

Design and Fabrication of Tobacco Leaf-stripping Machine to Enhance Economic Production of Farmers in Phetchabun Province

Saksirichai Srisawad^{1,*}, Thongchai Khrueaphue¹, Suwimon Thaikthum²

¹Program in Production Technology, Faculty of Agricultural and Industrial Technology, Phetchabun Rajabhat University, Amphoe Mueang Phetchabun, Phetchabun, 67000 Thailand.

²Program in Production and Management Engineering, Faculty of Agricultural and Industrial Technology, Phetchabun Rajabhat University, Amphoe Mueang Phetchabun, Phetchabun, 67000 Thailand.

*Corresponding Author: Seksunsek@pcru.ac.th

Received: 07 April 2020; Revised: 26 June 2020; Accepted: 30 June 2020; Available online: 1 September 2020

Abstract

The objective of this work is to design and fabricate tobacco leaf-stripping machine to enhance economic production of farmers in Phetchabun province. The evaluation score and acceptance level of the machine design was 4.46 ± 0.88 and agree, respectively. The evaluation score of the machine after use was 4.53 ± 0.86 which the acceptance was in the level of totally agree. In this research, tobacco leaves with 400 – 420 mm, 421 – 440 mm and 441 – 460 mm lengths were tested with the machine at speed of 50 rpm, 100 rpm and 150 rpm. The results showed that the machine set at 100 rpm gave the best leaf appearance. While the leaves were widely damaged at 50 and 150 rpm. The comparison of tobacco leaf-stripping between traditional method (manual stripping) and the machine was also investigated. The machine gave higher production rate and better leave appearance compared to traditional method. At 100 rpm, 56 leaves out of 60 leaves was in a good appearance. However, calculation of economic production was based on 500 kg of tobacco leaf. Operation time of traditional method was 6.2 h per day while this tobacco leaf-stripping machine was 3.9 h per day. The reduction of manpower and working time was observed. The manpower and working time were reduced from 5 – 8 people per day to 3 – 5 people per day and 4 – 6 h per day to 2 – 4 h per day, respectively.

Keywords: Tobacco Leaf-stripping Machine; Economic Production Enhancement; Tobacco Farmers of Phetchabun Province.

©2020 Sakon Nakhon Rajabhat University reserved

1. Introduction

Phetchabun province is located in northern part of central Thailand region. This area is suitable for agricultural cultivation. The agricultural products lead to 33.33% of farmers income or more than 8,849.064 million Baht [1]. The popular agricultural products are vegetable, sugarcane, tapioca as well as tobacco. According to Tobacco Authority, cultivation of tobacco is one of the major incomes of 6,091 farmers in Phetchabun province. The production rate is 19,860,839 kg per year or 800 – 1,000 million baht per year. An increase of export value which is 1,500 million Baht to 2,800 million Baht [2]. Moreover, the survey showed that tobacco is able to cultivate for whole year and is main income of farmers. Nowadays tobacco cultivation in Phetchabun is divided into 2 types which are inserted stem method and shear stem method [3]. The most popular method is shear stem method (Fig. 1) which price per kilogram is higher. However, traditional method for tobacco leaf

stripping is labor intensive [4] and some tobacco leaves are transversely tear apart as shown in Fig. 2 which leads to a reduction of selling price [5].

Therefore, tobacco leaf-stripping machine has been invented to increase production efficiency, reduce lab our and waste, increase production speed. The technology is designed to serve targeted user. It helps increase economic security especially in the topic of agricultural management as a quote of University for local development. The key is scientific knowledge and technology is applied to enhance production efficiency of farmers [6]. This research team had an idea to invent and transfer tobacco leaf-stripping machine for adding value of economic for Phetchabun farmers. This research aims to study of performance of the machine, increasing of economic value and satisfactory evaluation of user.



Fig. 1 Complete tobacco shred. **Fig. 2** Tearing the tobacco leaf transverse.

2. Materials and methods

Design of tobacco leaf-stripping machine.

Design of machine frame was shown in Fig. 3. The frame was assembled by welding 25 mm angle steel with the thickness of 3 mm and 3 mm flat steel. After that 7.86 mm hole grating plate was assembled to the frame as a cooling system and restudies container [3].

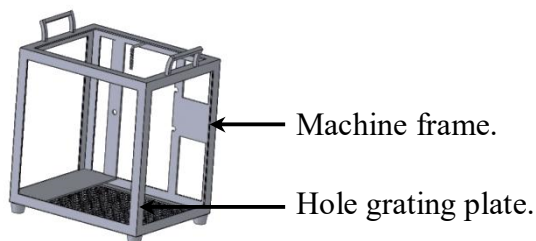


Fig. 3 Machine structure design.

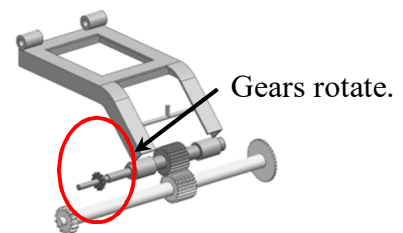


Fig. 4 Design of tobacco leaf pull set.

Fig. 4 shows design of puller system. It consists of 2 pieces of 60 mm gears which the distance is set at 5 mm. The gears rotate in the same direction. They are responsible for pulling the tobacco stem out of leaves (Ellipse).

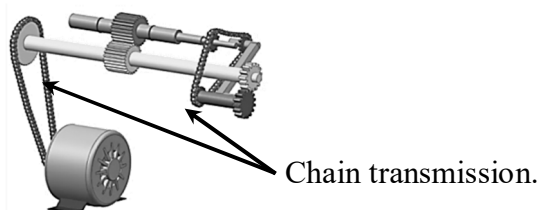


Fig. 5 Power transmission system.

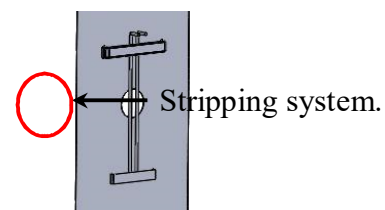


Fig. 6 Design of tobacco leaf tearing system.

A chain transmission method was selected to use in a design of the power transmission system (Fig. 5) to drive the puller system. A motor of $\frac{1}{4}$ horsepower gear was selected to control the power during operation. The maximum rpm was at 300 rpm. The rpm was able to control via inverter according to experimental variable.

Design of stripping system is for separation of leaf and stem (Fig. 6). It consists of metal plate with 30 mm hold and 2 stainless steel blades with 5 mm distance (Ellipse) [3].

Design of tobacco stem outlet shows in Fig 7. This angle of outlet was set at 62° which was the suitable angle to prevent damage of tobacco stem.

Design of control panel (Fig. 8) is one of the most important due to vibration during operation. Therefore, vibration absorbing material was equipped with electronic circuit board which is for control of motor speed by inverter [3].

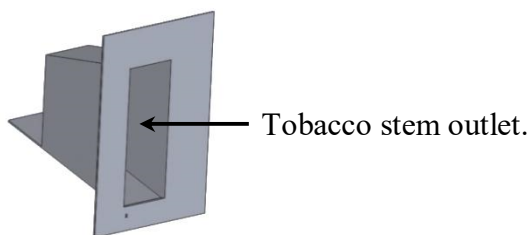


Fig. 7 Design of the tobacco stem outlet.

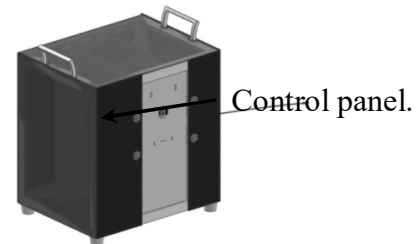


Fig. 8 Control unit design.

Fabrication of tobacco leaf-stripping machine.

Fig. 9 shows fabrication of tobacco leaf-stripping machine. The objective of this design aims at economic cost saving for farmers who is going to invest in this machine. The machine was made of easy to find and inexpensive materials. The machine was designed to be uncomplicated, easy maintenance [3], durable and safety. Dimension and weight of the machine were $400 \times 450 \times 310$ mm and 16.59 kg, respectively. The structure was designed to be portable and light weight in square shape and assembled with angle steel, acrylic sheet with a thickness of 5 mm and 4 wheels.

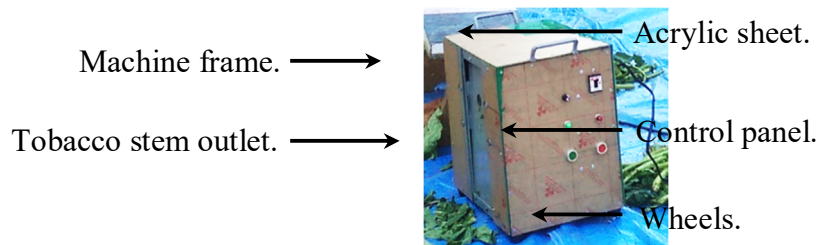


Fig. 9 The invention of tobacco shredder.

Experimental variables and methods.

Three different length of tobacco leaves that farmers normally sell was studied. The length was 400 – 420 mm, 421 – 440 mm and 441 – 460 mm. (The length that the farmers sell in 3 types). The leaves were fresh and harvested less than 1 – 2 days. The testers were 3 male and 3 female tobacco farmers. Each variable was investigated using 10 tobacco leaves per farmer. The experiment was performed at the speed of 50, 100 and 150 rpm (The speed was from preliminary study, which can be used to tear the tobacco stems at 50 – 150 rpm, so the speed, minimum, maximum and medium values are selected). The average result was at least 80% of completeness (The experiment on extracting tobacco leaves from 60 variables in each variable requires not less than 80% of the complete tobacco

leaves). The design of machine was evaluated. The efficiency of machine was evaluated. The technology was transferred to 32 farmers in Phetchabun province. All data of survey and machine evaluation was analysed and reported in average, standard deviation following criteria. The criteria of acceptance were separated into 5 levels which were 1.00 – 1.50 rarely agree, 1.51 – 2.50 slightly agree, 2.51 – 3.50 moderated agree, 3.51 – 4.50 almost agree, 4.51 – 5.00 totally agree [3].

3. Results and Discussion

Evaluation of design of tobacco leaf-stripping machine.

The evaluation was performed by 5 experts consisting of 3 assistant professors who expert in industrial engineering (3 experts) and 2 famers who expert in agricultural machine. The evaluation results were shown in Table 1.

Table 1 Results of evaluation of tobacco leaf shredder designs.

Assessment Details.	(\bar{x})	(S.D.)	Conclusion
Design the size of the machine. Structure.	4.40	0.90	Accept
Design of tobacco leaf pull set.	4.20	0.91	Accept
The design of the power transmission.	4.60	0.80	Accept
Design of tobacco leaf tearing set.	4.30	0.85	Accept
The design of the tobacco stem.	4.80	0.93	Accept
Design of operation control circuits.	4.50	0.89	Accept
Average.	4.46	0.88	Accept

Evaluation of tobacco leaf-striping machine design was performed by the experts using 6 items of IOC (Index of item objective congruence) is the accuracy of the questionnaire or the corresponding value between the question and the purpose. It was reported in average and standard deviation. The results showed that average of evaluation score was 4.46 ± 0.88 which was in the level of totally agree due to the design of structure, power transmission and striping systems was appropriate [3].

Efficiency evaluation of tobacco leaf-stripping machine.

The evaluation was performed by famers who experts in tobacco cultivation in Phetchabun province. Fresh tobacco leaves harvested less than 1 – 2 days were used in this study. Because dried leaves were fragile [7] and leaves kept in sacks for more than 1 – 2 days were moist and deteriorated due to heat. Both type of tobacco leaves was not suitable for this study (Table 2). The experts were 3 male and 3 female tobacco farmers. The age was in the range of 20 – 35 years and 36 – 50 years. The experience was in the range of 6 – 10 years and 11 – 15 years. The evaluation was performed using 8 items of IOC (Index of item objective congruence). The results showed that average of evaluation score was 4.53 ± 0.86 which was in the level of totally agree due to the machine had high efficiency and met the requirements of farmers [3].

Table 2 Results of finding efficiency of tobacco leaf shredder.

Comments.	(\bar{x})	(S.D.)	Summary
In terms of maintenance.	4.60	0.80	Accept
Strength.	4.83	0.93	Accept
The machine size is appropriate.	4.40	0.84	Accept
Ease of moving.	4.60	0.80	Accept
Ease of work.	4.40	0.84	Accept
Safety at work.	4.39	0.88	Accept
In terms of economic construction costs.	4.80	0.93	Accept
Value for money.	4.28	0.91	Accept
Average.	4.53	0.86	Accept

Results of stem leaf extraction experiments.

For 400 – 420 mm length tobacco leaves (Table 3), the experiment was performed by 6 farmers (3 male and 3 female farmers). The speed was set at 50, 100 and 150 rpm. 10 tobacco leaves were studied in each experiment [3]. The results showed that tobacco leaves had highest quality at 100 rpm. 55 out of 60 leaves was in good appearance which accounted for 91.66%. While the leaves were tear apart at 50 and 150 rpm as shown in Fig. 10 and Fig. 11 [5].

**Fig. 10** Demolition of tobacco leaves. **Fig. 11** Transverse tear of the leaves.**Table 3** Results of experiments pulling tobacco leaves, length 400 – 420 mm.

The person who	Speed (rpm)		
	50	100	150
1	6/10	9/10	4/10
2	9/10	8/10	6/10
3	5/10	9/10	5/10
4	6/10	10/10	6/10
5	7/10	9/10	9/10
6	7/10	10/10	6/10
Number	40/60	55/60	36/60
Percentage	66.66	91.66	60

Note: XX / XX is the completion / Number of tobacco leaves.

Table 4 Results of experiments pulling tobacco leaves with a length of 421 – 440 mm.

The person who	Speed (rpm)		
	50	100	150
1	8/10	9/10	6/10
2	6/10	10/10	5/10
3	8/10	9/10	7/10
4	7/10	9/10	6/10
5	7/10	10/10	7/10
6	5/10	9/10	7/10
Number	41/60	56/60	38/60
Percentage	68.33	93.33	63.33

Note: XX / XX is the completion / Number of tobacco leaves.

For 421 – 440 mm length tobacco leaves (Table 4), the experiment was performed by 6 farmers (3 male and 3 female farmers). The speed was set at 50, 100 and 150 rpm. 10 tobacco leaves were studied in each experiment. The results showed that tobacco leaves had highest quality at 100 rpm. 56 out of 60 leaves was in good appearance which accounted for 93.33%. 68.33% and 63.33% of tobacco leaves undergone the motor speed of 50 and 150 rpm were torn apart. Both tobacco leaves undergone 50 and 150 rpm was lower than the standard [8].

For 441 – 460 mm length tobacco leaves (Table 5), the experiment was studied at different motor speed which were 50, 100 and 150 rpm. It was performed by 6 farmers (3 male and 3 female farmers). 10 tobacco leaves were studied in each experiment. The results showed that tobacco leaves had highest quality at 100 rpm. 90% of tobacco leaves was in a good quality (54 out of 60) [4].

Table 5 Results of experiments pulling tobacco leaves, length 441 – 460 mm.

The person who	Speed (rpm)		
	50	100	150
1	5/10	9/10	7/10
2	8/10	9/10	7/10
3	8/10	9/10	5/10
4	6/10	10/10	8/10
5	7/10	9/10	5/10
6	4/10	8/10	4/10
Number	38/60	54/60	36/60
Percentage	63.33	90	60

Note: XX / XX is the completion / Number of tobacco leaves.

Comparison between traditional method (stripping by hand) and tobacco leaf-stripping machine was investigated. 300 – 500 kg of tobacco leaves was process per day. Traditional method was lab our intensive and required 4 – 6 h per day leads to quality of products following economic [9].

Table 6 The results of the experiment on work duration.

The person who	Normal way The farmer	Speed (rpm)		
		50	100	150
1	69 : 6	52 : 8	50 : 9	48 : 6
2	85 : 5	49 : 6	45 : 10	43 : 5
3	73 : 6	50 : 8	48 : 9	42 : 7
4	78 : 6	48 : 7	46 : 9	45 : 6
5	68 : 5	50 : 7	45 : 10	44 : 7
6	80 : 7	49 : 5	47 : 9	43 : 7
Number	453 : 35	298 : 41	281 : 56	265 : 38
Percentage	58.33	68.33	93.33	63.33

Note: XX: XX is the time (seconds): Completion.

Comparison of working time between tobacco leaf-stripping machine and traditional method (Table 6). The experiment was studied at different motor speed which were 50, 100 and 150 rpm. It was performed by 6 farmers (3 male and 3 female farmers). 10 tobacco leaves were studied in each experiment. The results showed that the machine gave faster production rate and good quality leaves compared to traditional method. However, tobacco leaves had highest quality at 100 rpm. 93.33% of tobacco leaves was in a good quality (56 out of 60). The working time was 281 s. 58.33% of tobacco leaves treated by the traditional method was in a good quality (35 out of 60). The working time was 453 s [4].

Therefore breakeven rate was evaluated by calculation of 10 kilogram of 50 – 60 tobacco leaves. At the best speed (100 rpm), working time was 281 s or 4.68 min for 60 tobacco leaves. While working time of traditional method was 453 s or 7.55 min. Based on 500 kg of tobacco leaves, working time of tobacco leaf-stripping machine was 3.9 h per day. And working time of traditional method was at least 6.2 h per day because of fatigue worker [9].

Technology transfer of tobacco leaf-stripping machine.

The technology of tobacco leaf-stripping machine was transferred to farmers in Phetchabun province which consists of 32 participants (22 female and 10 male). All participants age was in the range of 20 – 50 years and had an experience on tobacco cultivation and processing for 6 – 15 years [10]. Evaluation of technology transfer (Table 7). The results showed that overall score was 4.11 ± 0.66 which was in the level of high [11]. Average satisfaction score was the highest (4.33 ± 0.67) compared to others. However, knowledge and understanding score was the lowest (3.96 ± 0.63) [8].

Table 7 Evaluation results from the transfer of tobacco shredder technology of agricultural groups in Phetchabun Province.

Assessment Details.	(\bar{x})	(S.D.)	Conclusion
In the process of transferring knowledge.			
Knowledgeable team of speakers And direct experience with demonstration training.	4.28	0.58	Accept
Techniques for transferring knowledge from speakers are easy to understand for farmers.	4.13	0.71	Accept
Ability to explain Answering questions from the speakers.	4.13	0.66	Accept
The media used for transferring various knowledge and suitable for the topic of the training.	4.25	0.62	Accept
Duration of demonstration training.	4.06	0.76	Accept
Average	4.17	0.67	Accept
Knowledge and understanding			
Knowledge before attending demonstration training About the medicine stalk.	3.88	0.61	Accept
Knowledge after participating in demonstration training About the medicine stalk.	4.03	0.65	Accept
Average	3.96	0.63	Accept
In terms of utilization			
You can apply knowledge and technology to apply in everyday life.	3.97	0.74	Accept
You can transfer the knowledge and technology that has been demonstrated to the training.	3.97	0.65	Accept
Average	3.97	0.70	Accept
Satisfaction			
You are interested in owning a medicine shredder.	4.41	0.71	Accept
You are satisfied with the technology transfer project and project activities.	4.25	0.62	Accept
Average	4.33	0.67	Accept
Average total	4.11	0.66	Accept

4. Conclusion

Evaluation of tobacco leaf-stripping machine design showed that average of evaluation score was 4.46 ± 0.88 which was in the level of totally agree due. The evaluation of tobacco leaf-stripping machine the results showed that average of evaluation score was 4.53 ± 0.86 which was in the level of good. After technology transfer of tobacco leaf-stripping machine, income of farmer who has used the machine was increased. An increase in price of processed tobacco leaves was observed. It was increased from 950 – 1,100 baht per sack to 1,200 – 1,500 baht per sack (10 kilogram per sack) due to better quality of tobacco leaves. The machine also reduce amount of workers, normally requires 5 – 8 workers per day, on average working 4 – 6 h per day, which currently reduces the labor to only 3 – 5 workers per day and can reduce working time to only 2 – 4 h per day

5. Acknowledgement

The research team would like to thank Research and Development Institute, Phetchabun Rajabhat University who provides financial support for this research project; Production Technology Department and Production and Management Engineering Program for supporting supported on

apparatus and equipment for this research. We also would like to thank tobacco cultivation farmers in Lom Sak District, Phetchabun province who provided research information to complete this research. Tobacco leaf-stripping machine was used by farmer and helped increase economic value. Finally, the research team would like to thank all who give suggestions and support.

6. References

- [1] S. Wisudhi, Thailand tobacco monopoly, annual report, Ministry of Finance, Bangkok, 2008.
- [2] A. Somchai, C. Chaler, Thailand tobacco monopoly, annual report, good agricultural, Ministry of Finance, Bangkok, 2012.
- [3] S. Saksirichai, C. Arawan, S. Thiraphong, M. Yodrak, Design and Invention of a Drug Stalk Shredder for a Group of Farmers in Phetchabun Province, Annual Report, Ministry of Higher Education, Science, Research and Innovation, Phetchabun, 2015.
- [4] S. Saksirichai, Development of Drug Stalk Shredder for Phetchabun Province Farmers Group Production Technology Program, Annual Report, Ministry of Higher Education, Science, Research and Innovation, Phetchabun, 2016.
- [5] Y. Artit, K. Pakorn, A Machine Vision System for Thai Flue-Cured Tobacco Classification, Ph.D. Engineering in Energy Engineering, King Mongkut's University of Technology Thonburi, Bangkok, 2005.
- [6] K.S. Prashant, Y. Amit, S. Lucky, S. Shalini, M. Ravi, Social determinants of dual tobacco use in India: An analysis based on the two rounds of global adult tobacco survey, *J. Pre-proofs*. 18 (2020) 1 – 9.
- [7] G. Sandri, A. Sandri, The defects of curing the leaves of tobacco bright, *Informatore Agrario*. 53(1997) 53 – 56.
- [8] W.H. Dumouchel, F.L. Brien, Integrating a robust option into a multiple regression computing environment, 21st Symposium on the Interface, Alexandria, American Statistical Association. 9 – 12 April 1989, 297 – 302.
- [9] C. Chirawat, Economic return and cost of berley varieties of smoked varieties, *J. NUJST*. 18 (2009) 37 – 49.
- [10] W. Phairat, Technology transfer in automobile assembly industry, *J. SWU*. 10 (2013) 60 – 72.
- [11] J.S. Campbell, Tobacco and environment: the continuous reduction of worldwide energy source used for green leaf curing, *J. EVISA's*. 16 (1995) 107 – 117.