Development of integrated machine for tillage, corn planter and fertilizer application

Harsono and U Budiharti
Indonesian Center for Agricultural Engineering Research and Development
Jln Sinarmas Boulevard, Pagedangan, Tanggerang, Banten 15338
E-mail: uning_b@yahoo.co.id

Abstract. Challenge in the expansion of maize and soybean planting areas is the limited agricultural labor from land processing activities, planting to post-harvest. Considering that the corn and soybean cultivation systems are still traditionally done using both human and livestock power so that the productivity and work efficiency produced is still low. This affects the area of land that can be cultivated, land productivity and the production of corn produced. To support the program to expand the planting area and increase the crop index to increase corn production, it is necessary to support the use of appropriate mechanization technology and under site-specific conditions. Therefore it is necessary to introduce agricultural machinery to support the corn cultivation system to increase productivity, work efficiency, increase yields and improve the quality of results. In this activity the implementation and development of mechanization technology for corn and soybean cultivation is appropriate and by site-specific conditions at the demonstration plot scale in the corn and soybean production centers by taking into account the technical, economic, and socio-economic conditions of the local community. Indonesian Center for Agricultural Engineering Research and Development has developed a rotary and planting machine that can do soil treatment and planting seeds at once. This machine is equipped with a solid fertilizer application. But in practice, farmers rarely use liquid fertilizer for corn /soybean cultivation. Test results of tillage and planting of corn seeds: Work depth of 12.1 cm; spacing in rows 38.5 cm; spacing in rows of 70 cm; number of seeds per fall 2.2 items; percentage of empty holes 4.1%; work width is an average of 162.88 cm; average working speed of 2.31 km / h; average work capacity of 4.08 hours / ha; fuel consumption of 20.32 lt / ha

1. Introduction
The Ministry of Agriculture's program is achieving food self-sufficiency especially rice, corn and soybeans. Corn and soybeans are the main crops in Indonesia, Corn is used as raw material for food and feed and can also be processed to bioethanol an use as bioenergy. While soybeans are used as raw materials for processed soy products such as tofu, tempeh, soy sauce, soybean extract, and others. Therefore, the need for corn and soybeans continues to increase from year to year along with the increasing population, also food and feed processing industries.

Based on data from the Central Bureau of Statistics, corn production continued to increase from 2013 to 2015, maize production in 2013 was 18.5 tons and increased 2.7% to 19 million tons in 2014. Corn production increased 3.16% to 19.6 million tons in 2015. Similarly, soybean production has increased production since 2013, from 780 thousand tons to 955 thousand ton in 2014, and 963 thousand tons in
2015. Land cultivation in corn planting is a major problem faced by most farmers due to high labour cost and time consuming, so the modern machines that able to increase effectiveness and efficiency is needed. Swamp land is Indonesia's hope for the development of new food center production area. The swamp land area in Indonesia is currently 34.12 million ha, consisting of 25.2 million hectares of swamp and 8.9 million hectares of tidal swamps. Of this amount, 14.18 million hectares (41%) have the potential for agriculture, but agriculture that has been utilized is still limited, which is only an area of 6.77 million ha for food crops and plantations. Indonesian Center for Agricultural Engineering Research and Development (ICAERD) developed a soil processing machine combined with a corn grower machine and application of fertilizers that can be applied on swamp land.

2. Methodology

2.1 Machine design
The machine was designed for planting in tidal swamp rice fields. The engineering process is reverse engineering, optimization of existing machine functions, namely the rotary tiller in order to perform the same function on swamp/tidal land. Schematically, the machine to be designed is shown in Figure 1.

![Figure 1](image1.jpg)

Figure 1. Schematic picture of Integrated machine for tillage, corn planter and fertilizer applicator.

2.2 Testing and analysis
Technical parameters and data to be observed in performance test are Field Performance (Forward speed, work capacity, wheel slip); quality of work (Depth of tillage, soil softness index); fuel consumption; labor (needs and wages of labor, efficiency) and level of ease of operation.

Financial analysis is carried out to determine the of operating cost, through the calculation of fixed costs and non-fixed costs. Fixed costs include: depreciation fees, interest and tax. Non-fixed costs include: fuel costs, electricity costs, labor costs and component repair costs. This financial analysis is also used to determine the engine operating costs per ha.
3. Result and Discussion
The design of an Integrated Machine for tillage, corn planter and fertilizer applicator can be seen in figure 2.

![Figure 2. Design of integrated machine for tillage, corn planter and fertilizer applicator.](image)

![Figure 3. Design of rotary tiller.](image)
Rotary blades function to loosen the soil easily in tillage so that it can be planted directly. The rotary blade used is type C with a length of 170 mm, width of 50 mm and thickness of 5 mm. The rotary is also equipped with a chopper knife of the same size. The addition of this chopper knife is to chop the remnants of the plant during processing so as to accelerate decay.

This rotary is covered with a cover from the eser plate with a thickness of about 2 mm. The use of this cover is to hold the ground thrown during processing so that the soil becomes loose, also used to flatten the processing land. Planting Section composed of openers / makers of soil grooves, seed grinders, grooves, soil compressors, seed storage boxes, main frames and coupling components to the composed of openers / makers of soil grooves, seed grinders, grooves, soil compressors, seed storage boxes, main frames and coupling components to the rotavator unit. Groove openers are made in the form of a pair of stainless steel plates of his size. 300x2 mm which can rotate freely which is joined by an angle of + 22.5o towards the forward line. Rotating this dish will produce grooves on the ground surface in a certain depth. Seed stapler were made form 200x8 mm diameter nylon disc with 6 holes for measuring corn seeds (8 holes when used for soybeans). The nylon plate is installed with an elevation angle of 30-37.5o to the horizontal plane (seedling system with elevation). The nylon disc rotates by carrying 1-2 grains of corn seeds on each hole in the disk and will fall when taking a 90o round to the directional channel towards the formed groove. This seed-level rotary power is obtained by utilizing the support wheel rotation which transmits with the RS 35 sprockets-chain ratio of 2: 1 and bevel gears with
a ratio of 1:1.

The groove cover is made in the form of a stainless steel iron plate of her size. 150x2 mm which can rotate freely. This dish is installed at an angle of 35-42.5° towards the direction of forward motion. The groove cover plate is equipped with a compressed spring to cover the uneven ground surface. The seed storage box (hopper) is made from a 1.2 mm stainless steel iron plate equipped with a seed distribution hole to the gauge and hopper cover to prevent the risk of spillage when a shock occurs. Supporting wheels are made of 2 mm iron plate and 26 cm diameter. The support wheels equipped with 12 mm iron fins at the edges will rotate when the drive unit moves forward. This round is used to move the seed gauge. The seed divider used is a vertical type. In this type of divider, the seed divider rotates directly from the turning wheel without changing direction, so that the power needed is lighter.

To reduce the driving wheel slip of the matering device, modifications are made to the wheel holder by adding spring which allows the wheels to move up or down according to the contour of the land. Thus the wheels will always tread the ground so that the possibility of slippage will decrease.

Tests were carried out in ICAERD, Serpong and soil type is red yellow podsol. This test was carried out to determine the performance of the engine in processing land as well as planting corn. Parameters observed in this test are engine rpm, engine speed when no load or load, ground depth, work width, total time, wheel slip and fuel consumption. Based on these data, then calculated work capacity (hours / ha) and field efficiency.

Test result:
Theoretical working width: 179 cm.
Position of gear: H - I
Turning motor rotation: 2200 rpm
The average yield of tillage and planting of corn seeds
Work depth: 12.1 cm
Spacing in rows: 38.3 cm
Spacing between lines: 70 cm
Number of seeds per fall: 2.2 items
Percentage of empty holes: 4.1%
Average work width: 162.88 cm
Average work speed: 2.31 km / hr
Average work capacity: 0.245 ha / hour (4.08 hours / ha)
Wheel slip average: 0.45%
Field efficiency: 67.39%
Fuel consumption: 4.98 lt / hour (20.32 lt / ha).

Financial analysis of the use of land preparation machines and planters is limited to the need for
operating costs for machine use. This fee includes costs for fuel, lubricating oil (oil) and operator costs. Based on the results of the field testing, the data obtained are:

- Rotatanam machine capacity: 4.36 hours / ha
- Fuel requirements: 26.29 l / ha
- Oil requirements: 0.4 l / ha

Assuming the price of diesel is IDR 5 500 / liter, the price of oil is IDR 32 000 / liter, and the operator's wages are IDR 100,000 / 8 hours. So the need for fuel costs is Rp. 144 600 / ha, the need for oil costs is Rp. 8,000 / ha, and the operator's need is Rp. 54 500 / ha. Then the total operational cost of the rotatanam machine is IDR 207 100 / ha. This fee does not include capital costs, depreciation and bank interest.

By using this machine, the activities of tillage, planting and fertilization are carried out at the same time, whereas in conventional ways only tillage using aslin, whereas planting is generally done manually and requires 20 HOK, fertilizing for the first is done when planting requires 5 HOK. So if compared then there is a difference of 25 HOK or If 1 HOK = Rp. 50000; then a total of Rp. 1,250,000, which can be saved from the use of integrated tillage, planting and fertilizing machines.

4. Conclusion

The integrated machine for tillage, corn planter and fertilizer application machine shows good performance in swamp land and able do several activities at once, i.e. tillage, planting and, whereas in conventional ways only tillage using machine, whereas planting is generally done manually and requires 20 HOK, fertilizing for the first is done when planting requires 5 HOK. So if compared then there is a difference of 25 HOK or If 1 HOK = Rp. 50000; then a total of Rp. 1,250,000, which can be saved from the use of integrated tillage, planting and fertilizing machines.

5. References

[1] Ananto E 2013 Development of Swamp Land to Support Increased Food Production. Proceedings of the National Suboptimal Land Seminar in Order to Support National Food Independence Palembang September 20-21 2013 ISBN 979-587-501-9
[2] Anonim 1991 Test and evaluation of IRRI hydrotiller Bangladesh Rice Research Institute Annual Internal Review 1989-90 (Gazipur)
[3] Anonymous 2009 Maize Cultivation (Aceh: Agricultural Food and Extension Resilience Agency Collaborates with NAD Agricultural Technology Research Institute)
[4] Anonymous 2015 Government Optimistic Corn Production Reaches 20.3 Million Tons [on line] http://www.indopos.co.id/2015/04/pemerintah-optimis-puksi-jagung-capai-203-juta- [accessed April 22, 2015]
[5] Asworo HTW 2015 Large land area, Indonesia’s lowest corn productivity in ASEAN. Agribusiness bisnis.com http://industri.bisnis.com/read/20150824/99/465290/lahan-ebaran-prod Productivity-jagung-indonesia-terendah-di-asean
[6] Bakhri S 2007 Cultivation of Corn with the Concept of Integrated Crop Management (PTT) Technical Instructions Central Sulawesi Institute for Agricultural Technology Studies
[7] Bunyamin Z and Andayani AA 2012 Analysis of Hybrid Corn Farming in the Agroecosystem [on line] http://www.academia.edu, [accessed April 16, 2015]
[8] Busyra BS, Adri and Endrizal 2014 Sub Optimal Land Optimization of Tidal Swamps Through Integrated Crop Management and Increased Crops Index Proc. of the 2014 Suboptimal La