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PERFORMANCE TEST OF SUGARCANE PLANTER WITH MINIMUM TILLAGE AT DIFFERENT DENSITIES OF SUGARCANE LEAF RESIDUES

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ABSTRACT

This paper attempts to demonstratethe performance of a sugarcane planter at the Agricultural Machinery Center, Kasetsart University Research from April 2014 to March 2015 with minimum tillage resulting from a slippery sliding rate (slip %), drawbar pull, drawbar power and PTO power as varied by the different densities of residues at 0, 2, 4, and 6 ton/ha and 2 depth levels of soil at 10 cm and 20 cm. The test was done over one and two rounds in the crop field, after the final sugarcane harvesting, with a moisture content of 22.115% (bulk density) and 19.202 % (bulk density) . It was discovered that the fuel consumption rate of the sugarcane planter was at125 m/l at a tractor velocity of 3.2616 km/hr, the slippery sliding rate at 4.44 %, the draft (pulling) of lower link and top link at 8.30 kW, PTO power at 16.56 kW .The performance and total power of the sugarcane planter with minimum tillage resulted from the depth level of the soil opener and the different densities of the sugar cane leaf residues at 0 2 4 and 6 ton/ha and depth level of the soil to affect performance of the sugarcane planter. Therefore, the angle of subsoil opener should be reduced to less than 31 degrees to reduce the effect of soil resistance.

Key words: drawbar (pulling) power, green technology, sustainable, deep placement fertilizer

INTRODUCTION

Padilla-Fernandez and Nuthall (2009) noted the important resource-use inefficiencies in sugar cane production in Central Negros, Philippines. Output could be increased by 22% through better use of available inputs by rationalizing the use of NPK, especially N-fertilizer, and seed inputs. A soil test should be conducted to determine fertilizer requirements of the soil in Central Negros. Under a specification of variable returns to scale, the mean technical, scale and overall technical efficiency indices were estimated to be 0.7580, 0.9884 and 0.7298. Input use differences between the technically efficient and inefficient farms are highly significant in terms of area, seeds and labor inputs. There was no significant difference in the use of fertilizer and power inputs.

The cubic dimensions of a prototype sugarcane planter were determined to 198 cm x 298 cm x 230 cm, weighing 1,270 kg with a capacity of at least 600 kg of sugarcane sticks. It operates in the crop field at the rate of 3.22 rai/hr with an efficient percentage of 48.16 and a break even area of 12.04 rai. It could plant new sugarcane sticks between the rows of the old sugarcane and could be filled with fertilizer (Tangwongkit et al. 2000). Krueaharncharnpong (2003) demonstrated that the use of power take-off (PTO) affected the average size of a clod of earth. Thus, at an increasing-forward speed, the average size of a clod of earth was bigger when PTO was not used. Hoki et al. (1988) experimented using PTO as a power generator and compared when driven or not driven by human force. Their findings revealed that it was better to use PTO as a power generator, thoroughly penetrating the soil disturbance. Moreover, in wet or soft soil conditions, it was better not to use PTO as a power generator. The need for power of this kind results from the speed of PTO, the speed of the tractor and the depth of tillage; thus the higher the PTO speed, the deeper the tillage.

Takanori et al. (2011) examined the need to vary power at different depth levels to add the fertilizer. It was determined that the measurement of PTO torque and the revolution speed (rpm) of the model/prototype (soil layer for tillage and adjustment of tillage types, potential of tillage, adding fertilizer at the same time, and determining the power need) can be ascertained from the values from the power origin. However, when the experiment was conducted in the actual paddy field, it was found that the PTO torque increased from 77% to 129%. As for the factor of the different angles of the plowing discs, a 30- degree angle of the plowing discs resulted in a bigger clod of earth than when engaging a 25- degree angle of the plowing discs, at an increasing-forwarding speed. Moreover Chaorakam et al. (2012) discovered that after using V-shaped, VR_A, VR_B and Bubble Coulter plowing discs and collecting soil samples from each furrow to bake at a temperature of 110 °C for 24 hours, the amount of soil particles in the furrow dug by a V-shaped plowing disc was significantly less than that in the other furrows dug by other plowing discs. Outputs by C-shaped-European-rotating-plow blade and prototype rotating-plow blade are as follows: the average size of a clod of earth was from 10.22 to 20.56 mm and from 12.17 to 24.80 mm, respectively. The percentage of the slippery sliding rate was from 4.60% to 7.85% and from 3.60% to7.69 %. Moreover, installation of the C shaped-European-rotating-plow blade required less special power than the installation of the prototype rotating-plow blade (Mongkol et al. 2008).

Prasertkarn (2009) reported that the tractor's speed affected the drawbar power as well as the total power, whereas the vibration and the width of vibratory range also affected the drawbar power and the area of soil distribution. Al-Janobi and Al-Suhaibani (1998) conducted an experiment to measure the draw pull of plowing discs in sandy loam soil. Their study revealed that the factors affecting the draw pull were the speed of the tractor and the depth of tillage. In this study, the plowing discs used in the experiment were those with a diameter of 660 mm and the working widths were at 1 and 115 mm. In this experiment, the pig-head-shaped plow, the chisel plow and the set of Offset Disk Harrow were compared. It was discovered that the plowing disc and the pig-head-shaped plow yielded a higher horizontal draft than the set for the Offset Disk Harrow at the same depth of tillage and forwarding speed. Manian et al. (2000) examined black clay loam and sand in artificial soil trays at disk angles of 40, 44 and 48 degrees, tilt angles of 16, 20 and 24 degrees, diameters of 51, 56 and 61 cm and at the forwarding speeds of 4, 7 and 10 km/ hr. It was demonstrated that the draw pull and the horizontal force in the black clay loam were rather high. Meanwhile, the vertical action force decreased when the moisture content in the 2 soil types increased.

Although tillage does not directly affect the growth of a plant, indirectly it does. Thus, such indirect advantages as greater soil porosity, better ventilation in soil, increased vaporization are helpful in the eradication of weeds and therefore good for the growth of the plant. Although tillage is good for plant growing, it can damage the agricultural system, particularly in changing the soil's physical and chemical properties. The disadvantages of tillage include increasing the density and stress from water. Using a mid-sized tractor can increase density and water stress in the soil at a 60-cm depth. Taking these problems into account, therefore, the opinion to grow sugarcane using a planter with minimum tillage in order to better the conditions of soil is growing in acceptance.

This study, therefore, sought to determine the performance of a sugarcane planter for an unprepared-soil area, and using the drawbar power to analytically determine the total power requirement for the planter installation via a tractor. This would test the performance of the sugarcane planter without PTO power tillage usage.

MATERIALS AND METHODS

This research was conducted in the Agricultural Machinery Center, Kasetsart University Thailand from 2014 to 2015. In order to measure the drawbar pull, the strain gauges, Wheatstone bridge type, were installed on the lower link and top link pin together with PTO-torque transducer (No. 3 in Fig. 1). Meanwhile, in order to measure the torque of PTO power; a potentiometer was installed (No.1) to measure the leaning angle between the plane and the core top link. Moreover, the PTO torque transducer (ONOSOKKIT), type HM-640, was also installed to measure the number of revolutions. All the electric signals from these devices will be sent to a dynamic recorder, Kyowa-EXD-100A, and analyzed using the program DCS-100A according to Fig. 1.

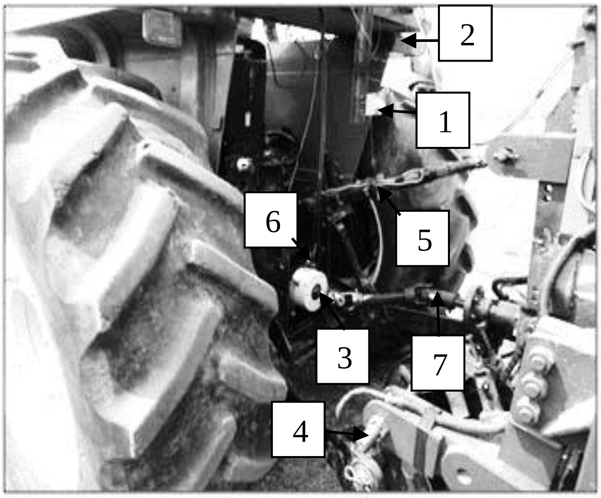

Fig. 1. Installation of measuring device for performance test of sugarcane planter
1) Potentiometer 2) Recorder EDX-100A 3) PTO - Torque transducer.
4) Lower link 5) Top link 6) PTO power Speed transducer 7) Driven shaft

EXPERIMENTAL CONDITIONS

Performance evaluation of sugar cane planter

The study was conducted in the Agricultural Machinery Center, Kasetsart University to determine the power need of the sugar cane planter at varying soil depths. The experimental field to test the performance of the sugarcane planter was designed with an area of 20 x 100 m^2 according to the terms in the factorial were 4 as: density of residue, depth of soil, moisture content and PTO power. The tested factors included the densities of the residues at 0, 2, 4, and 6 ton/ha; the depth of soil at 0-15 cm and 0-21 cm; the moisture content of the residue and soils at 22.115% bulk density and 19.202 % bulk density and PTO power at 16.56 kw.

Four furrows of sugarcane were specified and each furrow was tested with 4 replications. The sugarcane planter (Fig. 2) was installed attached to the tri-pod on a tractor to open the soil into a furrow for each sugarcane line. The driven force in a multifactor experiment type was used. The factors of interest were the following: the PTO power used in the experiment, the effects of the residues, the speed of the tractor: 0.906 m/s or 3.261 km/hr at 2,200 rpm, and low gear was used in 4 rounds of plowing. The depth and moisture contents were also measured and collected for further calculations to determine various factors affecting the performance of the sugarcane planter such as the pulling power, the PTO power and other power usages in the multifactor experiment.

Fig. 2. Sugarcane planter prototype

THEORETICAL CALCULATIONS

The horizontal drawbar pull was calculated from the lower link pins transducer and the top link transducer to determine the drawbar power formulae as follow.

$$\text{Drawbar power} = F \times V \qquad \text{[Equation 1]}$$

Where the drawbar measures the pulling force (kw), F measures the horizontal drawbar pull (kN) and V measures the velocity (m/s) formulae as follows:

$$\text{PTO power} = \frac{2\pi NT}{60{,}000} \qquad \text{[Equation 2]}$$

Where:

PTO	is the power of the supporting axle (kw),
N	is the revolution speed of the supporting axle (rpm)
T	is the torque of the supporting axle (N-m)

This can be determined by the calculation of the Data Rocker-EDX-100A formulae as follow.

$$\text{Total power} = \text{Drawbar power} + \text{PTO power} \qquad \text{[Equation 3]}$$

Where:

Total power	are all the whole power (kw),
PTO power	is the power take-off (kW)
Drawbar power	is the pulling power (kw)

RESULTS AND DISCUSSION

A comparison was made on the effects of the different densities of sugarcane leaf residue on the performance of a sugarcane planter with minimum tillage in terms of the depth of the soil, the slip present or slippery sliding rate, drawbar power, PTO power and total power. The experiment was conducted at the speed of 3.2616 km/hr and an engine revolution of 2200 rpm. Fig. 3 shows the relationship of PTO power compared with the depths of soil resulting from soil opening by sub-soil. Both the depths of the soil and the density of sugarcane leaf residue at 6 t/ha, could affect the tendency to use the maximum PTO power of 15.027 kw at 16.5 cm soil depth.

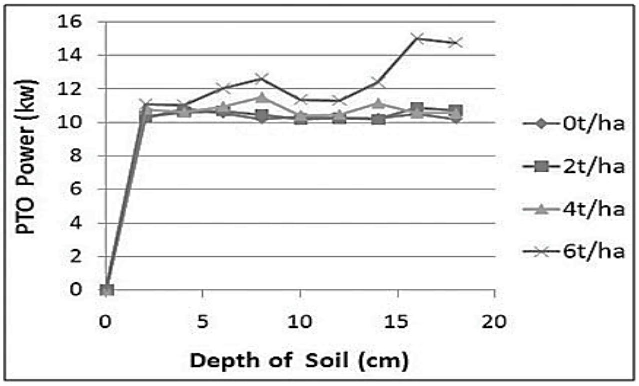

Fig. 3. Relationship between PTO Power and depth of soil

The graph shows the relationship between the depth of soil and the drawbar power varied according to the different density of residue seen in (Fig. 4). It could affect the tendency to use the maximum draft 8000 N at a soil depth of 20 cm. The drawbar power is likely to be higher when the depth of soil and the density of residue increase. It was, therefore, draft of 7162.99 N at velocity of 2.536 km/hr, according to Fig. 5.

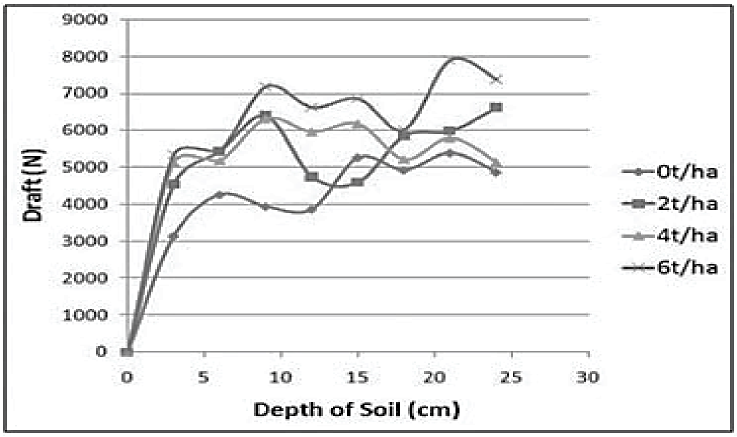

Fig. 4. Relationship between draft and depth of soil

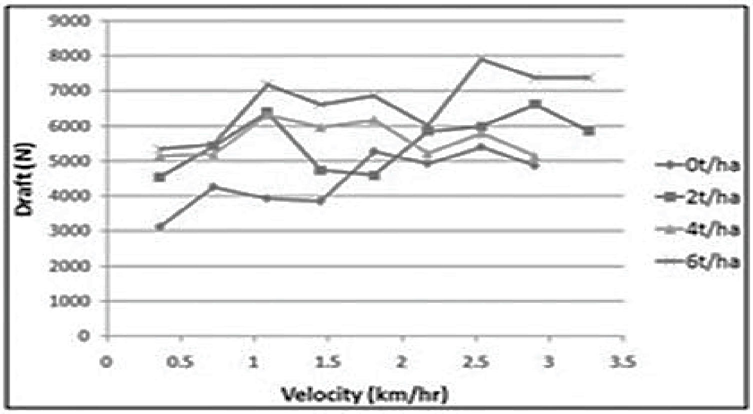

Fig. 5. Relationship between draft and velocity

The depth of soil is affected by drawbar power, it could affect the tendency to use the maximum draft 7100 N at depth of soil 20.8 cm (Fig. 6). The drawbar power is likely to be higher when the depth of soil and the density of residue are greater. Thus, drawbar power of 7162.99 w at velocity of 2.536 km/hr, according to Fig. 7.

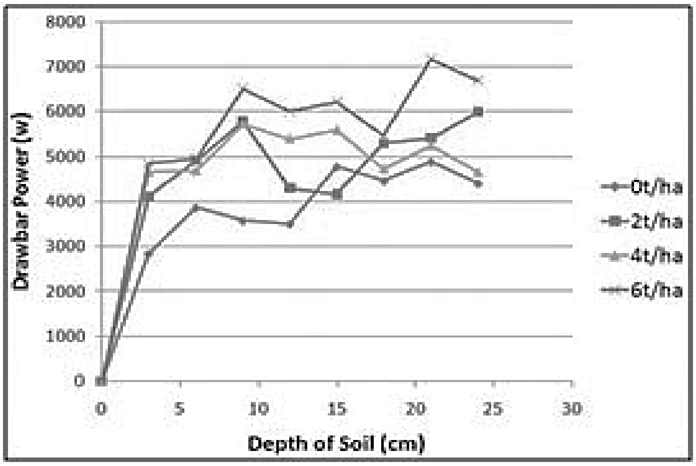

Fig. 6. Relationship between drawbar power and depth of soil

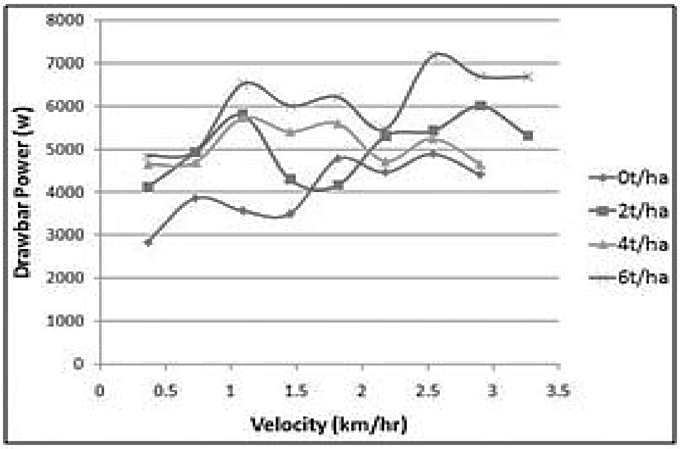

Fig. 7. Relationship between drawbar power and velocity

CONCLUSIONS

The field experiment findings demonstrate that the prototype sugarcane planter is suitable to be installed on a 33.337 hp tractor. The horizontal drawbar pull was taken from the lower link and top link pins transducer at 8.30 kw. Thus, the use of agricultural machinery as a power origin together with an agricultural tool can affect the performance and efficiency of the agricultural tool. Specifically, the power requirement of tractor is not appropriate to use with an agricultural tool because the end result will be an over-fuel consumption rate, pollution and damage to the rear connecting devices of the tractor. The different densities of the residues at 0, 2, 4 and 6 ton/ha and depth level of the soil affected the performance of the sugarcane planter.

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