

Field Evaluation of Subsoiling and Liquid Fertilizer Injection for Minimum Tillage of Sugarcane Planter (Part 2) - Effects of Subsoiling and Liquid Fertilizer Injection on Crop Growth

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Abstract

Field investigation of subsoiling and liquid fertilizer injection under minimum tillage practice of sugarcane planter has been tested. This experiment has been conducted at the field of National Agricultural Machinery Center (NAMC), Kasetsart University and Flying Training School, RTAF, Khampaengsaen in 2010. The seeding trial was done with three models of sugarcane planter including a conventional sugarcane planter (CP), subsoiling sugarcane planter (SP) and combination of subsoiling with liquid fertilizer injection sugarcane planter (SFIP). Significant of the three different models of the sugarcane planter, soil types and seeding depths has been discussed. Comparative study on this experiment under rain-fed condition found that the significant of soil types were found in the crop growth whereas the other major parameters and the interaction among the major parameters were found to be not significantly different in this specific research study. However, the growth of the crop has been showed satisfactorily done under SP and SFIP. These come from the fact that the growth of the crop has been prone to depend on the pertinent quality of the soil such as organic matter, soil moisture, and tillage management. Subsoiling and liquid fertilizer can improve the aeration, infiltration, drainage rate, the moisture in soil and subsoil improvement lead to improve the growth of sugarcane crop under minimum tillage practice.

Keywords: planter, sugarcane, minimum tillage, subsoiling, fertilizer injection, crop growth

1. Introduction

Minimum tillage practice is generally defined as “planting crops in undisturbed soil by opening a sufficient width and depth of the narrow slot to obtain the proper seed put in place and remain the significant scattered residue on the soil surface which now popularly use in efficient farm management system as one of the advantages of this practice.

This tillage practice, in general, has been found to reduce the cost and fuel consumption, erosion, moisture conservation, accumulate the organic matter in the soil, and less time in land preparation and also increase in microbial biomass and micro-flora activity to serve as an energy source for microorganism that ensure to recognize the sustainability concept of this system practice [1, 2, 3].

Whereas, conventional agricultural cultivation system, with intensive soil tillage, normally will lead to soil degradation and loss of crop productivity thus can imply that soil quality had a strong impact on plant establishment at the given seeding rate, and plant growth.

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Under these considerations, a new developed sugarcane planter that enable carrying out of subsoiling, liquid fertilizer injection and planting simultaneously, has been developed to simplify the tillage sequence. Then taking into account of the advantage of subsoiling treatment on crop growth was studied in comparison with the conventional system.

2. Materials and methods

2.1 Field preparation

Perennial weeds are a problem in the sugarcane field when using minimum tillage practice. Under this field trial, chopping or mowing machine equipment has been used to manage the weed residue on the field for proper field trial before seeding operation of the developed planter. As a result, moisture conservation was kept as a criterion managed to keep it as a target for stable plant growth especially under rain-fed condition.

Under the case of conventional practice, twice a time of three disc plow has been used for land preparation and then followed by seven disc plow and planted by using a conventional sugarcane planter. This sugarcane cultivation practice has been now popularly use in Thailand.

2.2 Experimental tests and site description

The tested fields were conducted at the research field of National Agricultural Machinery Center, Kasetsart University, Khampaengsaen Campus Nakorn Prathom, Thailand (latitude 14° 1' 53.63"N, longitude 99° 58' 6.88"E) and Flying Training School, RTAF, Khampaengsaen, Nakorn Prathom, Thailand (latitude 14° 5' 6.16"N, longitude 99° 55' 53.74"E) from April 2010-May 2011.

A cone penetrometer (Daiki Rika Kogyo Co., Ltd., Japan, Model DIK 5500) has been used for measurement of soil hardness with a 30° of cone apex angle and 78.57mm² base area at three places of each plot.

Soils were sampled at the depth of 100mm by using a 50mmØ soil core sampler and then brought to the laboratory for the measurements of soil moisture content and its distribution of each treatment. Then, soil samplers were dried at 110°C for 24h to determine the moisture content and the dry bulk density. The particle size distribution of the soil was analyzed by the pipette method using a kohn-type pipette analyzer. Accordingly, the laboratory results of the percentage finer found that the tested soils were found to consist of 13.73% clay, 31.76% silt, and 54.51% sand for the field of NAMC and 17.25% clay, 32.99 silt, and 49.76% sand for the field of RTAF respectively. Therefore, the soil types were classified as sandy loam and loam respectively. Summarized items of soil properties at both locations showed different values of soil particle size distribution, organic matter and moisture content of the soil as showed in Table 1.

Table 1: Summarized items related with the soil properties

Item	NAMC		RTAF	
	Tillage practice	Minimum tillage practice	Tillage practice	Minimum tillage practice
Sand; [%]	54.51		49.76	
Silt; [%]	31.76		32.99	
Clay; [%]	13.73		17.25	
Soil texture	Sandy Loam		Loam	
OM [%]	0.91		1.37	
MC [% d.b.]	14.51		12.39	
Bulk density [Mg/m ³]	1-1.4		1.06-1.43	
CI [MPa]	1.4	1.7	1.4	1.75
Seeding depth [mm]	75, 100		75, 100	

2.3 Implement tested

Three different models of sugarcane planter composed of conventional sugarcane planter (CP), subsoiling sugarcane planter (SP) and subsoiling with fertilizer injection sugarcane planter (SFIP) have been tested to evaluate the performance of crop growth.



(a) Subsoiling and liquid fertilizer tube



(b) Conventional planter by removal of subsoiler



(c) Onsite mechanical action under covered residue in the field

Fig. 1 Developed sugarcane planter and conventional practice

The developed planter has been developed through the modification of the commercial sugarcane planter attachment as a base as illustrated in Fig. 1(a). Subsoiling implement has been attached in front of the commercial sugarcane planter with the setting of working depth at 300mm from the ground surface. The stainless tube with 25mmØ with 300mm of length also has been attached at the rear side for liquid fertilizer injection. The tank of 1000 liters of liquid fertilizer has been put on the roof with the supportive structure of the tractor as shown in Fig. 1(b). Under minimum tillage practice, subsoiling and liquid fertilizer injection simultaneously has been represented in Fig. 1(c). The submersible pump has been installed inside the tank with the setting of the capacity of the liquid fertilizer at 2l/m. Aiming toward low soil disturbance, minimize soil moisture loss from the slot, aeration, infiltration and subsoil improvement for better seedbed preparation after the seeding process has been designed using subsoiler and liquid fertilizer injection concurrently.

2.4 Methodology of the field experiment and experimental design

Three different type of sugarcane planters were evaluated with the seeding performance tests regarding with crop growth. The field experiment at both sites has been subdivided into 6 plots. Each plot was $15 \times 50\text{m}^2$ to perform for this experiment. The target of the traveling speed of the tractor was set at 2.5m/s with 75 and 100mm deep of the seeding depth. This experiment has been blended 0-52-34 formula of 1kg with 200L of water for liquid fertilizer in this specific research activity. This fertilizer aimed for germination improvement, nutrient accumulation and stable growth of the seedling. A $2 \times 2 \times 3$ factorial experiment in completely randomized design was conducted for each operational trial.

Each treatment was replicated five times each and the mean values of the treatments were analyzed using Least Significant Difference (LSD) method. A statistical analysis was performed using the SAS statistical software. The result of these analyses on crop growth was satisfactorily expected to assess the capability of the machines evaluation.

(1) Effect of subsoiling and liquid fertilizer injection of developed sugarcane planter on crop growth

The combination of crop residue retention and minimum tillage practice are believed to be increase microbial biomass and micro-flora activity that induce better soil health. Soil organic matter has been played and importance role determined of soil fertility, productivity, and sustainability that influenced by agricultural management such as tillage, mulching, crop residue retention and application of organic fertilizer. Whereas, conventional tillage practice, especially, by removal of crop residue from the field has been prone to be hasten decrease soil organic carbon, [4, 5]. The effect of subsoiling and liquid fertilizer injection of the developed sugarcane planter has been observed at 90DAP. Before substantial tests, two rows of the boarder side and 5 meters apart from each hedge of each subdivided plot has been omitted to prevent the edge effects. The five remaining rows with 5m of length of each inside of the subdivided plots have been selected for this experiment. Then, taking into account of the average of crop growth of each treatment of the selected sub-plot in the inter-rows of the seedling can be done. Field observations of the crop growth of the seedling after machine operation at all treatments were comparatively discussed in conjunction with the developed sugarcane planter.

3. Results and discussion

Three different types of sugarcane planter were comparatively studied in relation to crop growth in the six subdivided plots at two locations. The growth of the crop was mainly used to confirm its contribution towards the improvement of the machine for the next research study.

(1) Effect of subsoiling and liquid fertilizer injection of sugarcane planter on crop growth

The growth of the crop has been measured in the field at 90DAP as represented in Fig. 2. Similar trend of the average growth between both experimental sites with different of seeding depths (75, 100mm) have been shown in Figs. 3-4.



(a) The growth of crop after 90DAP at NAMC



(b) The growth of the crop at 90DAP at RTAF



(C) Onsite measurement of the crop

Fig. 2 Presented seedlings growth and onsite measurement

In general, with an increase of seeding depth, it could be found that the height of the seedling decreased gradually. However, the decreasing rate of the height of the sugarcane seedling fluctuated irregularly due to the effect of field surface condition and the pertinent of soil type in particular. In the case of SP and SFIP, both planters generated good performance of the average crop growth under entire combinations. Highly values of the growth of the crop could be obviously observed and performed by SFIP due partly to the additive nutrient from the fertilizer. In the case of CP, similar trend results showed minimum average crop growth comparison under this particular experiment.

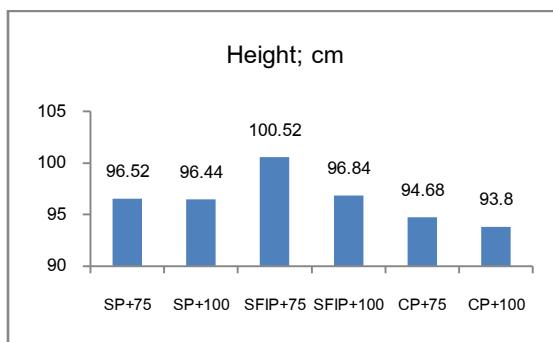
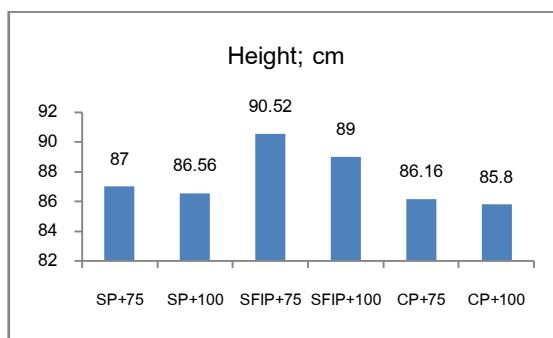
**Fig. 3 Growth rate at sandy loam soil tested field****Fig. 4 Growth rate at loamy soil tested field**

Table. 2 ANOVA results related to crop growth

	Degree-of-Freedom	Sum of Squares	Mean Square	F
Treatment	11	1424.55	129.51	2.88*
A (Soil type)	1	1204.22	1204.22	26.76*
B (Planter type)	2	172.74	86.37	1.92 ^{ns}
C (Depth)	1	20.18	20.18	0.45 ^{ns}
AxB	2	5.20	2.60	0.06 ^{ns}
AxC	1	2.24	2.24	0.05 ^{ns}
BxC	2	15.88	7.94	0.18 ^{ns}
AxBxC	2	4.09	2.05.	0.05 ^{ns}
Error	48	2160.40	45.01	
Total	59	3584.95		

* significant at P=0.05

Moreover, variation analysis of the experiment was used to clarify the practical significance of field performance tested, as represented in Table. 2. The results from ANOVA indicated that the major parameter factor of soil type has been found to be significantly different at P=0.05. This results due partly to the pertinent of physical soil properties in particular. The statistical analysis showed no significant different in others major factors and the interaction parameters, thus implying an engineering significance concept for morphological improvement of the major design parameter of the developed sugarcane planter.

A comparison of the mean values using LSD method has been demonstrated in Table. 3. Through this analysis of the experiment, it could be found that highly growth rate values had been observed after the operation of SFIP under the entire combinations. These come from fact that the combination of the subsoiling and liquid fertilizer injection can enhance the growth rate of the sugarcane cropping under this particular setting condition of the experiment.

Table. 3 Comparison between mean values of growth rate

Soil type	Depth, mm	Mean value		
		CP	SP	SFIP
Sandy loam	75	94.68 ^{a-c}	96.52 ^{ab}	100.52 ^a
	100	93.8 ^{a-d}	96.44 ^{ab}	96.84 ^{ab}
Loam	75	86.16 ^{cd}	87.00 ^{cd}	90.52 ^{b-d}
	100	85.80 ^d	86.56 ^{cd}	89.00 ^{b-d}
LSD 0.05		8.53		
CV. (%)		7.29		

Note: Means followed by the different superscript in the same row indicate significant difference between the mean values at P=0.05.

Means followed by the different superscript in the same column indicate significant difference between the mean values at P=0.05.

In the case of CP, similar trends comparison of research results showed among three different sugarcane planters. Loosing moisture in the soil after intensive tillage practice showed some disadvantage of the crop growth in alls combination practice especially the pertinent of the soil properties in each location.

For the case of SP, subsoiling practice showed something specific in enhance the growth of the crop compared with conventional sugarcane planter in alls combination. The research results could guaranteed in beneficial of minimum tillage practice using subsoiling sugarcane planter.

Similar trend of highly values of the average crop growth have been obviously observed in both different of soil types under the case of SFIP. The fluctuated results data sets were due to irregular field surface and some partly to physical properties of the different of the tested soil.

This behavior of the planter tends to enhance the growth of the sugarcane crop. The results could be concluded that subsoil improvement using subsoiling in conjunction with liquid fertilizer injection generate something more satisfactorily done to adapt for more theoretical design of the machine improvement.

4. Conclusions

This research has been conducted to clarify the performance test of subsoiling and liquid fertilizer injection of minimum tillage of sugarcane planter by taking into account of the advantage of subsoiling treatment and liquid fertilizer injection on crop growth had been discussed extensively based on the field experiment. The conclusion of the results can be drawn as follows.

- (1) Minimum crop growth has been obviously observed under conventional cultivation practice. Loosening moisture in the soil after intensive tillage practice showed some disadvantage of the growth of the sugarcane crop.
- (2) Subsoiling sugarcane planter could perform to enhance the growth of the crop compared with conventional sugarcane planter. This come from the fact that moisture conservation in the soil, aeration, infiltration and the drainage rate could be created for better seed-soil contact that lead to stable plant growth.
- (3) Subsoiling in conjunction with liquid fertilizer injection sugarcane planter was confirmed to be effective regarding in crop growth under entire combinations. This machine demonstrated practical significant and recommendable performance of minimum tillage of sugarcane planter in which desirable seedbed preparation could be created to meet the requirements of stable plant growth.
- (4) Subsoiling device has been proved in practice applicable regarding soil-seed-implement phenomenon. Subsoil improvement using subsoiling device for seedbed preparation could be done that lead to stable circumstance of the plant growth. However, modification of the design criteria in regarding the relative setting position of this device together with the tillage sequence mechanism were found to improve the field performance even with an uncultivated soil profile.
- (5) Under this field experimental trial, the growth of the sugarcane crop prone to depend on the pertinent of the soil properties and crop management.

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