



Development of a mung bean seeder for sugarcane furrows

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Abstract

This project aims to develop a mung bean seeder for planting in sugarcane rows. The machine has a height of 70 cm and a width of 50 cm. Its main components include a mung bean seed hopper, a screw-type seeding unit, a control system powered by a 12-volt electric motor, and a mounting base. The testing and evaluation were conducted to determine suitable operating conditions and to assess the machine's performance. The tests were carried out at three travel speeds: 2.60, 3.39 and 4.63 km/h, and three seeding unit rotational speeds: 30, 40 and 50 rpm. The results showed that using gear M3 at a travel speed of 4.63 km/h provided the highest field capacity. Increasing the rotational speed of the seeding unit from 30 to 50 rpm resulted in a decrease in both the seeding rate and uniformity, while the fuel consumption rate decreased slightly. In addition, field tests in actual sugarcane plots indicated that the machine's actual performance was close to the theoretical values, with a field efficiency of 95.72% and an average fuel consumption rate of 2.14 l/h. These results demonstrate that the machine is suitable and efficient for use under real sugarcane field conditions.

Keywords: Mung bean seeder, Tractor-mounted seeder, Mung bean, Sugarcane rows, Seeding mechanism

1. Introduction

The sugarcane industry is an important agricultural sector contributing significantly to the national economy. Domestic sugar consumption is approximately 1.6–1.7 million tons per year, valued at around 17,000–19,000 million baht. In addition, more than 3 million tons of sugar are exported annually, generating approximately 20,000–30,000 million baht in revenue. As a result, Thailand ranks as the third-largest sugar exporter in the world [1]. The sugarcane production process includes land preparation, planting, crop maintenance, harvesting, and processing in factories. Agricultural machinery is widely used in these processes to reduce labor costs, improve efficiency, and increase productivity. Intercropping mung beans in sugarcane rows is one approach to promoting sustainable sugarcane production. Mung beans, as leguminous crops, can fix atmospheric nitrogen and enrich the soil, improving soil fertility, enhancing soil structure, increasing organic matter, and reducing soil erosion. Additionally, mung bean cultivation helps suppress weed growth in the field. Proper field management for sugarcane intercropped with mung beans includes adequate water supply, weed control, and pest management to ensure optimal growth of both crops. Fertilizer application should primarily meet the needs of sugarcane, especially during the early growth stage to promote tillering and stem development. After mung beans are grown and incorporated into the soil as green manure, they contribute to increasing nitrogen and organic matter content in the soil [2]. Based on the benefits of intercropping mung beans in sugarcane fields as green manure, this study proposes the development of a mung bean seeder designed specifically for sugarcane rows. The objective is to achieve uniform seed distribution, control the seeding rate according to planting requirements, reduce seed loss, and minimize labor and operational time. The machine can be integrated with existing agricultural machinery to improve overall planting efficiency. Currently, planting machinery such as automatic seed and fertilizer drills mounted on tractors has been developed to provide efficient and uniform operation, with precise control of seed and fertilizer application, reduced losses, and lower labor and time requirements [3]. Studies on crop rotation systems involving mung beans and soybeans have shown improvements in soil properties and increased growth and yield of sugarcane [4]. Research on the growth and yield components of mung beans in suitable areas has also been conducted [5]. Furthermore, recommendations from Surin Sugar Factory have suggested the development of a front-mounted tractor mung bean seeder using a screw conveyor system that minimizes seed damage and allows control of motor speed for precise seed distribution [6, 7]. Based on the above information, this project aims to design and develop a front-mounted mung bean seeder for tractors to improve soil conditions and enhance sugarcane production efficiency. The machine is designed for ease of operation and accurate seed distribution, and can be used in combination

with a rear-mounted rotary tiller to cover the seeds after sowing. It is expected to improve planting efficiency and reduce labor costs while providing sufficient green manure for optimal sugarcane growth.

2. Materials and methods

2.1 Design and construction of a mung bean seeder for planting in sugarcane rows

The design and construction of a mung bean seeder for planting in sugarcane rows were based on data regarding mung bean seed requirements per sugarcane planting area, principles of green manure production using mung beans with machinery, and the dimensions of sugarcane rows [8, 9]. These factors were considered in the design process. The design criteria specified that the machine must be capable of seeding at a rate of not less than 8 kg/rai. The seeder is designed for use with small tractors not exceeding 27 hp and utilizes a screw-type seed metering system to control seed distribution. The main components of the seeder include a screw conveyor, a seed hopper, and a mounting base. The seed hopper has a capacity of 40 kg of mung bean seeds. The construction of the mung bean seeder consists of key components, including the seed hopper, screw-type seeding unit, motor control system, and a frame for mounting the hopper onto the tractor. The construction process is as follows.

2.2 Performance testing

2.2.1 Theoretical testing

The testing and evaluation were conducted to obtain data on appropriate operating conditions and to determine the performance of the machine. The details of the testing are as follows

- 1) Mung bean seeds of the Chainat 84-1 variety were used.
- 2) The rotational speeds of the seeding unit were set at 30, 40 and 50 rpm.
- 3) The engine speed was set at 1300 rpm.

2.2.2 Testing procedure

- 1) Prepare the test area with a length of 20 m and a width of 1 m.
- 2) Prepare the equipment and fill the fuel to the required level.
- 3) Prepare the mung bean seeds.
- 4) Conduct the seeding test at travel speeds of 2.60, 4.63 and 3.39 km/h, and at seeding unit rotational speeds of 30, 40 and 50 rpm.
- 5) Record the time during testing to calculate the field capacity.
- 6) Collect samples from each block and weigh them.
- 7) Measure fuel consumption by filling 100 mL of fuel into a beaker, refilling the tractor fuel tank to full, and measuring the remaining fuel in the beaker.
- 8) Calculation of performance parameters follows as [10];

- Field capacity

$$\text{Field capacity (rai/h)} = \frac{\text{Working area (rai)}}{\text{Time (h)}} \quad (1)$$

Where is working area = L×W, L = length of operation (m), W = width of operation (m) [10].

- Seeding rate

$$\text{Seeding rate (kg/rai)} = \frac{\text{Seed weight (kg)}}{\text{Seed area (rai)}} \quad (2)$$

- Uniformity

$$\text{Uniformity (g/block)} = \frac{\text{Total seed weight (g)}}{\text{Number of block}} \quad (3)$$

- Fuel consumption rate

$$\text{Fuel consumption rate (L/h)} = \frac{\text{Fuel used (L)}}{\text{Time (h)}} \quad (4)$$



Figure 1 Theoretical test

2.2.3 Field testing in sugarcane plots

The testing of the mung bean seeder in sugarcane rows was conducted under actual field conditions. The results showed that, at a travel speed of 4.63 km/h and seeding unit rotational speeds of 30, 40 and 50 rpm, the machine achieved corresponding mung bean seeding rates in the sugarcane field.

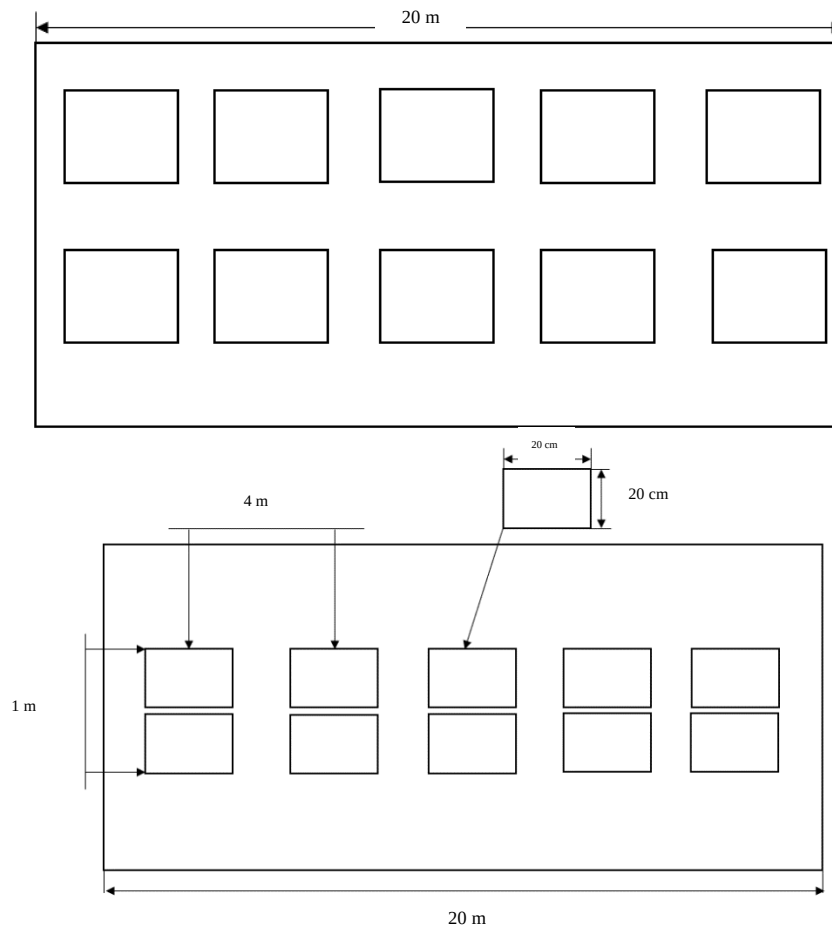


Figure 2 Field testing in sugarcane plots

3. Results and discussion

3.1 Instructions for the machine

The operating principle of the machine begins when the tractor moves into the sugarcane rows. The switch is then turned on to activate the motor, which controls the seed distribution. The seeding rate and speed can be adjusted to appropriate levels. Mung bean seeds are dispensed into the sugarcane rows, after which a rotary tiller is used to cover the seeds with soil. The covered soil helps

ensure good seed-to-soil contact and adequate moisture, resulting in uniform germination, reduced seed loss, and no adverse effects on sugarcane growth. This process enhances the efficiency of intercropping mung beans with sugarcane [9, 11, 12].

3.2 Test results

3.2.1 Theoretical test

Table 1 Theoretical performance test results at an engine speed of 1300 rpm

Gear	Operating speed (km/h)	Seeding unit rotational speed (rpm)	Field capacity (rai/h)	Seeding rate (kg/rai)	Fuel consumption rate (L/h)	Seeding uniformity (g/block)
M2	2.60	30	1.03	43.56	1.17	2.10
		40	1.01	41.35	1.15	4.09
		50	1.00	70.74	1.15	0.98
M3	4.63	30	1.90	78.57	2.18	8.53
		40	1.87	69.92	2.14	1.35
		50	1.85	72.42	2.11	1.12
H1	3.39	30	1.47	50.31	1.68	3.18
		40	1.47	46.70	1.68	2.32
		50	1.46	46.47	1.67	1.30

From Table 1, at gear M2 with an average travel speed of 2.60 km/h and seeding unit rotational speeds of 30, 40, and 50 rpm, the field capacities were 1.03, 1.01 and 1.00 rai/h, respectively. The seeding rates were 43.56, 41.35 and 70.74 kg/rai, respectively. The uniformity values were 2.10, 4.09 and 0.98 g/block, respectively. The fuel consumption rates were 1.17, 1.15 and 1.15 L/h, respectively. At gear M3 with an average travel speed of 4.63 km/h and seeding unit rotational speeds of 30, 40 and 50 rpm, the field capacities were 1.90, 1.87 and 1.85 rai/h, respectively. The seeding rates were 78.57, 69.92 and 72.42 kg/rai, respectively. The uniformity values were 8.53, 1.35 and 1.12 g/block, respectively. The fuel consumption rates were 2.18, 2.14 and 2.11 L/h, respectively. At gear H1 with an average travel speed of 3.39 km/h and seeding unit rotational speeds of 30, 40 and 50 rpm, the field capacities were 1.47, 1.47 and 1.46 rai/h, respectively. The seeding rates were 50.31, 46.70 and 46.47 kg/rai, respectively. The uniformity values were 3.18, 2.32 and 1.30 g/block, respectively. The fuel consumption rates were 1.68, 1.68 and 1.67 L/h, respectively.

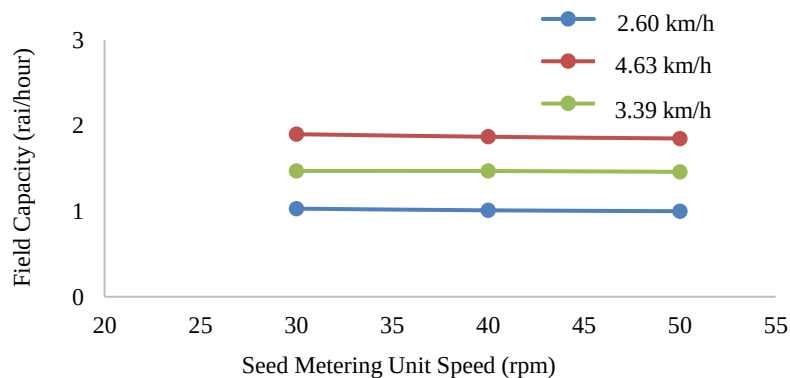


Figure 3 Result of the field capacity

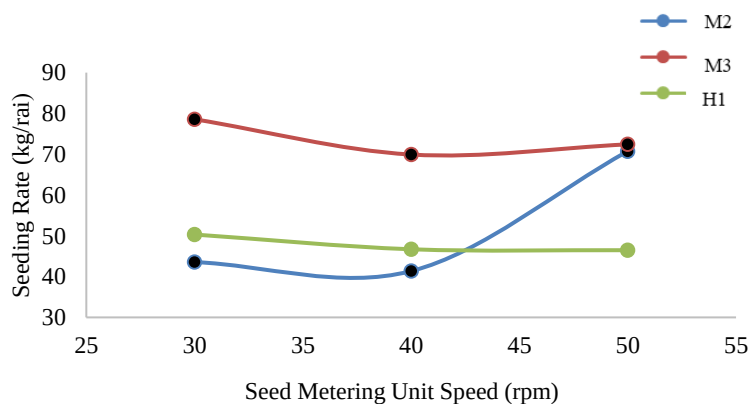


Figure 4 Theoretical seeding capacity

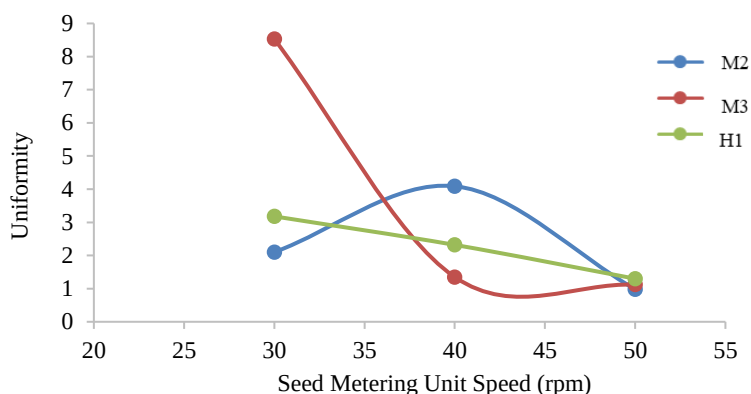


Figure 5 Theoretical of uniformity

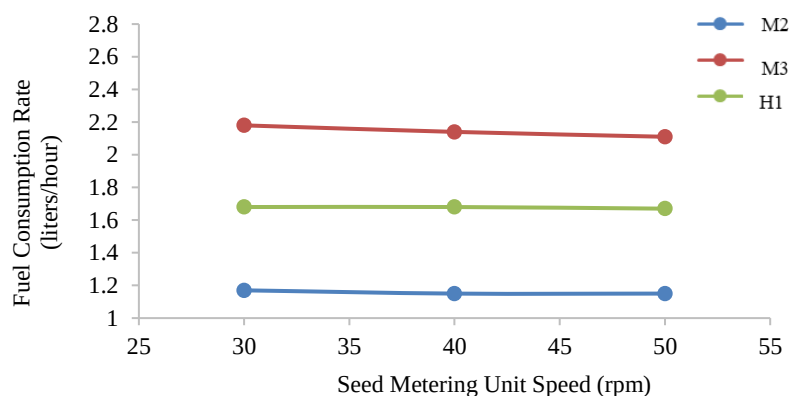


Figure 6 Theoretical of fuel consumption

3.2.2 Field test

The field testing of the mung bean seeder in sugarcane rows was conducted under actual conditions. The results showed that at a travel speed of 4.63 km/h and seeding unit rotational speeds of 30, 40 and 50 rpm, the mung bean seeding rates were obtained as shown in Table 2

Table 2 Time efficiency performance of field testing in sugarcane plots

Operating speed (km/h)	Seeding unit rotational speed (rpm)	Time taken (seconds)		Test area (m ²)		TFC	EFC	EFF
		Theoretical	Actual	Theoretical	Actual			
4.63	30	16.56	104	14	80	1.90	1.72	90.59
	40	16.84	104	14	80	1.87	1.72	91.87
	50	17.06	101	14	80	1.85	1.77	95.72

From Table 2, at gear M3 with an average travel speed of 4.63 km/h and seeding unit rotational speeds of 30, 40, and 50 rpm, the theoretical times required were 16.56, 16.84, and 17.06 seconds, respectively. The actual times required were 104, 104, and 101 seconds, respectively. The theoretical field capacities were 1.90, 1.87, and 1.85 rai/h, while the actual field capacities were 1.72, 1.72, and 1.77 rai/h, respectively. The field efficiencies were 90.59%, 91.87%, and 95.72%, respectively. Therefore, the results indicate that the highest field efficiency was achieved at a seeding unit rotational speed of 50 rpm [13, 14].

Table 3 Fuel consumption rate in field testing of sugarcane plots

Gear	Fuel consumption (mL)	Time taken (seconds)	Fuel consumption rate (L/h)
M2	10	31.13	1.15
M3	10	16.82	2.14
H1	10	21.52	1.67

From Table 4.3, at gear M2, the fuel consumption was 10 mL with an operating time of 31.13 seconds, resulting in a fuel consumption rate of 1.15 L/h. At gear M3, the fuel consumption was 10 mL with an operating time of 16.82 seconds, resulting in a fuel consumption rate of 2.14 L/h. At gear H1, the fuel consumption was 10 mL with an operating time of 21.52 seconds, resulting in a fuel consumption rate of 1.67 L/h.

The developed mung bean seeder achieved a maximum field efficiency of 95.72% and an effective field capacity of 1.77 rai/h at a travel speed of 4.63 km/h and a seeding unit rotational speed of 50 rpm. These values are higher than those reported by Kathirvel et al. [15], who obtained a field efficiency of 71.43% for a till planter. Similarly, Karayel [16] reported that machine performance improved with increasing operating speed when seed delivery remained stable. The high efficiency achieved in the present study demonstrates the machine's suitability for sowing mung bean in sugarcane furrows and highlights its potential to improve labor productivity and operational efficiency [15, 16]. Although the machine operated successfully in sugarcane furrows, the seeding rates were higher than the recommended planting rate of 8 kg/rai. Therefore, further refinement of the seed metering mechanism is required to improve seeding accuracy and reduce seed usage.

4. Conclusions

1. The mung bean seeder was designed under the condition that it must be capable of seeding at a rate of not less than 8 kg/rai. The machine is intended for planting mung beans in sugarcane rows and is compatible with small tractors not exceeding 27 hp. The seeding process is controlled by a screw-type metering system. The main components of the seeder include a mounting frame, seed hopper, screw conveyor, 12-volt motor, and motor control unit.

2. The theoretical performance testing indicated that gear M3 was the most suitable at an engine speed of 1,300 rpm and a travel speed of 4.63 km/h, as it provided the highest theoretical field capacity. The field capacity values were relatively close, ranging from 1.85 to 1.90 rai/h. The seeding rate decreased within the range of 78.57 to 72.42 kg/rai, while the uniformity decreased from 8.53 to 1.12. The fuel consumption rate also decreased slightly, ranging from 2.18 to 2.11 L/h.

3. The field test results in sugarcane plots showed that, at gear M3 with an average travel speed of 4.63 km/h and a seeding unit rotational speed of 50 rpm, the theoretical time was 17.06 s, while the actual time was 101 s. The theoretical field capacity was 1.85 rai/h, and the actual field capacity was 1.77 rai/h, resulting in a field efficiency of 95.72%. The fuel consumption at gear M3 was approximately 10 mL with an operating time of 16.82 s, corresponding to a fuel consumption rate of 2.14 L/h.

5. Acknowledgements

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