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Development of "Wheel Hoe" Appropriate Tool for Supporting Organic Farming

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Abstract. Development of "Wheel Hoe" is aimed to produce the multifunction tools according to the agriculture field condition in West Sumatra. Wheel Hoe has three implements which used to trim weeds (blade assembly), to cultivate a soil (tine cultivator), to make the drainage (furrower) on the dried soils. This research did at The Laboratory of Production and Agricultural Machinery Management, Agricultural Engineering Program, Agricultural Technology Faculty, Andalas University. The research method is designing a prototype wheel hoe and testing in West Sumatra through observations involved: the speed, wheel slip, work capacity, spacious efficient, and time lost of wheel hoe. Wheel hoe used an engine 5 HP by Dymos. In this research have been produced a wheel hoe that has a dimension length: 180cm, width: 60cm and height: 100cm and weight: 145.35 kg. Wheel hoe test result used tine cultivator implement with an average speed of 0,01 m/s. The width of the plowed land with tine cultivator implement is 50cm. the spacious efficient of wheel hoe using the implement of tine cultivator is high on a red-yellow podsolic soil as much as 97,67% and tine cultivator on andosol soil and litosol soil as much as 96,12 % and 96,17%. Base on the spacious efficient has been got, so we got a conclusion that wheel hoe using tine cultivator implement can be used on all of the type soil in West Sumatra.

Keyword: wheel hoe, implement and the type of soil

1. Introduction

The organic food system or often mentioned the organic agriculture is one of the Indonesian Government Program to decrease usage of chemical fertilizers and pesticides which is causing reduced soil fertility and an environmental damage. An organic agriculture is defined as the holistic and integrated system of agricultural productions, through optimizing the health and productivity of agro-economy so, it will be producing the good quality of food. There are principles of organic agriculture that is the fertility and soil biological activity must be maintained, the soil must behave right humus and loose, trimming weed is using mechanical or semi-mechanical.

Organic agriculture development in West Sumatra has been a government program since 2006. It seems in the West Sumatra strategic plan. An area of organic agriculture reaching 1360 ha located on the several regencies in 2014 in West Sumatra [8]. West Sumatra farmer problems are lack of agricultural mechanization to support the productivity of agricultural product. The West Sumatra farmers are still using the traditional tools in their agricultural activities.

Tillage is one of the important things in the agricultural activities by both organic agriculture and the inorganic agriculture. It's a process preparing the land to plant and taking care of the plant in order to be apart from weeds for the plant growth. The main purpose of tillage divided into 3 phase that is to open a planting path, to eradicate weeds, and to repair the land conditions. [6] had done tiller rotary modification as implement on a tractor, [2] had made a weed cutters design on SRI and having a power capacity 3 HP/6000 rpm, and [6] had modified the agriculture engines and tools of weeds cutters. Base on the last researches, the agriculture engines, and tools are used to tillage, to open drainage path, to cut the weeds and in its tool operating we must have the skill to master it. So, wheel hoe is a problem-solving. It can be used on the small farm area, and it can be used to cultivate land, to cut the weeds, and to open the drainage path.

Wheel hoe is an appropriate tool for supporting farmers in their activities. The wheel hoe benefit is nearly the same as a hoe and a tractor. It has several implements according to user requirement.

In developed countries, wheel hoe had so many been used in the farming activities and the household scale, but it is a semi-mechanical tool. West Sumatra farmers have not used the wheel hoe, therefore, it is required developing semi-mechanical tools to support organic farming in West Sumatra.

The hypothesis of research are: 1) the small wheel hoe is more efficiently used in a small area 2) wheel hoe will be able to decrease the cost productions. The general aim of research is to develop the multifunction tools (wheel hoe) according to the tillage in West Sumatra while the particular aims in this research are 1) to design a prototype wheel hoe 2) to do technical testing on wheel hoe for each of its implementation.

2. Research Method

2.1 Tools and Materials

This research divided into 3 phase are the design phase, making a prototype phase and performance test phase. In the design phase, tools and materials used are computers including SolidWorks. To make a prototype, tools used are a drill, grinder, electric welding, lathe, etc while materials are the iron plate, iron shaft, rubber wheel, mor, bolt, paint. In a performance test phase, tools and materials used are the prototypes, wheel hoe, camera, stationary and meter.

2.2 Establishment Wheel Hoe

To make wheel hoe we required a few of implement that is to trim weeds (blade assembly), to cultivate a soil (tine cultivator), to make the drainage path (furrower) while the wheel hoe component that is following:

2.2.1 *Drive Motor*. To determine the power of the wheel hoe, the formula can be used that is

$$Pl = \frac{Ds \; x \; (d \; x \; L) \; x \; V}{75} \qquad\qquad (1)$$

Where:

P1	: The power for a tillage, tine cultivator (HP)
Ds	: Draft spesific land (kgf.m/cm^2)
d	: Depth of tillage, tine cultivator (cm)
l	: Widht of tine cultivator (cm)
V	: Speed (m/s)
75	: unit convertion, 1 HP = 75 kgf.m/second

To determine the power to drive the wheel's Wheel Hoe:

$$P2 = \frac{Crr \; x \; w \; x \; V}{75} \qquad\qquad (2)$$

Where:

P2	: The power to drive the wheel (HP)
Crr	: coefficient of rolling resistance (without unit)

W	: Weight tractor (kg)
v	: Speed (m/second)
76	: Unit convertion, 1 HP = 75 kgf.m/second

Design of the drive motor power (Engine) Wheel Hoe

$$PE = \frac{P1}{\eta 1} + \frac{P2}{\eta 2} \tag{3}$$

Where:

PE	: The power of motor *wheel hoe* (HP)
P1	: The power of the tillage using *tine cultivator* (HP)
P2	: The power of the drive motor *wheel hoe* with a implement *tine cultivator* (HP)
η1	: the efficiency of the power from motor to *tine cultivator* (desimal)
η2	: the efficiency of the power from motor to the whell's *wheel hoe* with an

implement *tine cultivator* (desimal)

To determine the minimum weight of Wheel Hoe

$$B\ min = \frac{Ds \ x \ d \ x \ l}{TR} \tag{4}$$

Where:

B *min*	: the minimum weight of wheel hoe (kg)
DS	: *Draft spesific* land (kg/cm^2)
l	: widht of the weeds cutter (cm)
d	: depht of the weeds cutter (cm)
TR	: *Traction ratio* (without unit)

To determine the maximum weight of Wheel Hoe

$$B\ maks = (Gp \ x \ 0.78 \ x \ l \ x \ 2 \ x \ \sqrt{R^2} - (R\text{-}S)^2 \ x \ 2) \tag{5}$$

Where:

B*maks*	: the maximum weight of *wheel hoe* (kg)
Gp	: *Bearing Capacity* (kg/cm^2)
l	: the wheel site widht(cm)
R	: wheel spokes (cm)
S	: the depth of wheel into the land (*zinkage)* (cm)
0,78	: Unit convertion, π / 4
2	: the amount of the wheel's *wheel hoe*

2.2.2   The Implement. Tine cultivator has a function to become loose the soil. In a design, tine cultivator has 4 blades with a slope of 15%. The opening tool of drainage path has a function to make a drainage path on soil. The weeds cutter (blade assembly) has a function to trim the weeds. In a design, its shape and size is made of thin steel with an angle of 15% to make it easy a back and forth motions.

2.2.3   The wheel hoe frame. Frame has a function as the place of the engine sustains and the implements of wheel hoe, besides it, frame is used to hold and control the wheel hoe. Wheel hoe size will be made of anthropometry test using 70 samples (35 men and 35 women). Anthropometry test is the numeric data having a related with the characteristic of human body that is a shape, size and power that used to the tools design or the workspace [12]. The wheel hoe frame is moved by two wheels, the space between the wheels is 120 cm, it's based on the width. To determine the wheel shaft diameter is used equation:

$$d \geq [\left(\frac{5.1}{Ta}\right) \sqrt{(km \ x \ M)^2 + (kt \ x \ T)^2}]^{1/3} \tag{6}$$

Where:
   d: The wheel shaft diameter (cm)
   Ta   : shear stress (kg/mm^2)
   Km   : key factor of Flexural moment
   M   : Flexural moment (kg.mm)
   T   : Twisting moment (kg.mm)
   Kt   : Correction factor of Twisting moment

The rotation on the design wheel shaft is calculated by equation:

$$RPM\ roda = \frac{60\ x\ Vteo}{2\ \pi\ R} \qquad (7)$$

$$Vteo = \frac{Vakt}{1-S} \qquad (8)$$

Where:
   Vteo   : Theoretical speed (m/second)
   Vakt   : Actual speed (m/ second)
   RPM   : the rotation of wheel shaft (rotation/minute)
   R   : wheel spokes (m)
   S   : wheel slip (%)

  The power transmission system has a function as a power distributor to run wheel hoe. In its design, the transmission system is used like sprocket-chains. Sprocket has been a function as a power conductor from the shaft speed reducer to the first shaft. The purpose is to avoid the high slip on the shafts because it needs more power.
  The color of the wheel hoe framing is orange and for the engine is yellow while the implements of wheel hoe is black.

2.3 Technical test of the wheel hoe
The performance test on the wheel hoe is done in an organic farming area with five repetitions. Testing is using all the component of the wheel hoe implements. To prototype testing of wheel hoe for the first time is using the tine cultivator implement to cultivate soils on an area as wide as $15m^2$, then the furrower is used to open the beds and irrigation path on the areas as long as 120 cm and 30 cm. after the plant is planted on the areas, we will cut the weeds with the blade assembly implement. Test pattern of the prototype path of the wheel hoe is zigzag according to a clockwise. There are the observations done on the wheel hoe technical testing that is:

2.3.1 A noise. One of the important things from the technical test is to quantify a noise rate because to know the quantified a noise rate, when the user is operating wheel hoe, they feel comfort.

2.3.2 Work speed. The working speed can be calculated by using a formula:

$$Vakt = \frac{S}{t} \qquad (9)$$

Where:
   Vakt : Actual speed (m/second)
   S : mileage (m)
   t : time (second)

2.3.3 Theoretical Work Capacity. Before calculating the theoretical work capacity, we would calculate a wheel slip, with a formula:

$$S = \frac{(\pi\ x\ D\ x\ (N-L))}{(\pi\ x\ D\ x\ N)}\ x\ 100\ \% \qquad (10)$$

Where:

S   : wheel slip (%)
D   : Diameter (m)
N   : the number of wheel turns that is 10 times
L   : mileage of the wheel hoe when rotated N times (m)

$$Vteo = \frac{Vakt}{(1-S)} \tag{11}$$

Where:

S   : wheel Slip

2.3.4 The Theoretical Work Capacity. The theoretical work capacity can be calculated using the formula:

$$Kt = Vteo\ x\ W\ x\ 0,36 \tag{12}$$

Where:
Kt   : theoretical capacity (ha/hours)
Vteo   : Work speed (m/second)
W   : work width of singkal (m)
0,36   : conversion rate from m^2/second to Ha/hours.

2.3.5 Effective Working Capacity. Effective working capacity can be calculated using the formula:

$$Ke = \frac{TL}{TW} \tag{13}$$

Where:
Ke   : Effective Working Capacity (ha/hours)
Tl : Total of area plowed (Ha)
TW: Total of time (jam)

2.3.6 Field Efficiency. Field efficiency can be calculated using the formula:

$$E = \frac{Ke}{Kt}\ x\ 100\% \tag{14}$$

Where:
E   : Field efficiency (%)
Ke   : Effective working capacity (ha/hours)
Kt   : Theoretical working capacity (ha/hours)

2.3.7 Losses Time When Turned. Losses time when turned can be calculated using the formula:

$$Lo = \frac{Wb}{(Wl + Wb)}\ x\ 100\ \% \tag{15}$$

Where:
Lo   : *Losses* time when turned (%)
Wb   : time for turned (second)
Wl   : time to the plow fields (second)

2.3.8 Operator Power. Operator power could be measured through an operator's heart rates. It's measured before and after doing to the plow fields. The classification of people work rates aged 20 to 50 years can be seen in Table 1.

Table 1. The classification of people work rates aged 20 to 50 years

Work level	Power Requirements (kW)	Heart Rate (minutes)
Very light	Less 0,17	Less 75
Light	0,17-0,33	75-100
Average	0,33-0,55	100-125
Weight	0,55-0,67	125-150
Very weight	0,67-0,84	150-175
Beyond the limits	Up 0,84	More 175

3. Result

3.1 Design Result

This research has produced an appropriate tool "wheel hoe" with a size length 180 cm, width 60 cm, and height 100cm. It could be operated by an operator. The number of a weight of wheel hoe (included all of the implements and engines) is 145,35 kg, it's according to the theoretical calculating on the minimum weight of Wheel Hoe as much as 119.07 kg and the maximum weight of Wheel Hoe as much as 154,74 kg. wheel hoe image can be seen in Figure1.

Figure 1. Wheel Hoe

The wheel hoe is the tillage engine consists of two wheels having a function to become loose the soils, to make drainage path on the beds, and to cut the weeds on the dried soils. To do all of the activities used several implements are tine cultivator, furrower, and blade assembly. The development aimed of wheel hoe is to increase the work capacities of farmers in various farming activities through an appropriate tool in various soil types.

The engine construction of wheel hoe refers to the design consists of several components:
- The main frame
- Wheel
- Machine
- Implements

The final result of the development wheel hoe and the machine testing could be described through that following table:

Table 2. Specification of *wheel hoe*

Specification of *wheel hoe*	
1 Price	Rp. 7.000.000,-

1	Dimension (L x W x H)	180 cm ×60 cm × 100 cm
2	Machine	Gasoline Motor
3	The number of Operator	1 person
4	Work capacity of *wheel hoe*	0,01 ha/hours
5	Efficiency	88,15 %
6	Frame construction	Strip Iron, Elbow Iron, Pipe Iron
7	The number of *Implements*	3
8	Weight	145,35 kg
9	Wheel Diameter	51,5 cm
10	Construction of Tine Cultivator	Round Iron
11	Construction of Furrower	Plat Iron
12	Construction of Blade Assembly	Strip Iron

3.2 The Main Frame of Wheel Hoe

The main frame of wheel hoe is made of the pipe and strip iron with length 180 cm and width 60 cm. the machine place is made of the elbow iron with length 80 cm. Base on the anthropometry test, we got an average of the height people in regency West Sumatra is 155-160 cm so, the height of wheel hoe is as much as 100 cm in order to the operator could be easy operating the wheel hoe.

Wheel on the wheel hoe is made of the round iron with diameter 51.5 cm, that's why that wheel could handle the weight of wheel hoe.

3.3 Machine

Machine used is a gasoline motor of 5HP by Dymos. It used according to the calculating of power requirement that is 3.5809 HP. When we had been testing on the wheel hoe, we used gasoline motor of 5HP in order to wheel hoe machine can be optimally worked. Chain and sprocket used is as much as four sprockets have a measurement of 15 T and 40 T and two chains have a measurement of 104 L.

Beside it, the transmission system of wheel hoe is using a pulleys and belt. Pulleys used is on the machine have a measurement of 1 inch. On the transmission system of the chain-sprocket used pulleys as big as 7 inch and using a belt to relate the pulleys in order to the wheel hoe could be run according to the machine speed.

3.4 Testing of The Implement

In this journal, the technical test is using the implement of tine cultivator. Tine cultivator has a function to become loose soils. On the implement of tine cultivator is made of the round iron sharpened with a slope 15% , the length is 100 cm, width is 30 cm. The gear of the tine cultivators are as much as 10 tine cultivators. The image of tine cultivator could be seen in Figure 2.

Figure 2. Implement of Tine Cultivator

The technical test of wheel hoe using tine cultivator has been done on three soil types that is the litosol soil in South Solok, the andosol soil in Alahan Panjang, the red-yellow podosolik soil in Limau Manis, Padang, West Sumatra. On each area, testing had been done for five times, that's because decreasing the error at data collections. The image of the wheel hoe technical testing is using the tine cultivator could be seen in Figure 3.
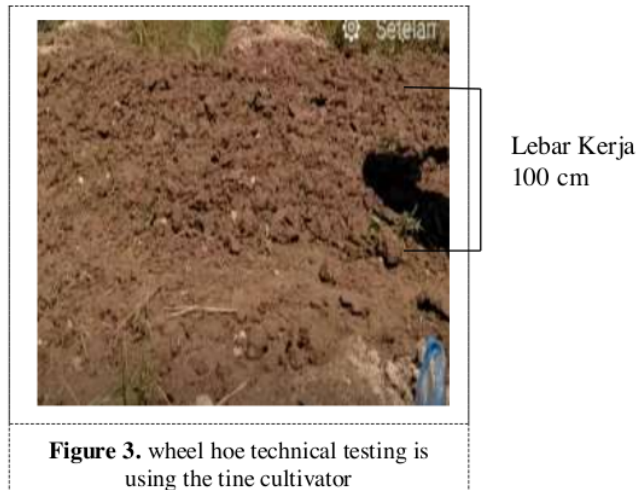

Figure 3. wheel hoe technical testing is using the tine cultivator

3.4.1 The Work Speed. The work speed is the required time by an operator to finish a job. It's a comparison between the mileage and times of wheel hoe. The large of the fields used to do the technical test is 15 m^2 while the length of fields is 5 m and the width of fields is 3 m. The work speed is using the implement of tine cultivator could be seen in Table 3.

Table 3. The calculating of wheel hoe's work speed with the implement of tine cultivator

Soil types	Litosol	Andosol	Red-Yellow Podsolik
the length of fields (m)	5	5	5
Times (s)	472	359	485,2
Actual speed (m/s)	0,011	0,014	0,010

Base on Table 3, we could see that an average working speed of wheel hoe on that three soil types is different that is 0.01 m/s that means in one second, wheel hoe could run 0.01 m with using the implement of tine cultivator. It's fast more than the conservative tillage or using a hoe. Time taken by wheel hoe on the same length of fields is different, that things is happened because the fields is different as well, on the fields having the rocks and wavy soils can hamper the wheel hoe working. According to [5], on the wavy and rocks soils could cause the wheel turned that is not running so need a thrust by an operator to move a tractor and make a time taken longer.

Base on the last research, its obtained actual speed on the dried fields is as big as 0.72 m/s [5], [6] described that an average of rotary hand tractor as big as 0.61 m/s. Then, [3] said that the cultivator

speed that designed depend on its face soils. The conclusion is if the speed of wheel hoe is high rather the other cultivator so will have a high slip as well.

Beside it, on [13] described that the actual speed of tine cultivator with an animal as a drive as much as 1.80 km/h. that thing is lower more than the actual speed on wheel hoe. It's because the farmers is hard when they are turned so, they need more times to operate tine cultivator.

3.4.2 Theoretical Work Capacity. Before calculating of the wheel hoe Theoretical work capacity, first we're calculating the wheel slip of wheel hoe. Slip testing had been done at a distance 10 times wheel turning. Wheel's diameter is 51.5 cm. Testing had been done as much as five times on each implement on three soil types. The result could be seen in following Table 4.

Table 4. wheel slip Testing on the tine cultivator.

	Litosol	Andosol	Red-yellow Podsolik
Wheel Diameter (m)	0.515	0.515	0.515
N	10	10	10
Mileage N time (m)	4.92	6.28	4.64
Wheel Slip (%)	69.56	61.17	71.31

Base on Table 4, we got an average of slip wheel using a tine cultivator implement that is more than 50%. It's happened because the speeds of wheel hoe when the operator is operating a wheel hoe fast. The slip value is related to the work speed, the higher the work speed the bigger the frequency of wheel rotation [9].

Base on Table 4, we got a theoretical work capacity of wheel hoe. The result could be seen in following table.

Table 5. Theoretical work capacity of wheel hoe on tine cultivator

	Litosol	Andosol	Red-yellow Podsolik
Actual speed (m/s)	0,011	0,014	0,010
Wheel Slip (%)	69,56	61,17	71,31
Theoretical work speed. (m/s)	0,035	0,036	0,036
Work Width (m)	1	1	1
Theoretical capacity (ha/hours)	0,0125	0,0129	0,0129

Base on Table 5 we know that andosol soil and red-yellow pedsolik soil are higher more than lithosol soil. the theoretical work capacity of lithosol soil is as much as 0.0125 ha/hours while on the andosol and red-yellow pedasolik soil are as much as 0.0129 ha/ hours. Theoretical work capacity is affected by the width of tillage and the actual speed of a tractor [5] He stated in his research (2005) that theoretical work capacity is the machine ability to finish a job on the fields and if it runs maximally.

In his research (2005), he got an average of theoretical work capacity is as much as 0.048 ha/hours that means it's bigger than the theoretical work capacity of wheel hoe. It's because the actual speed of the wheel hoe on the implement of tine cultivator is faster so it got an effect on the wheel slip on wheel hoe higher.

3.4.3 Effective Work Capacity. Effective work capacity is a works speed to be obtained by a tillage machine based on the field area per total times (ha/hours) and it's an effective average ability. The wheel hoe calculating of the effective work capacity using the tine cultivator implement had been done

as much as five times on three soil types. There is the following table that is the calculating of the effective work capacity on the implement of tine cultivator.

Table 6. The calculating of the effective work capacity on the implement of tine cultivator.

	Litosol	Andosol	Red-yellow Podsolik
Total of tillage (ha)	0,0015	0,0015	0,0015
Total times (hours)	0,1244	0,1208	0,1194
Effective work capacity (ha/hours)	0,0121	0,0124	0,0126

Base on Table 6, we know that the wheel hoe average of speed work using the tine cultivator on three soil type is nearly the same that is 0.012 ha /hours. The number of effective speed is determined by the number of the wheel slip on wheel hoe, area conditions, operator skills. Beside it, the effective work capacity is affected by that water and soil contents. So, the smaller time taken, the higher the effective work capacity [5].

The effective work capacity is usually calculated from the area tillage per time taken. Generally, the effective time much then the time theoretical. It's because 1) the loss of time when turning 2) the loss of time cleaning the machine 3) the loss of time to take a rest [5]. While [1] stated that the effective work capacity is affected by the actual work speed, width of work, time to be turned.

3.4.4 Field Efficiency. Field Efficiency of wheel is a comparison between the effective work capacity and the theoretical work capacity stated in percent (%). There is a comparison between the effective work capacity and the theoretical work capacity of wheel hoe on the implement of tine cultivator could be seen in the Figure 4.

Base on Figure 4 we could see that the effective work capacity is smaller than the theoretical work capacity cause to get the Field efficiency of wheel hoe, the effective work capacity must be smaller than the theoretical work capacity. Field Efficiency of wheel hoe using the tine cultivator implement could see in the following Table 7.
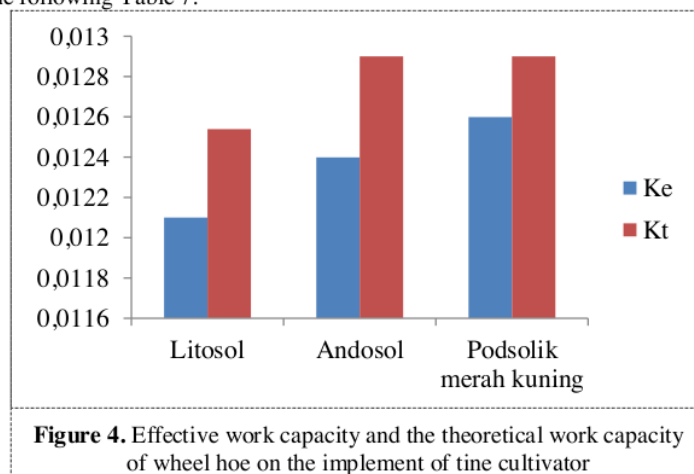

Figure 4. Effective work capacity and the theoretical work capacity of wheel hoe on the implement of tine cultivator

Table 7. The Field Efficiency of wheel hoe calculating using the tine cultivator implement.

	Litosol	Andosol	Red-yellow Podsolik
effective work capacity (ha/hours)	0,0121	0,0124	0,0126
the theoretical work capacity (ha/hours)	0,01254	0,0129	0,0129
Field Efficiency (%)	96,49 %	96,12 %	97,67 %

According to Table 7, we could see that field efficiency of wheel hoe using the tine cultivator implement is around 90-97%. It's affected by the work speed of wheel hoe to finish the tillage as wide as 15 m^2. Beside it, the field efficiency is affected by the work times that is 1) the loss of time because a wheel slip, area conditions and operator skill. Base on the analysis, the number of tillage, the field efficiency is around 75-95% [10]. There is the field efficiency using the tine cultivator implement could see in Figure 5.
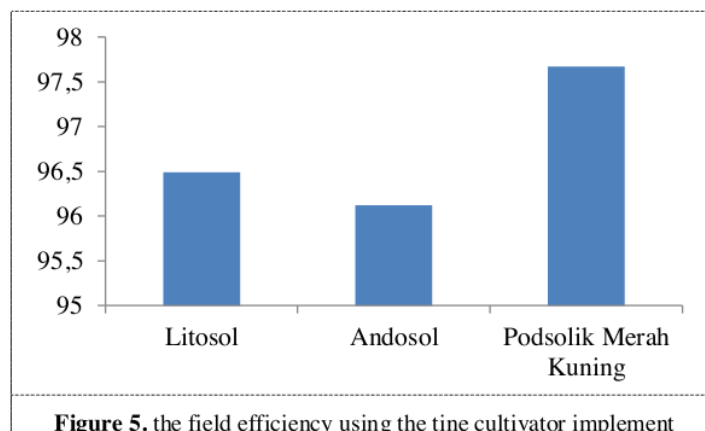

Figure 5. the field efficiency using the tine cultivator implement

3.4.5 The Percentage of The Loss of Times when Turning. Turning at the corner or the end of the field will be impacted a loss of time, particularly at the small fields. The number of turning times per width unit for a tool will be inversely proportional to the length fields. Effective times used during working, that number is determined by the ineffective time [10]. The percentage of the loss of times when turning table using the tine cultivator implement could see in the following Table 8.

Table 8. The percentage of the loss of times when turning on wheel hoe using the tine cultivator implement

	Litosol	Andosol	Red-yellow Podsolik
Times for turning (s)	10	11	11,8
Straight Walk Time (s)	20	20,2	21,6
The loss of times (%)	33,33	35,26	35,33

Base on Table 8 we could see that the loss of times of wheel hoe using the tine cultivator implement is pretty high around 33-35%. It's because the wheel slip, generally involved when wheel hoe is turning and an operator need power more to hold wheel hoe in order to the wheel hoe could walk straight so it needs time more.

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If it's compared with the last research about the performance of hand tractor by [5], explained that the actual work speed of the hand tractor obtains around 0.4 -0.7 m/second. That thing is fast more than the actual speed of wheel hoe using the tine cultivator in the tillage that is 0.01 m/second while the wheel hoe is around 90-97%. It's because the work speed of wheel hoe is high so, the theoretical work capacity is high as well.

3.4.6 Noise. Noise is the sound that not wanted and disturbed the environmental comfort stated in decibel (dB). On the wheel hoe, a noise rate is measured to determine how big a sound producing when the operator is operating the wheel hoe. The noise rate could be measured using Sound Level Meter tool with a type: Extech 407736, and the noise rate of wheel hoe is 98,1 dB.

The sound in that range is very noisy. Base on the health minister regulation RI no 1405/MENKES/SK/XI/2002 about Health Requirements of Office and Industrial Work Environment, so to avoid deaf, operator is allowed operating wheel hoe without an earmuff for eight hours/day. The Noise categories and noise verges can be seen in Appendix 8.

3.4.7 The Power of Operator. The light weight of the operator's workload can be known by the operator's pulse or heart per minute. This heart rate can be measured using a stopwatch because using a stopwatch the operator's heart rate per minute can be recorded. After getting the heart rate at rest and work then it is then matched with the workload level table by Christensen (Santosa, et al 2005) which is based on the heart rate per minute of humans aged 20-50 years. Table of occupational level classification in people aged 20 to 50 years can be seen in Table 1.

Based on tests conducted on operators in Appendix 10. It can be concluded that this wheel hoe is included in the lightweight category with power requirements of 0.17 - 0.33 kW, the power value makes the wheel hoe can be operated by anyone whether male or female.

4. Conclusion

Base on the development of wheel hoe using machine 5 HP, the total weight of wheel hoe is 145.35 kg used to cultivate the dried fields, a dimension of wheel hoe is length 180 cm, width 60 cm, and height 100 cm. the average of speed on every implement is 0.01 m/s and the average wheel slip is 70%. The average of the work capacity on every implement is 0.01 ha/hours and the average Field Efficiency of wheel hoe on three soil types is 76%. Base on the resulting test, the implement of tine cultivator is more suitable for use to andosol soil

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