Organic fertilizer applicators design for supporting rice production

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Abstract. Intensive agricultural land use tends to reduce the content of organic matter in the soil. Organic content in the soil affects the soils ability to bind water and the efficiency of fertilizer absorption by plants as well as an important source of nutrients for plants. Therefore, the addition of organic matter in the form of compost is essential for maintaining the productivity of agricultural land. Problems that occur at the time of application of compost is needed workforce and considerable expense, so it needs an efficient technology in the form of mechanical equipment that is simple and easy to operate. The purpose of this research is to design an organic fertilizer applicator for paddy that can be operated on rice fields. Applicators have been made and functioning well and able to apply organic fertilizer with a dose of 15 tons/ha.

1. Introduction
Rice is a carbohydrate-producing food consumed by almost all Indonesians (96.87% of the population) and contributes more than 90% of caloric needs. With a population of about 250 people and annual population growth of 1.49%, (national rice needs reach 38 million tons. National production in 2013 based on the BPS of 71.29 million tons of dried unhulled grain. Fertilization is important to increase production, even until now regarded as a dominant factor in agricultural production. Until the end of the 20th-century fertilization is an important factor to increase production because there is no other alternative to replace [1].

Recently, organic fertilizer (compost) has been considered the heart of organic farming systems [2]. The function of compost is as a soil conditioner. Regarding increasing the soil bearing capacity, compost is superior and environmentally friendly than synthetic chemical fertilizers because it can increase the content of organic matter in the soil. The content of organic matter in the soil has a very important and the amount of organic material that is often used for directly measuring soil fertility index. The compost can provide benefits for the soil and plants, among others: offer nutrients to the plants, improve soil structure, increase the population and activity of soil organisms, improve the ability to water holding and soil aggregates, increases infiltration, preventing erosion, supporting the deployment and penetration of plant roots, and to strengthen plant resistance to pests and diseases.

Application compost as a fertilizer on agricultural land must be in large amounts (high dose), the nutrient content of the compost causes this is low when compared with inorganic fertilizer so that to get an equivalent dose of the nutrient needs of plants.
Problems that occur at the time of application of compost is needed manpower and considerable expense, so it needs an appropriate technology like mechanical equipment that is simple and easy to operate.

Applicator compost is one alternative problems solver in the application of compost on the farm. This study was conducted to modify the sugarcane plant compost applicator dry land pull by four-wheel tractor can be used in the field of horticultural crops (vegetables) pull by hand tractor. Compost applicator is designed to help the process of fertilization use compost on the farm. Compost applicator design has previously been performed were used for the process of fertilization on sugarcane plantations. The Results of the research, shown the rationing metering device mechanism using a type of conveyor belt has been able to function properly [3]. The spending rate of compost can be adjusted to the height of door openings regulator or the percentage of door openings regulator. The width of the door opening and the forward speed of the applicator can be adjusted to the rate of expenditure or dose of compost desired when the application of compost in the cane fields.

The application compost equipment or applicator compost in the field is a specifically designed to apply organic fertilizer or compost into the soil or in between the plants with a specific dose of compost. Compost applicator is a trailer pulled by a tractor. The components of the applicator are an auger, a pit where the discharge of compost, regulator doors, conveyor belt as a metering device, and fertilizers bin as the main framework. The applicator will be operated by hand tractor.

The purpose of this research is to design prototype applicator of organic fertilizer that can be operated on paddy field pull by using tractor two wheel.

2. Material and Method

2.1. Tools and Materials.
The tools used in the design process are welding equipment, tools kit, drill, grinder, hacksaw, and gauges. In the process of designing the applicators used are steel, iron plate, iron, welding wire, bolts, wheels, rubber conveyor belt, sprocket, auger, iron shaft, chain, wooden planks, and bearing.

2.2. Applicator Design.
The expected of the applicator is it capable of putting organic fertilizer on the soil or paddy field. Applicator designed using drawbar pull and able to put the fertilizer on the soil surface. The important components of the applicator are a metering device.

2.3. Design Method.
The manufacturing step of the applicator is following the flowchart of the design. Manufacture begins with calculating the dimensions, the design, and selection of technical drawings as well as the purchase of raw materials for the applicator. The framework is the part that made first. In this framework, there is a section that will connect the coupling rod applicator and the tractor.

Prototype manufacture followed by made fertilizer bin of from iron (L type) and trapezoidal shaped. The next step is to assemble a conveyor belt on the shaft of the metering device and coat the inner frame wall with an iron plate. Each shaft of the metering device mounted use two bearings placed on each end of the shaft.

Open-close mechanism of the door regulator made of an iron plate with open-close system manually. Furthermore, the manufacture of auger shaft parts. As the shaft of the metering device, the auger shaft installed using two bearings placed on each end of the shaft. Then mounted auger transmission system of fertilizer by taking the power source of motion of the wheel axle applicators are connected by pulleys auger of fertilizer. While the rotary power to drive metering device of conveyor belt, taking the source of fertilizer auger pulley attached to a conveyor belt pulleys. This transmission splicing system uses a chain and sprocket.
3. Results and Discussion
The design of organic fertilizer applicator with drawbar pull coupling mechanism requires calculation to obtain expected performance. The expected operation of the applicator is to put fertilizer on the soil surface before tillage. The component or part of the most suitable applicator is the metering device of the fertilizer.

Specifications required in the design of this applicator, among others:
1. Able to transport organic fertilizer
2. Ready to raise fertilizer according to the expected dose
3. Able to place organic fertilizer at ground level
4. Able to move and turn
5. Ability to hold or keep the fertilizer does not come out when the applicator turns or when not cultivate.
6. Can be coupled with a towing tractor

3.1. Functional Design.
The main function of the applicator is to apply organic fertilizer on the soil surface in paddy fields.

3.1.1. Frame. Serves as a support load of organic fertilizer container and as coupling tool with the tractor. The part that will be the component is the mainframe and the bearing shaft.

3.1.2. Organic Fertilizer Container. Made to accommodate organic fertilizer well and become a bearing of metering device shaft because it works in the container tub. In the container, there are belt conveyor and door regulator of organic fertilizer expenditure.

3.1.3. Metering Device. The main function of the applicator is to ration organic fertilizer according to the expected dose. The most suitable fertilizer applying mechanism applied in making model prototype applicator is by using metering device belt conveyor type. Organic fertilizers will be channeled using a belt to the discharge hole, where the fertilizer discharge or dosage can be adjusted by the adjusting door (dosage regulator) above the belt. This applicator will utilize the power coming from the applicator wheel shaft transmitted through the chain. Large doses cause the type of metering device selected is a conveyor belt type, where this tool can be used to remove fertilizer at a relatively high rate due to large doses. Fertilizer expenditure can be divided into several streams according to need by auger.

3.1.4. Regulator Door. When a tractor does not perform fertilizer applications such as turns or transportation requirements and fertilizer replenishment, this door can serve to prevent expenditure or spillage of fertilizer in undesirable places. Another function is to regulate the dose or capacity of fertilizer expenditure at the time of application in the field. The opening or closing process of this regulator door is still done manually, and the design is made quite simple. This regulating door is made of iron plate.

3.1.5. Transmission System. Turning power sources for tractor implementations often do not have the same velocity value or place as the bearing shaft. Therefore, transmission is needed to change the rotational speed of the input shaft to fit the needs of the rotation in the rotor shaft. The rotary power for the climber or belt conveyor applicator is sourced from the rotation of the applicator wheel. Transmission systems made from chain and sprocket components (gear).

3.1.6. Auger. Serves to channel organic fertilizer that has fallen from the container tub to the exhaust hole to further fall to the ground. Auger can distribute the fertilizer of both directions, toward the left and right end where there are exhaust holes.
3.2. Technical Analysis.

The process of designing organic fertilizer applicator requires several parameters, which are the basic data to design it. Appliance data and field conditions in which applicators work need to be known to make the design work properly. These data include data on physical characteristics of organic fertilizers and rice cultivation land conditions, rice cultivation techniques, soil conditions, tensile resources, and fertilizer doses.

3.2.1. Rice Cultivation. Rice cultivation is done in wetlands (rice fields). Planting of rice seeds is done after the soil tillage. The process of land preparation and soil tillage is done by using two-wheel tractor by using a moldboard plow which then splashes with a harrow. The cultivation system of rice, use the “legowo jajar” planting pattern.

3.2.2. Does Fertilization. 5 - 7 days after planting fertilized 100 kg urea / ha + 100 kg NPK 15-15-15/ha. For plants with 30 days after planting, fertilized 100 kg NPK 15-15-15/ha. Furthermore, for plants 44 days after planting, fertilized 100 kg NPK 15-15-15/ha.

3.2.3. Physical Properties and Characteristics of Organic Fertilizer. Organic fertilizer is a fertilizer derived from the rest of the plant in the form of leaves, twigs, and other organic materials in the form of animal waste. The type of organic fertilizer used is 375 kg/m³.

3.2.4. Hopper. It serves as a container before it is applied in the field. This box is a tub that can be made with necessary materials such as stainless steel, iron plates, wood (board) and plastics. It is can prismatic hollow elongated or truncated cone that tapers toward the drain holes. The outlet can be circular or square usually located at the bottom or the bottom of the tub wall.

3.2.5. The Metering device hole. The function of the metering device hole is as a regulator of the output dose of fertilizer before it is applied to land. What it used in applicator design model is a type of conveyor belt assisted by the auger. Type of conveyor belt is a unit that serves issued a fertilizer with a relatively high speed. Fertilizer pushed onto the running belt, and the dose is set by adjusting the width of the door opening at the top of the running belt. Auger is the type of metering device that is entirely taken manure to drain holes between the rotating screw thread [4]. The dose is set by adjusting the forward speed of the tractor which is connected to the shaft of the belt conveyor and auger shaft.

3.2.6. The Transmission. It is a component serves to distribute or move a motion from sources such as motors, PTO or drive wheel. Some types of transmission to be used in the design of these applicators include sprocket and chains, gears and chains.

3.3. Prototype of applicator.

The applicator consists of several parts of the framework, like a hopper, door openings regulator (dose), a metering device (conveyor belt), the shaft conveyor belt, transmission systems, auger, and outlet holes. Applicators have a height of 150 cm (from the ground), a length of 200 cm and a width of 100 cm.

The bin of applicator is trapezium shaped prism and has a volume is 2 m³, equivalent to 750 kg of organic fertilizer if the density of fertilizer is 375 kg/m³. The function of the bin is to accommodate the fertilizer ready to be applied to plants. Additionally, tub holder fertilizer should be strong for the pivot shaft of the metering device because they work in a tub of fertilizer. Because there is a hole of the metering device and door openings, it takes place for the best distributor, auger, and the regulator door of fertilizer. The bin is made from a steel frame with walls of sheet iron plate.

Doses of organic fertilizer that will be applied are 15 tons/ha. If the density of organic fertilizer is 375 kg/m³, the total volume of compost is 10000 kg divided by 375 kg/m³ = 26.7 m³. This is a very large volume and weight, so it will affect less well on land as it can cause soil compaction and requires a huge tractor. Therefore, in designing the volume of organic fertilizer tub, applicators only operate with the organic fertilizer along the 100 m length of the groove, and then fill up again and so on.
4. Conclusions
The prototype of organic fertilizer applicator conveyor belt type had been made. It is functioning properly. The shape of applicator bin is prism trapezium and the volume is about 2 m³ or equivalent 750 kg of organic fertilizer.

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