SALAGA Journal
Vol. 02, No. 2, December 2024, pp. 73~79
ISSN: 3032-2677
DOI: 10.70124/salaga.v2i2.1777

Performance Test and Operational Cost Analysis of the Jajar Legowo RTP-2040 Rice Transplanter in Padaelo Village, Lamuru District

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Article Info

Keywords:

Cost
Efficiency
Rice Transplanter

ABSTRACT

Rice fields are used as an alternative to achieve food self-sufficiency because they have many advantages such as providing lots of water, land close to rivers, and the ability to choose land for farming. So this research is needed to determine the work efficiency and operational costs of the Jajar Legowo RTP 2040 rice transplanter. So that it can maximize the performance of this planting tool when it is later used by farmers. The aim of this research is to determine the work efficiency and operational costs of the Jajar Legowo RTP 2040 rice transplanter on rice fields in Bone Regency. The procedure used begins with the seeding stage, land processing, and the rice transplanter operation stage. The Jajar Legowo RTP 2040 rice transpanter was operated with a test distance of 10 x 10 m and carried out 3 repetitions using a speed of 2 km/hour on the land according to the planting work pattern. The results of this research obtained a KLT value of 0.257 ha/hour, KLE of 0.193 ha/hour, and field efficiency of 75.15%. Meanwhile, the wheel slip value obtained was 15.42. As for the cost analysis, the fixed costs are obtained at Rp.8.842.988,-/year, while the total variable costs are Rp. 5.154.240,-/year. Basic operational costs obtained are IDR. 13.997.228.-/year.

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1. INTRODUCTION

Rice fields are a vital natural resource for agricultural production, particularly for rice cultivation. They play a crucial role in achieving food self-sufficiency due to their numerous advantages, such as abundant water supply, proximity to rivers, and the ability to select large areas of land suitable for mechanized farming, typically around 2.0 hectares per household. These factors make rice fields an essential component of agricultural systems, especially in regions where rice is a staple food.

One of the critical factors supporting lowland rice cultivation is the availability of an adequate labor force. However, the workforce for land preparation and planting is shrinking. Most of the current agricultural labor force has reached retirement age, and the younger generation shows declining interest in working on agricultural land, especially under conventional farming systems. This situation has raised concerns about maintaining stable food security, as the lack of labor and unsynchronized planting schedules have become significant challenges (Umar et al., 2017).

In Lamuru District, Bone Regency, traditional reverse planting techniques (known as TANDUR) are commonly used for rice cultivation. However, the decline in agricultural labor and the rising cost of hiring laborers have led to dissatisfaction among farmers. This has created a pressing need for technological advancements in the form of automated planting systems. Agricultural machinery has become a primary necessity for the industry, not only to address labor shortages but also to enhance efficiency by saving time, labor, and production costs.

In 2021, the Bone Regency Government distributed agricultural machinery, including the Jajar Legowo RTP 2040 rice transplanter. The Jajar Legowo planting system is a traditional Indonesian method that involves arranging rice seedlings in a specific pattern to optimize sunlight exposure and nutrient absorption. This system has been widely adopted in Indonesia and has been adapted for mechanized farming with the introduction of the Jajar Legowo RTP 2040 rice transplanter. Despite its potential, many farmers have yet to utilize this tool, primarily because it is relatively new to them.

Based on the challenges and opportunities outlined above, this research aims to determine the work efficiency and operational costs of the Jajar Legowo RTP 2040 rice transplanter. By evaluating its performance, this study seeks to maximize the effectiveness of this planting tool and encourage its adoption among farmers in Bone Regency and beyond.

2. MATERIALS AND METHODS

2.1. Materials

The tools used in this research include:

- **Jajar Legowo RTP 2040 Rice Transplanter**: The main tool used for planting rice.
- **Dapog (seedling tray)**: Used for germinating rice seeds before planting.
- **Measuring tape**: Used to measure di stance and land area.
- **Stopwatch**: Used to measure the operational time of the tool.

The materials used in this research include:

- **Rice seeds**: The variety of rice seeds used for planting.
- **Rice husk ash**: Used as a planting medium during the germination process.
- **Gasoline**: Used as fuel to operate the transplanter.
- **Water**: Used for germination and land preparation.
- **Oil**: Used as a lubricant for the transplanter engine.

2.2. Calculation of Theoretical Field Capacity (KLT)

Theoretical field capacity (KLT) is the amount of work that a tool or machine can perform when used according to its operational specifications. KLT can be calculated using the following formula:

$$KLT = 0.36\ x\ (v\ x\ 1) \quad (1)$$

Where:

- *KLT*: Theoretical field capacity (ha/hour)
- *v*: Machine speed (m/sec)
- *l*: Working width of the tool (m)

2.3. Calculation of Effective Field Capacity (KLE)

Effective field capacity (KLE) is determined by the theoretical working width of the machine, the percentage of the theoretical area actually used, the operating speed, and the amount of time wasted during operation. KLE can be calculated using the following formula:

$$KLE = \frac{Land\ Area\ (ha)}{Total\ Working\ Time\ (hours)} \quad (2)$$

2.4. Calculation of Field Efficiency

Field efficiency is calculated based on the comparison between effective field capacity (KLE) and theoretical field capacity (KLT). Efficiency is expressed as a percentage and can be calculated using the following formula:

$$Ef = \left(\frac{KLE}{KLT}\right)\ x\ 100\% \quad (3)$$

Where:

- *Ef*: Field efficiency (%)
- *KLE*: Effective field capacity (ha/hour)
- *KLT*: Theoretical field capacity (ha/hour)

2.5. Calculation of Wheel Slip

Wheel slip is the reduction in the tractor's forward speed caused by operational loads in the field. Wheel slip can be calculated using the following formula:

$$SI = \left(\frac{So - Sb}{So}\right)\ x\ 100\% \quad (4)$$

Where:

- *SI*: Wheel slip (%)
- *So*: Distance traveled by the wheel without load (m)
- *Sb*: Distance traveled by the wheel under load (m)

2.6. Calculation of Fixed Cost

2.6.1. Depreciation Cost

Depreciation cost is calculated based on the value of the machine at the end of each year. The formula used is:

$$Vt = P - (P - S)\ x\ \left(A/_F, i\%, N\right)\ x\ \left(F/_A, i\%, t\right) \quad (5)$$

Where:

- *Vt*: Value of the machine at the end of the year (Rp)
- *P*: Initial purchase price of the machine (Rp)
- *S*: Final value of the machine (Rp/unit)
- *i*: Capital interest rate (%)
- *N*: Economic life of the tool (years)
- *t*: Service life of the machine at the beginning of the following year

2.6.2. Capital Interest Costs

Capital interest cost is calculated using the following formula:

$$I = i\ x\ \frac{P - s\ x\ (N + 1)}{2N} \quad (6)$$

Where:

- I: Capital interest cost (Rp/year)
- i: Bank interest rate (%/year)Tax costs

2.6.3. Tax cost

Tax cost is calculated using the following formula:

$$BP = Pp\ x\ (P - S) \quad (7)$$

Where:

- *P*: Tax cost (Rp)
- *p*: Percentage of tax cost (2% or 0.02)

2.6.4. Garage Cost

Garage cost is calculated using the following formula:

$$Bg = Pg\ x\ (P - S) \quad (8)$$

Where:

- *Bg*: Garage cost (Rp)
- *Pg*: Percentage of garage cost (1% or 0.01)

2.6.5. Social Cost

Social cost is calculated using the following formula:

$$BS = Pp\ x\ (P - S) \quad (9)$$

Where:

- *BS*: Social cost (Rp)
- *Pp*: Percentage of social cost (2% or 0.02)

2.7. Calculation of Variable Costs

Variable costs are costs incurred when the tool or machine is used. These costs may vary depending on the usage of the tool or machine.

2.7.1. Fuel Cost

Fuel cost is calculated using the following formula:

$$Bb = Kb\ x\ Hb \quad (10)$$

Where:

- *Bb*: Gasoline cost (Rp/hour)
- *Kb*: Quantity of gasoline used (liters/hour)
- *Hb*: Price of gasoline (Rp/liter)

2.7.2. Lubricant Cost

Lubricant cost is calculated using the following formula:

$$Bp = Kp\ x\ Hp \quad (11)$$

Where:

- *Bp*: Lubricant cost (Rp/hour)
- *Kp*: Quantity of lubricant used (liters)
- *Hp*: Price of lubricant (Rp/liter)

2.7.3. Maintenance Cost

Maintenance cost is calculated using the following formula:

$$Br = 1.2\ \%\ x \frac{P - S}{100\ hours} \tag{12}$$

Where:

- *Br*: Maintenance cost (Rp/hour)
- *P*: Initial price of the tool (Rp/unit)
- *S*: Final value of the tool (Rp/unit)

2.7.4. Operator Cost

Operator cost is calculated using the following formula:

$$BO = U\ x\ \frac{1\ Day}{Jk}\ x\ Jo \tag{13}$$

Where:

- *BO*: Operator cost (Rp/hour)
- *U*: Operator wage per day (Rp/day)
- *Jk*: Working hours per day (hours/day)
- *Jo*: Number of operators (people)

2.7.5. Operational Cost

Operational cost is calculated by summing fixed costs and variable costs. The formula used is:

$$Bp = Bt + Bv \tag{14}$$

Where:

- *Bp*: Operational cost (Rp/year)
- *Bt*: Fixed costs (Rp/year)
- *Bv*: Variable costs (Rp/year)

3. RESULTS AND DISCUSSION

3.1. Land characteristics and sowing seeds

The rice transplanter testing was conducted under muddy soil conditions, with the rice field prepared and processed appropriately for planting. The field was prepared using a 2-wheeled tractor and left to settle for 2 days, achieving a water puddle height of 4-5 cm and a mud depth of up to 25 cm. These conditions align with the findings of Sudirman et al. (2017), who reported that rice transplanters perform optimally in paddy fields with mud depths of 20-30 cm (average 27 cm), ensuring effective results.

For the sowing stage, CL 220 variety rice seeds were used. The seeds were soaked for 24 hours before being spread onto a dapog/tray containing a planting medium composed of soil and rice husk ash in a 2:1 ratio. The seeds were sown at a depth of 2 cm and watered twice daily for 15 days. After this period, the seedlings reached an average height of 15 cm, making them suitable for transplanting. This practice is consistent with the recommendations of Umar et al. (2017), who noted that rice seeds for transplanting machines should be grown for 15-18 days or until they reach a height of 15-20 cm.

3.2. Rice Transplanter Working Capacity

In the process of planting rice seeds using a rice transplanter, two types of field capacity are considered: theoretical field capacity and effective field capacity. The working efficiency of the rice transplanter is determined by comparing these two capacities, as the efficiency of the machine is derived from the difference between the theoretical and effective field capacities. The following data were obtained during the research process:

Table 1. Rice Transplanter Working Capacity

Plots	Land Area (ha)	KLT ha/hour	KLE ha/hour	Efficiency (%)
I	0.01	0.256	0.189	74.09
II	0.01	0.256	0.191	74.55
III	0.01	0.258	0.198	76.81
Average	0.01	0.257	0.193	75.15

Table 1 shows the data from the KLT test results on Plot I obtained a result of 0.256 ha / hour using a speed of 0.582 m / s or 2.09 km / hour. In Plots II obtained a result of 0.256 ha / hour using a speed of 0.584 m / s or 2.10 km / hour and Plots III obtained a result of 0.258 ha / hour using a speed of 0.587 m / s or 2.11 km / hour.

The results of testing the three plots obtained average KLT value of 0.257 ha / hour. In KLE testing on the same land, the results obtained on Plot I amounted to 0.189 ha/hour, on Plot II obtained KLE of 0.191 ha/hour and on Plot III obtained KLE of 0.198 ha/hour. In the KLE test results on the three plots, the average result is 0.193 ha / hour so that it can be said that the KLE data obtained is in accordance with the minimum standards set out in (Badan Standarisasi Nasional, 2010) which is 0.15 ha / hour. The value of the working capacity of the rice transplanter obtained is highly dependent on the condition of the land and the length of the fertilization used. This is in accordance with the opinion of (Salim et al., 2021) which states that land conditions with a good blasting process with a long time can produce good land for rice transplanter planting.

The results of the KLT and KLE calculations are used to obtain the work efficiency value of the rice transplanter machine. The lowest efficiency obtained was 74.09% in Plot I, then increased in Plot II and Plot III where in Plot II an efficiency value of 74.55% was obtained and in Plot III an efficiency value of 76.81% was obtained. The average result of the efficiency value obtained from the three plots is 75.15% so that it can be said that the efficiency value obtained has met the minimum standard of field efficiency regulated in (Badan Standarisasi Nasional, 2010)which is 70%. "From the obtained data, the average efficiency achieved is around 70%, which is significantly higher compared to using a seed planter, which only ranges around 50% (Fitri Amalia & Syafruddin, 2022).

3.3. Wheel Slip

Traction wheel slip is the difference in the distance traveled by the planting machine wheels with the implement during operation divided by the distance traveled by the planting machine wheel with the implement without operation on the same soil conditions. Increasing wheel slip can reduce traction capability, engine pulling force can still be increased by reducing slip by up to 30%, optimum slip on the engine is 10-17%. The wheel slip obtained from this research can be seen in the table below.

Table 2. Wheel Slip

Plots	**Wheel Spin Distance on the Paddy Field (m)**	**Distance of 6 turns of non-field wheel (m)**	**Wheel Slip (%)**
I	8.1	9.58	15.46
II	8.0	9.58	16.49
III	8.2	9.58	14.40
Average	**8.1**	**9.58**	**15.45**

Table 2 shows the wheel slip test data on a rice transplanter in paddy fields. The wheel slip test was carried out 3 times on each plot of rice field. Testing of the tool is carried out using a wheel rotation of 5 times. In Plot I with a rotation distance of 8.1 meters, the wheel slip result was 15.46%. In Plot II with a rotation distance of 8.0 meters the wheel slip results were 16.49% and in Plot III with a rotation distance of 8.2 meters the wheel slip results were 14.40%. The average result of the wheel slip value obtained in the third plot was 15.45%, where the wheel slip data obtained met the maximum standard regulated in (Badan Standarisasi Nasional, 2010), namely 30%. The difference in wheel slip in Plots I, II and III decreased, this was due to the muddy land conditions so that the soil stuck to the wheels of the tools used, thus affecting the wheel slip values obtained. This is in accordance with the statement of (Idkham et al., 2018) which states that increasing the stickiness of the soil on the wheel fins will result in a reduction in the lifting and thrust forces on the fins, thereby affecting the slip value on the tool wheel, land muddying processes, flooded land conditions, uneven land surface conditions.

3.4. Rice Transplanter Cost Analysis

In determining the basic operating costs of using the Jajar Legowo RTP 2040 rice transplanter, it is first necessary to know the fixed and variable costs of the tool.

Table 3. Fixed Cost

No.	Fixed Cost	Rate	Unit
1	Depreciation costs	Rp. 5.050.130,-	Rp./Years
2	Interest cost of capital	Rp. 1.542.857,-	Rp./Years
3	Tax cost	Rp. 900.000,-	Rp./Years
4	Garage costs	Rp. 450.000,-	Rp./Years
5	Social cost	Rp. 900.000,-	Rp./Years
Total Fixed Cost		**Rp. 8.842.988,-**	**Rp./Years**

Table 3 shows the fixed cost analysis data of the rice transplanter jajar legowo RTP 2040 with an economic life of 7 years. Fixed costs are obtained from the sum of depreciation costs, capital interest costs, tax costs and garage costs. Depreciation costs, capital interest, taxes and social costs are calculated using BRI bank KUR data in 2023 with interest worth 6% and 2% tax so as to obtain a total fixed cost of Rp. 8,842,988, - / year. Fixed cost data obtained on the machine is relatively constant every year this is because fixed costs are not affected by production activities. This is in accordance with the statement of (Sherly et al., 2021) which states that fixed costs remain constant and are not affected by changes in the volume of activities or activities with certain activities.the engine capacity of the vehicle, the higher the consumption from fuel use, because more energy is needed for combustion.

Table 4. Variable Cost

No.	Variable Cost	Price/hour	Price/year
1	Fuel Costs	Rp. 7.600/Hour	Rp. 638.400/Years
2	Oil Costs	Rp. 3.360/Hour	Rp. 282.240/Years
3	Maintenance Cost	Rp. 5.400/Hour	Rp. 453.600/Years
4	Operator Fees	Rp. 45.000/Hour	Rp.3.780.000/Years
Total Variable Costs			**Rp.5.154.240/Years**

Variable costs are obtained by calculating fuel costs, lubricant costs, maintenance costs and operator costs. Table 4 shows the data from the analysis of non-fixed costs on the RTP 2040 jajar legowo rice transplanter machine that works on 6 hectares of rice fields and is processed 2 times a year. on the rice fields used, it is assumed that the fuel used when operating is 64 liters with a land area of 12 hectares for 84 hours.

The cost of using lubricants during the operation of rice transplanter is 6.8 liters with a total of 2 times or 84 hours of rice field processing so that the total cost of lubricants is Rp. 3,360 / hour. While the maintenance cost is obtained by reducing the initial price of the tool with the final price of the tool then multiplied by 1.2% of 100 working hours and obtained a value of Rp. 5,400 / hour. For operator costs in the cost analysis data, the results obtained are Rp. 45,000 / hour where the data is obtained by looking at the funds spent on machine operators is Rp. 120,000, - per person, operators who operate rice transplanter as many as 3 people, 1 machine operator and 2 helpers with a length of time for processing rice fields 42 hours with an area of 6 hectares and carried out 2 times a year. By obtaining data on fuel costs, lubricant costs, maintenance costs and operator costs, calculations can be made in determining the non-fixed costs of using rice transplanter. In addition, the cost of fuel, lubricants and maintenance costs themselves are costs that have variations depending on the use of rice transplanter machines. This is in accordance with the statement of (Melly et al., 2020) which states that non-fixed costs are costs incurred when the tool/machine is used. These non-fixed costs vary according to the use of the tool/machine or are strongly influenced by the usage time of the tool/machine.

3.5. Cost of operation

Table 5. Cost of operation

No	Cost of operation	Price (Rp/Years)
1	Fixed Cost	8.842.988
2	Variable Cost	5.154.240
	Total Cost	**13.997.228**

The results of fixed and non-fixed cost analysis data will be a reference in obtaining the cost of rice transplanter operations per year. Where the cost of operations is obtained by summing the results of the analysis of fixed costs and non-fixed costs which then obtained a result of Rp. 13.997.228, - per year for a land area of 6 hectares which is processed 2 times a year. Based on the results of the analysis of the cost of operating the rice transplanter machine jajar legowo RTP 2040, it can be determined that the cost of renting a rice transplanter machine in the village of Padaelo Kec. Lamuru is Rp. 2.000.000 / ha. According to (Annisah, 2015) tenant farmers only pay the cost of machine rental while the cost of fuel, operators, and damage is fully borne by the tool owner. For the determination of the cost of renting agricultural equipment, it is determined based on the area of land and the results of agricultural production.

4. CONCLUSION

Based on the research of Performance Test and Cost Analysis of Operation of Rice Transplanter Jajar Legowo RTP-2040 in Padaelo Village, Lamuru Sub-district, it can be concluded that: Rice transplanter jajar legowo RTP 2040 get a field efficiency value of 75.15% on paddy fields in Padaelo Village, Lamuru Sub-district. The cost of operating rice transplanter jajar legowo RTP 2040 is Rp. 13,997,228/year.

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