Performance Test and Economic Analysis of the Fertilizer Applicator Technique (Basal Type) in the Fertilization Process at Division 2 of PT. Pemukasakti Manisindah, Way Kanan Regency

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ABSTRACT

Sugarcane is a tropical and subtropical crop that requires optimal maintenance, one of which is through fertilization. Fertilization plays an important role in increasing productivity by adding nutrients, both organically and inorganically. However, its implementation is often hampered by limited time, labor, and land area. Inefficient conventional methods cause low yields and production quality, so a more effective and efficient fertilization approach is needed. The purpose of this Final Project Report is to determine the application of basal type fertilizer applicators in the fertilization process, calculate the unit requirements for these tools according to land conditions, and evaluate the efficiency of their use. In addition, this report also aims to analyze the fixed and variable costs incurred in the operation of basal type fertilizer applicators. The methods used in compiling this final project report are observation, interviews, literature studies and the creation of a final project report. The application of basal type fertilizer applicators at PT Pemukasakti Manisindah is carried out using a spiral pattern with a row of barriers to facilitate tractor maneuvers and save fuel. The tractor starts from the center of the land and moves in a spiral to the right until the entire area is fertilized. Based on calculations, three fertilizer applicators are required to support the fertilization process. The equipment's performance shows a Theoretical Field Capacity (FTC) of 1.24 ha/hour, an Effective Field Capacity (EFC) of 1.02 ha/hour, with a Field Efficiency of 82%. Annual fixed costs consist of depreciation of Rp31,500,000, taxes of Rp14,000,000, and a building or garage of Rp10,500,000, totaling Rp56,000 per year. Furthermore, variable costs per hour include fuel of Rp134,640, lubricants of Rp660,000, operators of Rp16,000, repairs and maintenance of Rp105,000, and other costs of Rp2,666.66.

Keywords: Sugarcane, Fertilization, Fertylizer applicator, Basal type

INTRODUCTION

The majority of Indonesia's population works in the agricultural sector. Agriculture plays a vital role in driving economic growth and meeting people's basic needs. The agricultural sector in Indonesia is one of the largest industries and an important source of national wealth. With population growth, demand for basic necessities also increases, making agriculture a strategic sector in ensuring food availability and improving public welfare (Ayun et al., 2020).

Sugarcane (Saccharum officinarum L.) is a commodity that plays a crucial role as the primary raw material for sugar production. Sugar itself is a staple in every household. As a strategic plantation crop, sugarcane not only serves as a raw material for the sugar industry but also makes a significant contribution to state revenue, creates jobs, and provides a livelihood for millions of farmers in Indonesia (Urbaiti et al., 2017).

Granulated sugar is a vital commodity in the Indonesian economy. The national sugar industry's primary goal is to meet domestic demand, although currently, production capacity is still limited and unable to meet all domestic demand. In recent years, the sugar industry has experienced a significant decline in production, with a low of 1.48 million tons occurring in 1999. Then, in 2002, sugar production increased to 1.76 million tons. However, this figure was still insufficient to meet the national demand of 3.3 million tons, resulting in a deficit of 1.54 million tons (Urbaiti et al., 2017).

One factor contributing to low sugar production in Indonesia is the low productivity of sugarcane fields, primarily due to suboptimal cultivation techniques, such as fertilization. The high nutrient requirements of sugarcane cause soil nutrient levels to rapidly decline, particularly in monoculture systems. Therefore, adequate fertilizer application is crucial for achieving optimal yields. Even very fertile soil cannot continuously provide large amounts of nutrients for years. Therefore, appropriate fertilization is necessary to replace or supplement lost nutrients to maintain optimal crop productivity (Cahyani et al., 2016).

In addition to technical cultivation issues, fertilization also faces obstacles in its implementation, such as limited working time, large land area, and a lack of labor. Efficient fertilization plays a crucial role in increasing production yields by providing inputs that can produce higher yields. However, conventional fertilization methods are often inefficient and require a large amount of labor, resulting in low productivity and low quality of agricultural products (Village et al., 2025). Therefore, the use of tools in the fertilization process can improve the efficiency and effectiveness of agricultural activities overall. Therefore, mechanical tools such as fertilizer applicators are needed to assist the fertilization process. By using this tool, the fertilization process can be more efficient, and an analysis of the ideal number of tools according to the area of land being worked is necessary. Fertilizer applicators function to apply fertilizer to sugarcane fields. This application will be successful if carried out correctly and precisely..

LITERATURE REVIEW

Sugarcane (Saccharum officinarum L.) is a vital commodity as the primary raw material for sugar production. Sugar itself is a staple in every household. As a strategic plantation crop, sugarcane not only serves as a raw material for the sugar industry but also contributes significantly to state revenue, creates jobs, and provides a livelihood for millions of farmers in Indonesia (Urbaiti et al., 2017).

A fertilizer applicator is an additional tool (implement) used in the fertilization process of sugarcane plants, for both initial (basal) and follow-up (ratoon) fertilization. This tool is operated by a tractor with a power of between 90 and 110 hp. The fertilizer applicator consists of several main components: a frame (beam) that supports the entire tool, a hopper used as a container for fertilizer, and a furrow opener that creates furrows in the soil for fertilizer entry, typically using a tyne. In addition, there is a metering device that regulates the amount of fertilizer delivered into the furrow according to the required dosage, which can be adjusted through an opening in the hopper. Other components include a drive motor that converts power from the Power Take-Off (PTO) into translational motion to operate the furrow opener, and a funnel that directs the fertilizer to fall accurately into the furrow. This tool is driven by a hydraulic oil motor driven by the tractor's hydraulic pump oil. Overall, this tool is designed to simplify and accelerate the mechanical sugarcane fertilization process (Yusroni, 2017).

RESEARCH METHODS

3.1 Time and Location

This Final Project Report is based on data obtained during the Field Work Practice (PKL) activities. The PKL was implemented over a four-month period, from March 3, 2025, to June

20, 2024. The PKL activities were conducted in Division 2 of PT. Pemukasakti Manisindah. The internship schedule is the same as employee working hours, Monday through Thursday, from 7:00 AM to 3:30 PM WIB, Friday from 7:00 AM to 4:00 PM WIB, and Saturday from 7:00 AM to 12:00 PM WIB.

3.2 Tools and Materials

a) Tools

The tools used in the data collection process for this Final Project Report are as follows:

a) Implement Fertylizer Applicator (Basal Type);
b) John Deere Tractor Unit type 6110b;
c) Rollmeter/tape measure;
d) Stationery;
e) Stopwatch; and
f) Mobile phone.

b) Materials

The materials needed for data collection for the preparation of this Final Project Report are sugarcane fields, specifically in the Makrup Area, Plot 155, Division 2.

RESULTS AND DISCUSSION

Implement fertilizer applicator performance testing can be performed by measuring the effectiveness and efficiency of its use. One way to test its performance is by observing a four-wheeled tractor using an implement fertilizer applicator during the fertilization process in the field. Measuring the working width of the implement and testing the implement fertilizer applicator are carried out to observe and determine the level of efficiency of the equipment's use. Testing is carried out to determine the field capacity and efficiency of the implement fertilizer applicator by measuring the time per pass for three samples, the width of the processed product, the total time and effective time, the length of the pass, and the area of the sampled land. The measurement of the processed product can be measured with a meter, then measuring the time on three passes is measured using a stopwatch to determine the tractor's speed. Tractor speed data can be seen in Table 1.

Tabel 1. Data kecepatan traktor

Repetition	Track Length	Traveling time	Tractor Speed
1	(m)	(s)	(m/s)
2	100	41	2,4
3	100	41	2,4
Average	100	44	2,2
Repetition	100	42	2,3

Source: Data collection results, 2025

Based on the data in Table 2, the performance speed of a fertilizer applicator with a John Deere 6110B tractor coupler, which was tested three times, yielded an average travel time of 42 seconds, with an average tractor speed of 2.3 m/s.

The working capacity of a tool or machine is the ability of the tool or machine to produce a certain amount of output (such as liters, hectares, or kilograms) within a specified time period. Meanwhile, working capacity in soil cultivation refers to the area of land a tool or machine can cultivate in a given time. Units typically used are hectares per hour, hours per hectare, or hectares per hour per tractor horsepower (hp).

1) Theoretical Field Capacity (TLC)

Theoretical field capacity is the ideal condition where a tool or machine can complete its work optimally based on its operational speed and working width, assuming there are no interruptions or obstacles during the operational process (Dewi et al., 2021). The formula for calculating theoretical field capacity is explained as follows:

KLT = 0,36 (V x Lp)

Information:
KLT = theoretical field capacity in ha/hour

0,36 = convert m/sec to ha/hour
V = tractor speed in m/s
Lp = working cutting width of the tool in m units

1) Effective Field Capacity
Effective field capacity is the condition at which

a tool or machine can complete its work, both in terms of the amount of material processed and the area worked, based on the total time used. The smaller the difference between the effective field capacity and the theoretical field capacity, the more efficient and optimal the performance of the tool or machine (Dewi et al., 2021). The formula for calculating theoretical field capacity is explained as follows:

$$KLE = \frac{LA}{WT}$$

Description:

KLE = Effective field capacity in hectares/hour
L = Area worked in hectares
Wt = Total time in hours

1) Field Efficiency
Field efficiency is the ratio between effective field capacity and theoretical field capacity, expressed as a percentage (Hanif et al., 2015). This comparison can determine the level of efficiency. The higher the percentage, closer to 100%, the more efficient the tool or machine is.

The formula for calculating field efficiency is as follows;

$$EL = \frac{KLE}{KLT}\ X\ 100\%$$

Description:

EL = Field Efficiency %

KLE = Effective Field Capacity in ha/hour

KLT = Theoretical Field Capacity in ha/hour

Performance of the implement fertilizer applicator in basal soil fertilization for sugarcane fields. The performance results of the implement fertilizer applicator are shown in Table 2.

Table 2. Performance results of the implement fertilizer applicator operation

tractor speed traktor	working width	KLT	KLE	EL
(m/s)	(m)	(ha/ hours)	(ha/ hours)	(%)
2,3	1,5	1,24	1,05	84

Source: Personal calculation results, 2025

Based on Table 3 above, it is known that the data from the calculation of the performance of the fertilizer applicator operation, namely with a working width of 1.5 meters and a walking speed of 2.3 m / s, the Theoretical Field Capacity (KLT) value is 1.24 ha / hour, which means that within 1 hour of fertilization activities using a fertilizer applicator can complete fertilization of 1.24 ha of land. Then with a land area of 1.55 ha and land processing time from start to finish, getting a total time of 1 hour 28 minutes, the calculation results for the Effective Field Capacity (KLE) of 1.05 ha / hour, meaning that within 1 hour of fertilization using the implement fertilizer applicator can complete work with an area of 1.55 ha. Furthermore, the Field Efficiency (EL) value is obtained as 84% from the comparison of the Theoretical Field Capacity (KLT) and the Effective Field Capacity (KLE) multiplied by 100%. The field efficiency value of 84% is considered good because it is close to 100% and the machine is able to work efficiently. The field efficiency value is influenced by several factors, namely the turning time during the machine operation process and the fertilizer refilling process which takes quite a lot of time.

4.4 Prediction of Number of Units Needed

Estimating the need for agricultural equipment and machinery aims to determine the optimal number of tools and machinery needed to support agricultural land cultivation according to the existing area. With accurate calculations, companies can optimize fertilizer use, reduce costs, and increase crop yields. The daily rainfall limit for land cultivation using agricultural machinery is <10 mm/day. Based on rainfall data for the last 10 years (2015-2024) PT Sinergi Gula Nusantara obtained 155 working days for April to September. The results of the calculation of fertilizer applicator unit requirements can be seen in Table 3.

Tabel 3. Hasil perhitungan kebutuhan unit fertylizer applicator

Unit	Area (ha)	working day (day)	working hours (housr/day)	Kebutuhan Implement	Jumlah Implement yang tersedia
Fertylizer Applicator	1.469	155	8	3	3

2025 Source: Personal calculation results, 2025

Based on the data obtained in Table 4, it can be seen that the data on the need for fertilizer applicators for fertilization activities on cane plants with a total area of 1,469 ha in Division 2 of PT Pemukasakti Manisindah (PT PSMI) is carried out from April to September. From the calculations in Appendix 5, the number of implements needed is 3 units, this number is in accordance with the availability of implement fertilizer applicators at PT Pemukasakti Manisindah, which is 3 units and is expected to support the fertilization process in the entire area efficiently. In addition, this can reduce costs and can increase crop yields.

4.5 Fertylizer Applicator Calibration

Calibration is the process of determining the amount of fertilizer dispensed by a fertilizer applicator. The ultimate goal is to determine the amount of fertilizer needed for a given area of land, including the fertilizer requirement per hectare. The benefits of calibration (Maulana, 2023):

1) Accurately determining application doses;
2) Avoiding excessive fertilizer use; and
3) Preparing uniform application calculations.

The fertilizer applicator calibration process at PT Pemukasakti Manisindah involves filling the hopper with fertilizer, calculating the spacing length per hectare, and dividing it by the fertilizer dose per hectare to determine the number of spacings that should be applied, corresponding to the amount of fertilizer in the hopper. The next step is to open the outlet opening. If the fertilizer runs out before the target spacing length is reached, the opening is too large, and vice versa. This method results in fertilizer waste, requiring improvements to the calibration method to minimize fertilizer waste. Calibration is performed by dividing the fertilizer dose per hectare by the spacing length per hectare to determine the amount of fertilizer that should be applied per meter of wheel travel. To prove this, you can do this by running the tractor 1 meter away and collecting the fertilizer that comes out in a container and then weighing it to see if it is in accordance with the calibration calculations that were carried out.

4.6 Calculation of Fertilizer Requirements

Calculating fertilizer requirements is a crucial step in fertilizer management, ensuring the soil provides sufficient nutrients for plant growth, ensuring optimal nutrient availability at each stage of growth. This process takes into account several factors, such as crop type, land area, specific crop nutrient requirements, and the nutrient content of the fertilizer to be used. With accurate calculations, companies can determine efficient application doses, thereby increasing crop productivity, reducing waste, and minimizing negative impacts on the environment. Furthermore, calculating fertilizer requirements also supports sustainable agricultural practices by maintaining nutrient balance in the soil.

4.7 Calculation of Operating Costs

4.7.1 Fixed costs

Fixed costs are costs that are not affected by the frequency of agricultural equipment or machinery use. The amount of fixed costs per year will remain the same, even if the number of hours the equipment is used changes throughout the year. These costs remain an expense even if the agricultural machinery is not operated at all. Costs included in fixed costs include:

1) Depreciation Costs

Depreciation costs are costs incurred due to the decline in value of a tool or machine as it ages, whether the tool is used or not. This decline in value can be caused by various factors, such as component damage, increased operational costs, or the emergence of new, more efficient and practical technology. The calculation of depreciation costs is based on the economic value of the tool or machine. Its economic life can be expressed in years or hours, and its duration is greatly influenced by how the tool or machine is maintained (Sebastian and Syah, 2018).

a) Depreciation equation that does not account for interest on capital

$$D = \frac{P - S}{L}$$

Where:
D = Annual depreciation expense (Rp/year)
P = Initial price (Rp)
S = Final price (Rp)
N = Estimated useful life (years)

From the results of the depreciation expense calculation using the straight-line method and taking into account the initial price of the tractor, the final price of the tractor, and the estimated useful life of the tractor, the depreciation expense is Rp31,500,000.00/year.

1) Tax Cost

The amount of tax on agricultural machinery varies between countries. In Indonesia, the application of tax on agricultural machinery is still uncommon. The most accurate tax value is the annual tax amount imposed on the machinery. In some countries, this tax amount is usually around 2% of the initial price of the machinery per year (Sebastian and Syah, 2018).

From the results of the tax cost calculation, taking into account the estimated average annual tax of 2% and the initial purchase price of the tractor, the tax expense is Rp14,000,000.00/year.

1) Building/Garage Costs

A building/garage is a storage area for agricultural tools and machinery. If a building is available, it can be considered a component of the production unit or a separate unit. If considered a separate unit, the cost is determined specifically by calculating depreciation, maintenance costs, and the economic life of the building. If considered an integral part of the production unit, the calculation can be based on annual costs, the floor area or volume of the space occupied by the machinery, or the cost per unit of production. If a building for storage is not available, the building cost must be calculated due to the absence of a garage/building for the equipment or machinery. Generally, if there is no garage/building for storage, the risk burden is 0.5% to 1.5% of the initial cost. This burden will depend on local conditions (Sebastian and Syah, 2018).

From the calculation of the garage cost, taking into account the 1.5% garage expense and the initial price of the tractor, the garage cost is Rp10,500,000.00/year.

4.7.2 Variable costs

Variable costs are expenses incurred when a tool or machine is operated, and the amount depends on the duration of use within working hours. These costs are calculated in rupiah per hour (Rp/h). Components of variable costs include operator costs, fuel, maintenance and repairs to the tool or machine, and other unforeseen costs (Sebastian and Syah, 2018).

1) Fuel Costs

Fuel costs are the expenses required to purchase fuel used in the combustion process in the heating chamber, such as gasoline, diesel, or electricity. For gasoline- or diesel-powered machines, consumption is usually measured in liters per hour (lt/h). By knowing the local price per liter, the hourly fuel cost can be calculated. Meanwhile, for machines powered by electricity, consumption is expressed in kilowatts (kw) or watts. By knowing the electricity tariff per kilowatt-hour (Rp/kWh), the hourly electricity cost can be calculated. Information on fuel consumption for various agricultural machines is available in Table 4.

Table 4. Fuel consumption of agricultural machinery

Engine Types	Fuel Consumption (lt/hp/hour)	
	Normal	Weight
Hand Tractors	0,09	0,17
Four-Wheel Tractors	0.12	0,18
Stationary Diesel Engines	0,11	0,18
Chain Tractors	0,10	0,18

Source: Sebastian and Bastaman, 2018

Based on the fuel cost calculation, which takes into account tractor power, fuel price, and heavy-duty fuel consumption due to the tractor being operated by pulling an implement, the fuel cost is Rp134,640.00/hour.

1) Lubricant Costs

Lubricants are used to create optimal operating conditions for machinery and equipment. Typical lubricants for tractors include engine oil, transmission oil, axle oil, and hydraulic oil. Meanwhile, agricultural processing machinery, such as water pumps and generators, does not require costs for axle oil or hydraulic oil. Lubricant costs are calculated based on the frequency of oil changes within a certain period and the price per liter of oil used (Sebastian and Syah, 2018).

The average oil requirement for a four-wheel tractor is 0.1 liters per horsepower per hour of operation. The average oil consumption for a four-wheel tractor can be seen in Table 5.

Table 5. Average Oil Consumption for a Four-Wheel Tractor

Machine Type	BHP	Oil Consumption (liters/hour)
Gasoline Engine	20-40	0,045
	40-60	0,054
	60-80	0,059
	80-100	0,073
Diesel Engine	20-40	0,050
	40-60	0,054
	60-80	0,059
	80-100	0,077
	100-120	0,095
	120-140	0,120

Source: Sebastian and Bastaman, 2018

Based on the calculation of lubricant costs, taking into account tractor power, oil price, and average oil consumption for a four- wheel tractor, the lubricant cost is IDR 660,000.00/hour.

1) Operator Costs

Operator costs are generally expressed in rupiah per day or rupiah per hour, depending on local conditions. If the operator receives a monthly salary, their wages can be converted to an hourly rate by dividing the total monthly salary by the number of hours worked in a month.

The calculation of operator costs, by dividing the daily salary by the number of hours worked, yields an operator cost of IDR 16,000.00/hour.

2) Repair and Maintenance Costs

Costs for repair and maintenance of agricultural equipment and machinery include replacement of worn components, labor for specialized repairs, painting, cleaning or washing, and repairs due to unforeseen events. This cost can be calculated as a percentage of the initial price of the agricultural machinery. On wheeled tractors, the average cost of repairs and maintenance is 1.5% of the initial price of the machine for every 100 hours of operation,

where P represents the initial price of the machine.

Calculating repair and maintenance costs by calculating an average repair cost of 1.5% of the initial machine price and dividing this by 100 hours yields a repair and maintenance cost of Rp105,000.00/hour.

1) Other/Special Costs

Other or special costs are expenses required to replace certain components or spare parts that require relatively frequent replacement due to routine use. The other costs typically calculated here include tire replacement costs, with an estimated tire life of 3,000 hours.

Calculating tire costs, taking into account both tire price and estimated tire life, yields a tire cost of Rp2,666.66/hour.

4.7.3 Total costs and prime costs

Total cost is the total cost required to operate a piece of agricultural machinery. This cost is the sum of fixed and variable costs, expressed in units of Rp/hour. The total cost of agricultural machinery per hour can be calculated using the following equation:

$$\text{Total Cost} = \frac{BT}{x} + BTT$$

Description:

BT = Fixed Costs (Rp/year)

BTT = Variable Costs (Rp/hour)

X = Estimated equipment operating hours per year (Hours/year)

The prime cost is the cost required by an agricultural machine for each unit of product. If the capacity of an agricultural tool or machine is known or can be calculated, the prime cost per unit of product can be found by dividing the prime cost by the capacity (units of product per unit of time), with the following equation:

$$\text{Cost of Goods} = \frac{\frac{BT}{x} + BTT}{K}$$

Description:

BT = Fixed costs (Rp/year)

BTT = Variable costs (Rp/hour)

K = Equipment capacity (product units/hour, e.g., kg/hour, lt/hour, ha/hour)

X = Estimated working hours per year (hours/year)

CONCLUSION

Based on the results and discussion above regarding "The Application of Fertilizer Applicators (Basal Type) in the Fertilization Process in Division 2 of PT Pemukasakti Manisindah, Way Kanan Regency," the following conclusions can be drawn:

1. The calculation of the fertilizer applicator's working capacity yields a KLT of 1.24 ha/hour, a KLE of 1.05 ha/hour, and an EL of 84%.
2. The calculation of the required number of fertilizer applicators (basal) for the fertilization process in Division 2 of PT Pemukasakti Manisindah is three units from April to September.
3. The calculation of fixed costs is Rp56,000,000.00/year, variable costs Rp918,306.66/hour, total costs Rp945,703.3/hour, and basic costs Rp927,160.1/ha.

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