have worked well in accordance with the predetermined plan. However, there are several components of rice seed planters that have not worked optimally.

Structural testing results show that all components of the rice planting tool are sturdy and strong, while functional testing shows that the driving wheel and transmission work in accordance with its function, namely to continue the wheel rotation to the planter unit. Buoys function properly in accordance with the desire to be able to withstand the load of the equipment while operating so as not to sink into the mud. Seed storage tanks and seed flow regulators also function well, namely flowing and feeding rice seeds to the stem of the planter for the planting process. However, the flow of rice seeds is still not working optimally because the regulator of the amount of seed flow is still not perfect. The planter's arm has functioned to take the rice seeds and add them to the rice field mud, but the embedded rice seedlings still collapsed and were not upright, this was caused by the less rapid rotation of the planter's arms. The number of seedlings needed follows the equation (1)

$$N = \left(\frac{10000}{L \times S} + 1\right) \times J \times B \quad (1)$$

N is the number of seedlings per hectare, L is working width of the tool(m), S is spacing in rows(m), J is The average number of seedlings per clump, B is number of transplanter lines.

Based on data and test results, the prototype of planting rice seedlings that have been made has specifications:

- Dimensions of 165cm(long), 96cm(wide), 55cm(high);
- Tool working width of 60cm;
- Number of lines one way of 2 lines;
- Spacing between rows of 40cm;
- Spacing in rows of 33cm;
- Average planting depth of 2.98cm;
- Work capacity of 0.03ha/hour;

- Road speed of 0.5km/hour;
- The average number of seedlings of 3seedlings per clump;
- Number of seedlings needed of 303037seedlings/ha.

Factors that influence the performance of this tool are field paddy readiness, age and height of rice seedlings, road speed, slope angle, smooth flow of seedlings, and shape and size of rice seed plant stalks. Research activities can be seen in figures 3.



Figure 3. (a) tool making process, (b) prototype tool, (c) laboratory test, (d) field test

6. Conclusion

The prototype of rice seedling transplanter which has been made has specifications, dimensions of 165cm(long), 96cm(wide), 55cm(high), tool working width of 60cm, number of lines one way of 2 lines, spacing between rows of 40cm, spacing in rows of 33cm, average planting depth of 2.98cm, the average number of seedlings of 2-3 seedlings per clump, work capacity of 0.03ha/hour, road speed of 0.5km/hour. This prototype needs improvement so that its performance is better, more efficient and more ergonomic, so that it can be applied to rural communities and narrow land conditions.

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