Transactions of the TSME (2019) Vol. 7, No. 2, 112-121
Journal of Research and Applications in Mechanical Engineering

ISSN 2229-2152 print
DOI: 10.14456/jrame.2019.11

Research Article

EFFECT OF THE ORIENTATION OF THE RICE SEED SWIVEL DISC ON THE SEED CONSUMPTION RATE OF THE DRY PADDY FIELD SOWING MACHINE

S. Hemathulin[1]
T. Lasopha[1]
N. Pannucharoenwong[2,*]
P. Rattanadecho[2]
S. Echaroj[2]
A. Phongsavath[3]
[1] *Department of Mechanical and Industrial, Faculty of Industrial Technology, Rajabhat Sakon Nakhon University 47000, Thailand*
[2] *Department of Mechanical Engineering, Faculty of Engineering, Thammasat University 12120, Thailand*
[3] *Research Institute of Energy and Mines (RIEM), Ministry of Energy and Mines, Lao PDR*

Received 23 April 2019
Revised 7 June 2019
Accepted 10 June 2019

ABSTRACT:
This research article aims to study the effect of rice seed swivel disc's orientation on the seed consumption rate of the 150 cm x 120 cm x 100 cm dry rice sowing machine. The experiment was conducted at Tan kon village, Sawang Daen Din district, Sakon Nakhon province. Data was collected for 5 hours and the system was connected to a 24-hp tractor equipped with a 10 liters fuel tank for diesel oil. The distance between each consecutive rice drop was 25 cm x 25 cm. Two types of rice seed swivel disc were investigated including vertical and horizontal. The engine speed was varied at 1500, 2000 and 2500 rpm. Results demonstrated that horizontal-type machine required grain seed input of 8.3, 9.6 and 10.4 Kg/rai. For the vertical-type an average grain seed input 5.2, 6.5 and 7.4 Kg/rai was required. This study shows that the vertical rice seed swivel disc can save more rice seeds compared with the horizontal-type by 37.35%, 32.29% and 28.85%. Traditional farming costs 3,200 baht per rai. By using the rice seed swivel disc in the vertical axis of the dry rice sowing machine the cost of farming reduced to 1500 baht/rai. This was a 53.1% decrease in the cost of farming and the payback period was within 20 days.

Keywords: *Sowing machine, Dry paddy field, Rice seed swivel disc, Payback Periods*

1. INTRODUCTION

Thailand is an agricultural country where agriculture accounted for 34% of the population 93% of which have plantations in rural area. [1]. The most popular type of crops grown in Thailand is rice with 67 million rai of planting area for consumption and exports. This accounted for 11.3% of the total fertile area in Thailand. Most farmers use paddy-sown field technique to grow rice instead of creating transplanted rice. This is because the former technique is not as complicated and is less expensive compared with the latter technique. Currently, small tractors are employed instead of animal. However, the paddy-sown technique required excess seeds, excess fertilizer, the quality of rice produced is not sufficient and labor cost is high. Due to intensive competition in many countries, many agricultures are now converting from using paddy sown technique to rice sowing machines yielding higher yields per rai [2, 3]. In many countries, sowing machines are usually employed for rice seed that is dried up to 80% [4]. The process for sowing rice was developed for many different types of rice seed in order to improve yield [5, 6]. This is an important improvement given difficulty that arise from the shortage in labor force and the higher cost of labor [7]. In 2016, a

* Corresponding author: N. Pannucharoenwong
E-mail address: pnattado@engr.tu.ac.th

novel rotating dish have been developed and installed in a vertical-type sowing machine with 6 outlets. However, testing results suggested that there are many flaws regarding this type of sowing machine including uneven distribution of seeds and difficulty in controlling the speed of the sowing machine. Additional this type of sowing machine also required a worker to walk behind the machine, which can be a very exhausting task. Therefore, a four wheel-based vehicle was developed to improve productivity of the machine [8, 9]. The device can be driven in order to reduce the time required to work and increase operational efficiency. This is also because the rotational speed of the tractor can be easily controlled and it consisted of a shaft which support the transmission to the attached tool.

Currently, agriculturer in the Exquisite Farming Center at Tan Kao Village, Tan Kao Sub-district, Sawang Daen Din District, Sakon Nakhon Province, make rice paddies using dry rice sowing to assist in rice farming by using rice husk machines with a horizontal rice seed rotation which is attached to a 24-horsepower tractor. One major disadvantage to this technique is that rice grain derived is usually broken because of the compressing force due to the rotating plate. This also resulted in the reduction in germination of rice plants, productivity and increase in waste rice seed.

This research aimed to study the arrangement of rotating plate on the rate of seed loss from the sowing machine by comparing between horizontal and vertical type. The appropriate rotation speed to acquire the lower rate of seed loss is also investigated by connecting the sowing machine to a 24 hp tractor. The experiment was conducted by using the sowing machine in a 10 rai of dry rice field plot.

2. DESIGN

Three types of design for this research included design of a rotating plate for a dry field plot sowing machine, design of horizontal and vertical seed swivel disc sowing machine.

2.1 Design of seed swivel disc for dry paddy field sowing machine

In the design of the rotary plate, rice seed and rice husk drills, the computer-aided design program is designed in three dimensions with the Solid work program. The rice seed rotation plate is made of steel material with a diameter of 200 mm in thickness and 2 mm hole for inserting the shaft with a size of 25 mm. The design purpose is to increase the accuracy of rice seed drops down to the ground as shown in Fig. 1. By designing and installing the rice sowing machine with the size of 150 cm x 120 cm x 100 cm which can be seeded up to 7 times per row. The size of the distance between the row of rice drops and the distance between the rice plants is 25 cm x 25 cm. The sowing machine was connected with a 24-horsepower tractor and a power transmission shaft as shown in Fig. 5 designed a system connected to the power transmission shaft of the tractor to see all the components before actually creating the machine and doing next test.

2.2 Design of seed swivel disc horizontal

Designing the working mechanism of placing the plate, rotating the rice seed horizontally by allowing the rice seed to be on the top and flowing down to find the rice seed rotation which is placed horizontally. To fall into the rice seed pipeline which is made into a channel and flows down to the ground by using a mechanism from the movement of the tractor to relate to the speed of the engine and relative to the power transmission shaft system of the tractor by designing the rotation of the rice seed In this landscape, it is shown in Fig. 2. In application of the group suction holes suction, if the interval between the holes was less than the length of seeds, it was likely that one seed was sucked by two suction holes at the same time. Some researchers suggested that following equation be used to determine the interval. Finding the distance of the sowing hole on the horizontal sowing plate, using the Eq. (1) and finding the sowing pipe size using the Eq. (2) [10, 11].

$$D = (1.2 - 1.3)L \quad (1)$$

$$d = (0.64 - 0.66)k \quad (2)$$

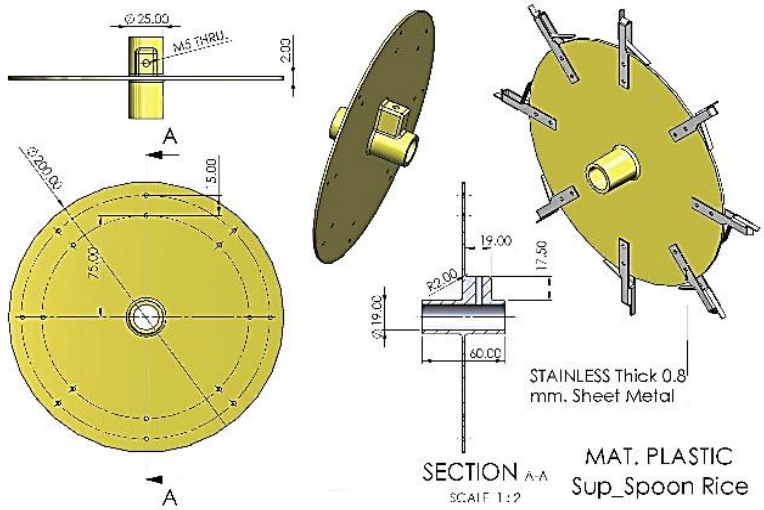

Fig. 1. Dimension of rice seed swivel disc

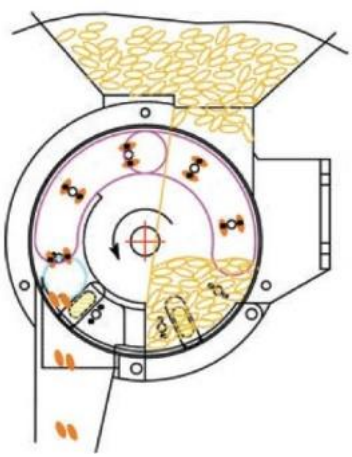

Fig. 2. Seed swivel disc horizontal [12]

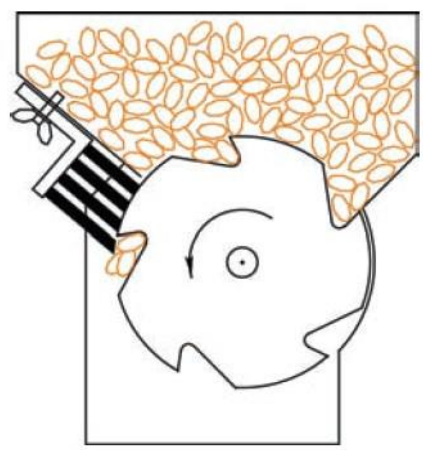

Fig. 3. Seed swivel disc vertical [13]

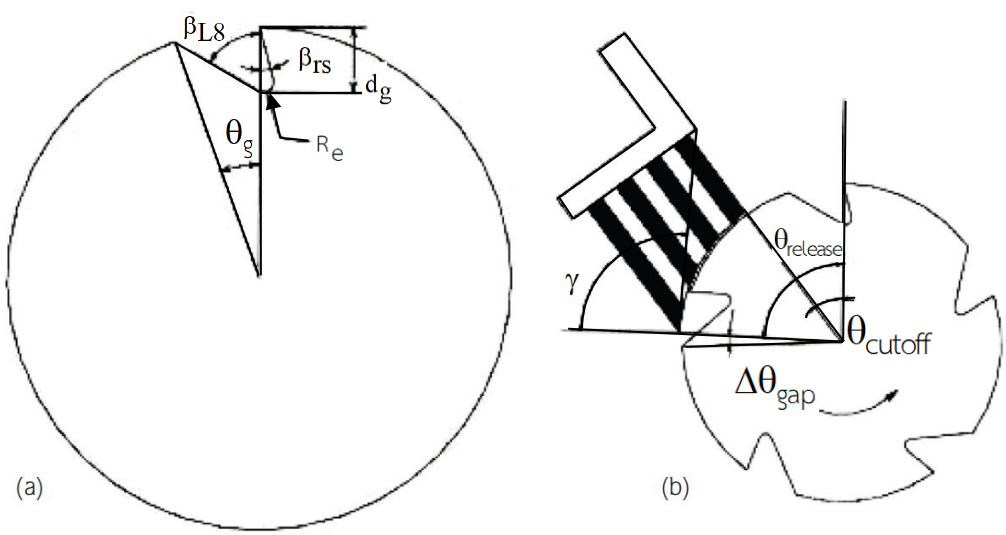

Fig. 4. a: Steep triangular-shaped groove (design variables) of seed metering device, b: Design variables of the brush of seed metering device [14]

2.3 Design of seed swivel disc vertical

The design of the working mechanism of the vertical rotation of the rice seed plate is shown in Fig. 3 by allowing the rice seed to be placed on top of the vertical rotating plate. The rice seed spoon will rotate and scoop the rice seed and send it. Grain seeds go down to the seed pipe which is made into the bottom channel and then flows into the ground and relies on the mechanism from the movement of the tractor in relation to the speed of the machine. The motor and associated with the transmission shaft of the tractor.

The vertical rotation plate design is very popular in Japan and Korea. [12-15] by calculating the values in Fig. 4, use the following formula as shown below.

$$\Delta\theta_{gap} = \sin^{-1}(2t_s / D) \tag{3}$$

$$n = 360D_{sc} / 100\theta_g \tag{4}$$

$$\theta_{release} = 1/2(270 + \theta_g - \beta_{ls} - \Delta\theta_{gap} - \phi_b - \phi_r) \tag{5}$$

$$\theta_{cutoff} < \frac{\theta_g}{2} + \theta_{sp} = \frac{\theta_g}{2} + (\phi_r - \beta_{ls} + 90) \tag{6}$$

$$\theta_{cutoff} = \theta_{release} - \theta_r \tag{7}$$

$$\theta_{fall} = \theta_{release} - (\theta_g - \Delta\theta_{gap}) \tag{8}$$

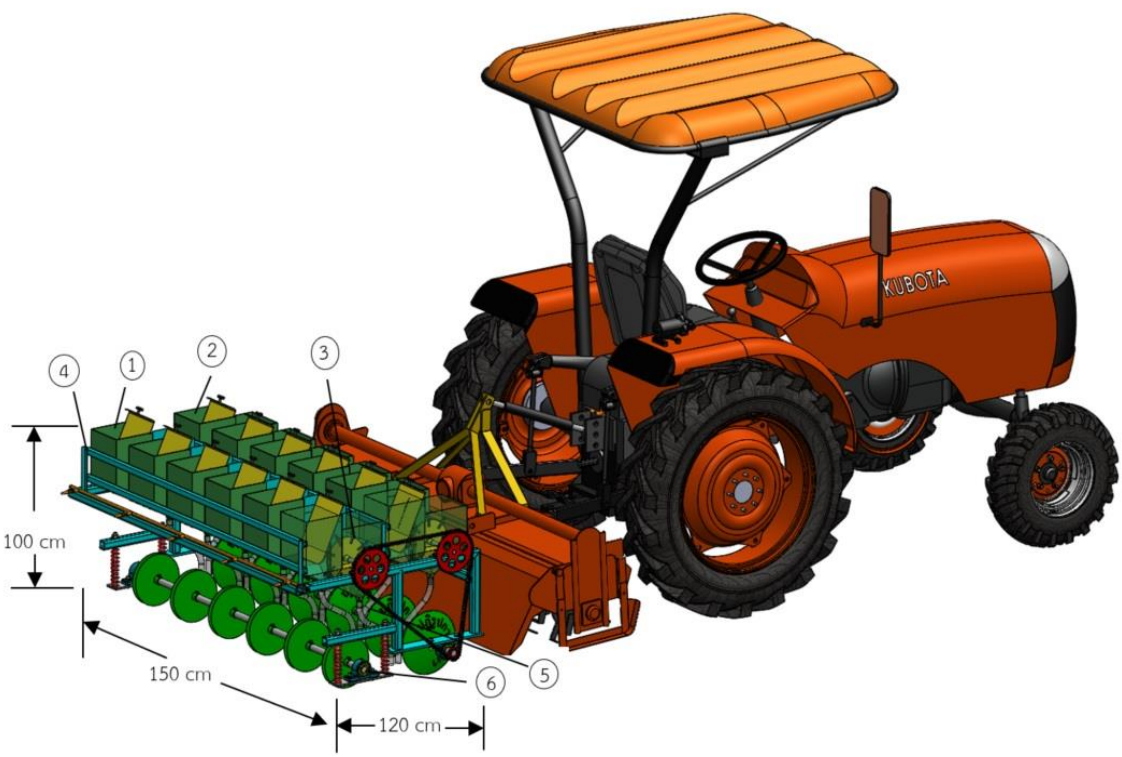

Fig. 5. Dry paddy field sowing machine part specification. 1. Seed box, 2. Fertilizer box, 3. Rice seed swivel disc, 4. Toolbar frame, 5. Seed delivery tube, 6. Depth control bar.

3. EXPERIMENTAL SETUP

3.1 Dry paddy field sowing machine set up

The components of the dry rice machine are shown in Fig. 5 with a size of 150 cm x 120 cm x 100 cm. Components 1. Seed box for storing rice seeds, 2. Fertilizer box for storing fertilizer, 3. Rice seed swivel disc for grain transport Rice varieties, 4. Toolbar frame of sowing machines, 5.Seed delivery tube for conveying seeds into the drop hole and 6. Depth control bar used to adjust the depth of rice seed drops.

The installation of the horizontal grain rotation plate is shown in Fig. 6 and the vertical grain rotation plate is installed, shown in Fig. 7 and attached to all equipment with a 24 horse power tractor. 7 rows each. Test the actual work in Tan Kao Village, Tan Kao Sub-district, Sawang Daen Din District, Sakon Nakhon Province 10 Rai. Replications test 5 times. Rice Varieties Used in Experiments Khao Dawk Mali 105 varieties before the seed drop test must be prepared in the plots that are to be used for testing by plowing and hitting the soil. Takes 5 hours to test and using a total of 10 liters of diesel fuel, the distance of 25 cm x 25 cm Fig. 8, the speed of the engine is 1,500 rpm, 2,000 rpm, and 2,500 rpm. 2 and 3 testing processes are shown in Fig. 8. The test procedure is shown in Fig. 9 and the results of the experiment are recorded. Seeding rate per average hole and the rate of seed use on the average area and comparing the results of experiments with research that had previously been [16]. Which can summarize the conditions of the test in Table. 1.

Table 1: Experimental condition

Parameter	Test condition	Unit
1. Total area	10	rai
2. Time to test	5	Hour
3. Total fuel	10	Liter
4. Engine speed	1500, 2000, 2500	rpm
5. Gear ratio	1, 2, 3	-
6. Weight	720	Kilogram
7. Replications test	5	-

Fig. 6. Seed swivel disc horizontal

Fig. 7. Prototype of seed swivel disc vertical connect to sowing machine

Fig. 8. Experimental spacing 25 cm x 25 cm

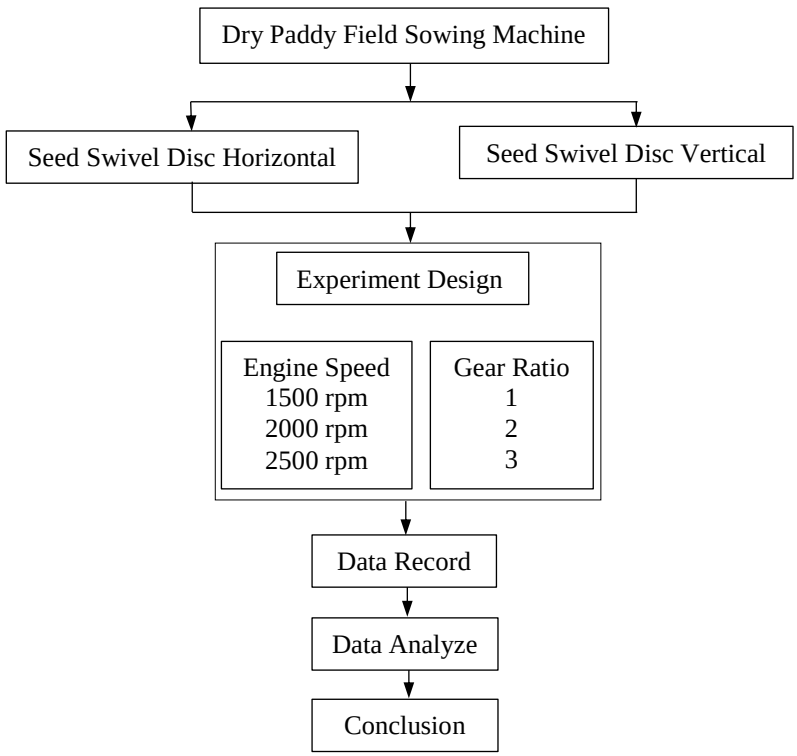

Fig. 9. Experiment Methods

3.2 Payback period

Payback period is an analysis of the amount of time that can be returned when compare with the cost of the cost [17]. The calculation method from the Eq. (9) which will be used to calculate the payback period of the dry rice dropper used in this test.

$$\text{Payback period} = \frac{\text{Cost}}{\text{Return on investment}} \tag{9}$$

Table 2: Seed rate per hill and per area as affected by engine speed and gear for Seed swivel disc horizontal

Engine speed (rpm)	Gear	Mass (kg)	Time (h)	Range number of seeds per hole (seed)	Average rice use (Kg/rai)	Average rice use (Kg/rai) [2]
1500	1	720	5	7-9	8.3	9.2
2000	1	720	5	8-10	9.4	10.3
2500	1	720	5	9-11	10.2	11.5
1500	2	720	5	8-10	9.6	10.3
2000	2	720	5	9-11	10.7	11.4
2500	2	720	5	10-12	11.6	12.7
1500	3	720	5	9-11	10.4	11.6
2000	3	720	5	10-12	11.8	12.8
2500	3	720	5	11-13	12.9	13.7

Table 3: Seed rate per hill and per area as affected by engine speed and gear for seed swivel disc vertical

Engine speed (rpm)	Gear	Mass (kg)	Time (h)	Range number of seeds per hole (seed)	Average rice use (Kg/rai)	Average rice use (Kg/rai) [2]
1500	1	720	5	4-6	5.2	6.4
2000	1	720	5	5-7	6.3	7.6
2500	1	720	5	6-8	7.6	8.7
1500	2	720	5	5-7	6.5	7.2
2000	2	720	5	6-8	7.8	8.5
2500	2	720	5	7-9	8.7	9.7
1500	3	720	5	6-8	7.4	8.7
2000	3	720	5	7-9	8.5	9.8
2500	3	720	5	8-10	9.7	10.8

Table 4: Cost of rice planting compared among many methods [18]

Employment	Cost (Baht/rai)			
	sow hand	Sprayed with machine	general sowing	dry paddy field sowing machine with seed swivel disc vertical
Soil Preparation	500	500	500	300
Spin soil	500	500	500	250
Sow	500	300	300	
Seed value	900 (30 Kg/rai)	600 (20 Kg/rai)	450 (15 Kg/rai)	150 (5 Kg/rai)
Fertilize+ Spray insecticide	800	800	800	800
Total	3,200	2,700	2,055	1,500

4. Results and Discussion

4.1 Result of swivel disc horizontal

The results of the experiment of rice seeding by placing the horizontal rice seed rotation plate are shown in Table. 2 When the result is converted into a graph shown in Fig. 10, the results of the rice seed drop experiment When using 1st gear to drive a tractor at a speed of 1500 rpm, 2000 rpm and 2500 rpm, the range number of seeds per hole 7-9 seeds, 8-10 seeds and 9-11 seeds, average seed use 8.3 Kg / rai , 9.4 Kg / rai and 10.2 Kg / rai, which the average amount of rice seed per hole increases with increasing speed. This is due to the increase in rotational speed of the grain seed plate which cause the output of grain seed into the plantation hole to increase. And the use of average rice seed per rai is increasing. When using 2nd gear to drive a tractor at a speed of 1500 rpm, 2000 rpm and 2500 rpm, the range number of seeds per hole 8-10 seeds, 9-11 seeds and 10-12 seeds. Average seeds are 9.6 Kg / rai, 10.7 Kg / rai and 11.6 Kg / rai and when using 3rd gear to drive the tractor at a speed of 1500 rpm, 2000 rpm and 2500 rpm. The range number of seeds per hole 9-11 seeds, 10-12 seeds and 11-13 seeds were used. The average seeds were 10.4 Kg / rai, 11.8 Kg / rai and 12.9 Kg / rai, which was the highest in this experiment. Compare with research [2] at a speed of 1500 rpm using gear 1. It is found that the average seed use in this experiment is less than that of seed saving 9.78%.

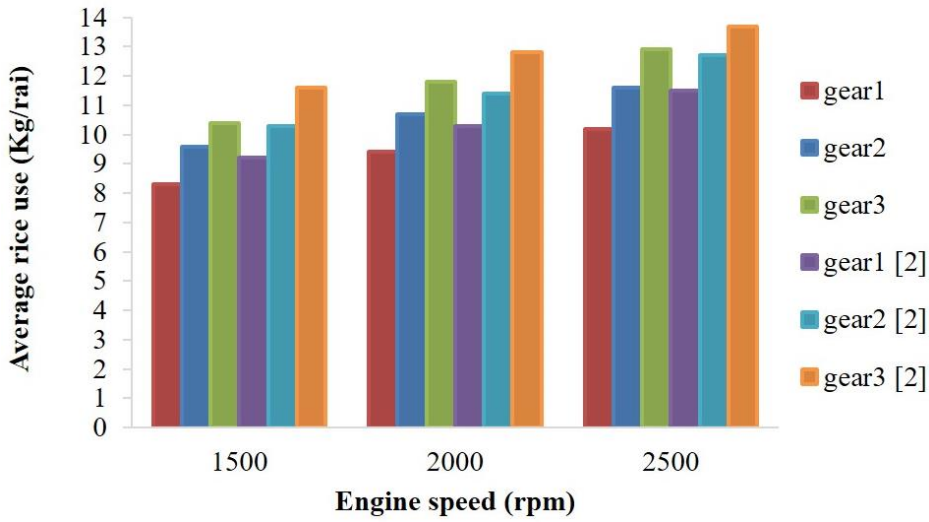

Fig. 10. Average rice use by engine speed and gear for seed swivel disc horizontal

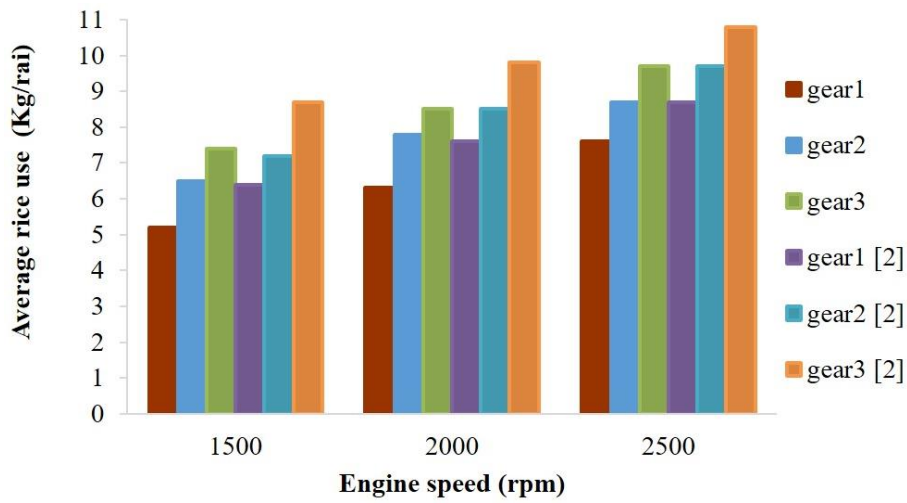

Fig. 11. Average rice use by engine speed and gear for seed swivel disc vertical

4.2 Result of swivel disc vertical

The results of the experiment of rice seeding by placing the vertical grain rotation plate shown in Table 3. When the result is converted to graph shown in Fig. 11, the results of the rice seed drop experiment when changing the speed of the engine at the ratio of the gear has a constant value. It is found that when using 1st gear to drive a tractor at a speed of 1500 rpm, 2000 rpm and 2500 rpm, the range number of seeds per hole 4-6 seeds, 5-7 seeds and 6-8 seeds are used. The average seed 5.2 Kg / rai, 6.3 Kg / rai and 7.6 Kg / rai which gave the average amount of rice seed per hole increases with increasing speed. Because the seed swivel disc rotates faster according to the increasing cycle and send more seeds to the hole. And the use of average rice seed per rai is increasing. When using the 2nd gear to drive the tractor at a speed of 1500 rpm, 2000 rpm and 2500 rpm, the range number of seeds per hole 5-7 seeds, 6-8 seeds and 7-9 seeds. The average seed is 6.5 Kg / rai, 7.8 Kg / rai and 8.7 Kg / rai and when using 3rd gear to drive the tractor at a speed of 1500 rpm, 2000 rpm and 2500 rpm, the range number of seeds per hole 6-8 seeds, 7-9 seeds and 8-10 seeds. The average seed is 7.4 Kg / rai, 8.5 Kg / rai and 9.7 Kg / rai and when compared with research [2] at a speed of 1500 rpm using gear 1, it is found that the average seed use in this experiment is less than that of seed saving 18.75 %.

4.3 Compare the cost of farming

In Table 4 shown the comparison of the cost of farming in each type. Hand-fed rice farming cost 3,200 baht / rai. The spraying with the grain sprayer cost 2,700 baht / rai. The general rice drills cost 2,055 baht / rai [17]. And the use of dry paddy field sowing machine with seed swivel disc vertical, soil preparation 300 baht / rai, spin soil and sow 250 baht / rai, seed value 150 baht / rai and fertilize spray insecticide 800 baht / rai. Total costing 1,500 baht / rai.

4.4 Payback period analysis

Engineering economic analysis by considering the price of the master machine. The total construction cost was 100,000 baht, using 1 operator person, working capacity of the machine was 10 rai / day, and rice drops service cost 500 baht / rai. The payback is 20 days after the machine was hired for delivery of grain seed into plantation site excluding the seed fee.

5. CONCLUSION

From the 10 rai rice drop experiment, it takes 5 hours to attach the machine to the 24-horsepower compact tractors, using 10 liters of diesel oil. Placing the horizontal rice seed roll using the average grain seed when using the speed of 1500 rpm, 2000 rpm and 2500 rpm, using the average seed 8.3 Kg / rai, 9.4 Kg / rai and 10.2 Kg / rai. The vertical grain rotation plate used the average seed size 5.2 Kg / rai, 6.5 Kg / rai and 7.4 Kg / rai can save rice seeds better than horizontal, accounting for 37.35%, 32.29% and 28.85%, and in this test, the optimum speed of sowing by using the lowest average seed grain is 1500 rpm. Cost of farming the original cost of 3,200 baht per rai. The cost of rice farming by using dry rice sowing machine cost 1,500 baht per rai. This is a cost reduction of 53.13% and can pay back on using the machine. The grain store within 20 days.

ACKNOWLEDGEMENT

This research would like to thank the elaboration from Exquisite Farming Center at Tan Kao Village, Tan Kao Sub-district, Sawang Daen Din District, Sakon Nakhon Province, which provides support for testing and consulting facilities until the research was successful. Thanks to the Department of Mechanical and Industrial Faculty of Industrial Technology Sakon Nakhon Rajabhat University and the Department of Mechanical Engineering Faculty of Engineering Thammasat University. That provides support throughout the research project.

NOMENCLATURE

D	distance between the holes, mm
L	the length of the seeds, mm
d	the diameter of the suction hole, mm
k	the thickness of the seed, mm
$\Delta\theta_{gap}$	Gap angle. It is defined as an angle between the lines connecting the lower ends of the brush and groove with the center of the roller, when seeds are released from the groove
t_s	Thickness of the seed, mm
D	Diameter of the roller, mm
n	Number of grooves
D_{SC}	Desired degree of scattering (%)
$\theta_{release}$	Release angle. It is defined as an angle between the vertical and the line connecting the lower end of the brush and the center of the roller
θ_g	The open angle of groove. It is defined as an angle between the 2 straight lines connecting the starting and final points of the groove and the center of the roller, respectively.
β_{ls}	The left side angle of the groove. It affects time delay between the seeds dropped successively from the grooves.
β_{rs}	The right-side angle of the groove. This angle determines the seed-holding capacity and the loading process of the groove.
R_e	Denotes radius of the curvature of groove bottom. Round groove bottom prevents seeds or other substances from clinging to the bottom.
θ_{cutoff}	Cutoff angle. It is defined as an angle between the upper surface of the brush and the vertical.

γ Contact angle of brush. It is defined as an angle between the tangent to the surface of the roller and the horizontal at the seed release point.

θ_{fall} 90° position or 99° from the vertical line.

ϕ_b Friction angles between the brush and seed.

ϕ_r Friction angles between the groove and seed.

REFERENCES

[1] Nattadon, P., Atichit, W., Chatchai, B., Jarinee, J. and Ponthep, V. Comparison of bio-methane gas wobbe index in different animal manure substrate, Energy Procedia, Vol. 138, 2017, pp. 273-277.

[2] Ali abdalla, A., Misra, A.N. and El- Azeem, S. Effect of leaf cutting on physiological traits and yield of two rice cultivars, African Journal of Plant Science, Vol. 2(12), 2008, pp. 147-150.

[3] Konboon, Y., Sripodok, S. and S, Rattannasriwong. Rice leaf cutting in Dry-seed broad casting rice, paper presented in Rice and temperate cereal crops annual conference 2007, Bangkok, Thailand.

[4] Fu, W., Zhang, Z., Zang, Y., Luo, X., Zeng, S. and Wang, Z. Development and experiment of rice hill-drop drilling machine for dry land based on proportional speed regulation, International Journal of Agricultural and Biological Engineering, Vol. 10(4), 2017, pp. 77-86.

[5] Roshan, V.M., Gajanan, P.T. and Swapnil, K.A. Design and implementation of multi seed sowing machine, International Journal of Mechanical Engineering and Robotics Research, Vol. 2(4), 2013, pp. 422-429.

[6] Kalay, K., Moses, S.C. and Kumar, A. The design and fabrication of a manually operated single row multi - crops planter, Journal of Agriculture and Veterinary Science, Vol. 8(10), 2015, pp. 147-158.

[7] Minghua, Z., Zaiman, W., Xiwen, L., Ying, Z., Wenwu, Y., He X., Baolong, W. and Yizheng, D. Review of precision rice hill-drop drilling technology and machine for Paddy, International Journal of Agricultural and Biological Engineering, Vol. 11(3), 2018, pp. 1 -11.

[8] Haque, M.E. and Bell, R.W. Development of machinery for smallholders in South and South East Asia, paper presented in Workshop on Modern Conservation Farming Systems and CIMMYT Science Week 2015, Lanzhou, China.

[9] Pananda, N., Daowiangkan, S., Intaphrom, N. and Kantapam, W. Influence of shock absorber installation angle to automotive vehicle response, Journal of Research and Applications in Mechanical Engineering, Vol. 5(2), 2017, pp. 94-105.

[10] Xing, H., Zang, Y., Wang, Z.M., Luo, X.W., Zhang, G.Z. and Cao, X.M. Design and experiment of stratified seed-filling room on rice pneumatic metering device, Transactions of the Chinese Society of Agricultural Engineering, Vol. 31(4), 2015, pp. 42-48.

[11] Zang, Y., Xing, H., Wang, Z.M., Luo, X.W., Cao, X.M. and Wang, B.L. Design and experiment of shield device on rice pneumatic metering device, Transactions of the Chinese Society of Agricultural Engineering, Vol. 46(5), 2015, pp. 33-38.

[13] Ryu, I.H. and Kim, K.U. Design of roller type metering device for precision planting, American Society of Agricultural and Biological Engineers, Vol. 41(4), 2013, pp. 923-930.

[14] Yoo, S.N., Choi, Y.S. and Suh, S.R. Development of a precision seed metering device for direct seeding of rice, Journal of Biosystems Engineering, Vol. 30(5), 2005, pp. 261-267.

[15] Ebrahim, A., Hamid, R.G., Mohammad, M. and Kyeong, U.K. Development of a precision seed drill for oilseed rape, Turkish Journal of Agriculture and Forestry, Vol. 35(5), 2008, pp. 451-458.

[16] Enamul, H., Richard W. Bell, Amir, K. and Nur Nobi, M. Versatile strip seed drill: A 2-wheel tractor-based option for smallholders to implement conservation agriculture in Asia and Africa, Environments, Vol.3(1), 2016, pp. 1-13.

[17] Thatphong, A. and Patcharin, S. Economic worthiness of organic vegetable business by using earthworm compost, RMUTL Journal of Humanities and Social Sciences, Vol. 3(2), 2015, pp. 99-105.

[18] Department of Foreign Trade, Thailand, 2018. Statistic Data, URL: http://www.dft.go.th, access on 10/03/2019.