Design of Experiments for Analyzing Factors Affecting
to Napier Grass Cutting Efficiency
การออกแบบการทดลองเพื่อวิเคราะห์ปัจจัยที่มีอิทธิพล
ต่อประสิทธิภาพการตัดหญ้าเนเปียร์

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Abstract

The purposes of the study were to investigate and analyze factors affecting to Napier mowing by using the *design of experiments*. The factors were the movement speed (kilometer/hour) and the speed of cutting head (round/minute) which affected the length of the grass. The experiment examined with 45 days and 60 days Napier through designing with full factorial design. After that, the grasses were cut by adjusting order. The data of the experiment were analyzed through the statistical analysis programs. The results had shown that the movement speed and the speed of cutting head of Napier mowing affected the length of the grass significantly at 0.05. Moreover, when cutting 45 days and 60 days old grass by the 50 horsepower tractor which the movement speed 5 kilometers/hour, and the speed of cutting head was 1,800 round/minute in an hour, the machine could cut the grass averagely at 6.84 tons with 3-5 centimeters long of grass.

Keywords: Design of Experiment, Statistical analysis program, Napier grass

บทคัดย่อ

งานวิจัยนี้มีวัตถุประสงค์เพื่อศึกษาและวิเคราะห์ปัจจัยที่มีอิทธิพลต่อประสิทธิภาพการตัดหญ้าเนเปียร์ โดยใช้วิธีการออกแบบการทดลอง ปัจจัยที่ทำการศึกษาประกอบด้วย ความเร็วการเคลื่อนที่ตัด (กิโลเมตร/ชั่วโมง) และความเร็วรอบชุดหัวตัด (รอบ/นาที) ที่ส่งผลต่อความยาวชิ้นหญ้าตามต้องการ การทดลองนี้ทำการตัดหญ้าเนเปียร์ที่อายุ 45 และ 60 วัน โดยการออกแบบการทดลองเชิงแฟกทอเรียลแบบเต็มรูป จากนั้นทำการตัดหญ้าโดยปรับตั้งค่าตามลำดับการทดลอง วิเคราะห์ผลการทดลองด้วยโปรแกรมวิเคราะห์ทางสถิติ ผลจากการทดลองพบว่าความเร็วการเคลื่อนที่ตัดและความเร็วรอบชุดหัวตัดของเครื่องตัดหญ้าเนเปียร์มีอิทธิพลต่อความยาวชิ้นหญ้าที่ทำการตัดอย่างมีนัยสำคัญทางสถิติที่ระดับ 0.05 พบว่าเมื่อตัดหญ้าที่อายุ 45 และ 60 วัน โดยใช้รถแทรกเตอร์ขนาด 12 แรงม้า ความเร็วการเคลื่อนที่ตัด 5 กิโลเมตรต่อชั่วโมง ความเร็วรอบชุดหัวตัดที่ 1,800 รอบต่อนาที
เวลา 1 ชั่วโมง สามารถตัดหญ้าได้เฉลี่ย 6.84 ตัน ที่ความยาวชิ้นหญ้า 3-5 เซนติเมตร

คำหลัก: การออกแบบการทดลอง, โปรแกรมวิเคราะห์ทางสถิติ, หญ้าเนเปียร์

1. Introduction

Napier grasses were grown 30 years ago which including 130 types. [1]

Figure 1 Napier Grass

Napier grass gets high quality for farm animals in terms of production, and nutrition, especially for dairy cattle, beef cattle, water buffalo, goat, and sheep. From the research, Napier Pak Chong 1 was nutritious than other types. This could produce 80 tons/rai/year which could be lawn 6-7 times a year meant that investing in growing Napier 1 time could have been harvested for 10 years which costly only 5,000-6,000 baths. This was low production costs. Nowadays, [2] Napier has been produced to be the renewable energy which gets high fiber and the moisture. As the research mentioned, this kind of grasses can be fired after decreasing moisture system and also be fermented as the biogas. There are various types of experiments that can be approved, for example, producing the Compress Bio Gas which replaced NGV. [3] When studying how to grow Napier grass in the present days since making plans until managing products could be divided into 3 parts 1. Growing and maintaining 2. Harvesting 3. Transforming

After collecting the data through the meeting, brainstorming, and interviewing, the results were presented as figure 2.
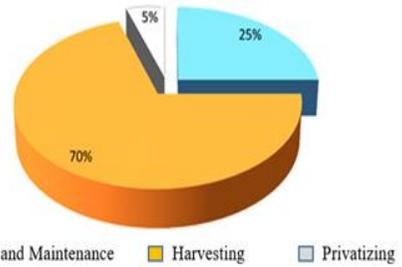

Figure 2 Problems of Growing Napier

As it is given in Figure 2, 3 problems of growing Napier were 1) harvesting too much grass growing that should be harvested in 45-60 days, and 2) the length of suitable grasses was 3-5 centimeters.

The researchers had realized the importance of the product management of Napier, therefore, after studying found that there are 2 kinds of harvesting; by a human, and by

machine as shown in table 1.

Table 1 The Comparison of how Harvesting between Human and Machine

Area	List	Human	Machine
1 rai (5tons/rai)	Working period	1.30 hours	1 hour
	Cost	1,500	1,250
	Numbers of workers	5 people	2 people

Source: Documents of Introducing Napier Grass Pak Chong 1, the Research and Development Center on Animals Food, Department of Livestock [4]

Table 1 shown that machines could decrease the numbers of humans, times, and costs of harvesting, therefore, using the machine was one of the important factors in harvesting Napier. The machines with producing in the country lacking qualities and capacities. Since lacking the criticized and designed approaches correctly from the

engineer and also lacking standards. Besides that, the ones with producing outside the country were not situated with the land's conditions because some parts were too small for using high-cost machines. Additionally, the costs of those ones were too high for some farmers and some organizations.

Consequently, the researchers found the chances of developing Napier mowing machine in the country besides outside the country by making the model which affecting Napier.

2. Literature Review

2.1 Designing the experiments with the Factorial Form

Yaowanat and Kanda mentioned that designing the experiments was the advanced techniques in adjusting status of processing with the accuracy results in analyzing the data by presenting through the statistic numbers which shown the levels of the variable to the process. [5] [6]

Paramet stated that the factorial design was the total of levels of all factors, for example, there were 2 factors; factor A, and factor B. Factor A included a level, and factor B got b level. In 1 replicate, there were ab experiments, and when the related factors forming as in the factorial form, it was meant that it crossed each other. In analyzing the variance of the factorial design 2^k which n replicate connected to pulling the ineffective result variable significant from the full model and criticize the residue to examine the sufficient of the model and to examine the accuracy of define hypothesis. Sometimes, there was the refinement of the model after analyzing the residue because of there were not sufficiency of the model or the define hypothesis was not accurate severely which caused analyzing through graphs with building graphs, the main effect, and the interaction [7]

2.2 The Data Analysis of the Basic Experiments

Montgomery D. stated that data analysis began with the examination the quality of the data that tested with the matrix design. Therefore, before analyzing the data, there would be tested effectively by proving through the model adequacy checking of the 3 factors; the independent test, the normality test, and the variance stability test. [8]

2.3 Analyzing and Managing the Statistic Data with Minitab

Warisa mentioned that Minitab programs was the processed program or the analytical statically instruments. The data were collected through worksheets, and the Minitab programs could be applied with various kinds of works, for example, the controlling, the basic analysis, the advanced analysis, the experiment design, the processing, and the making instruments. [9]

3. Methodology

This study was started with studying interview literature, defining factors, designing experiments, preparing instruments, testing, analyzing, and summarizing. The methodology was as Figure 3.
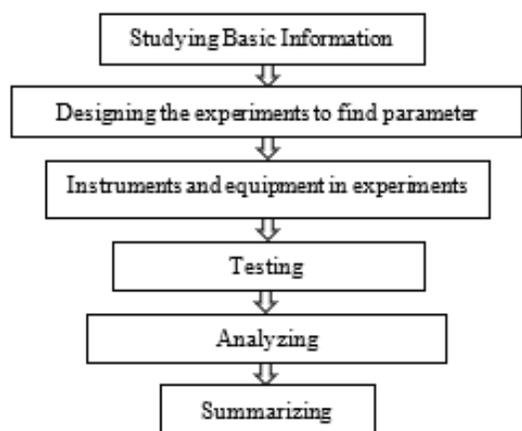

Figure 3 Research Methodology

4. The Results

4.1 Studying Basic Data

The results from studying, found that the appropriate ages of mowing grasses were 45-60 days and the length of grasses was 3-5 centimeters.

4.2 Designing Experiment

4.2.1 Factors/ Variables in Testing

From studying, the data and reviewed literatures affecting the length of grasses in the experiment. There were 2 variables; the movement speed (kilometer/hour), and the speed of cutting head (round/minute). This experiment, the researchers defined 4 times for the experiment because the data were described regularly, and to making sure that the experiment was efficient so the researchers avoided to meet the repeating testing.

4.2.2 Boundary of Variables The defined variables included 2 variables with 3 levels as shown in Table 2.

Table 2 Levels and Boundary of Variables

Variables/Unit	Level		
1. Cutting speed (Kilometer/hour)	5	10	15
2. Speed of cutting head (round/minute)	1,500	1,800	2,000

Consideration to 2 variables, each variable involved 3 levels through the full factorial experiment was in 3^2 equal 9 experiments with 4 repetitions totally 36 times of experiment.

4.3 Instruments and Equipment for Experiment

Figure 4 The Model of the Experiment with 50 Horsepower Tractor

Figure 5 45 Days and 60 Days Napier

4.4 The Results of the Experiment

The figure blow presented the results of cutting 45 days and 60 days.

Figure 6 Napier Cutting in the Experiment

Figure 7 The Length of Grass

The results of cutting 45 days and 60 days Napier grass with adjusting and examining the length of grass 36 times of experiment as shown in Table 3.

Table 3 The Experiment of Napier Cutting

No.	Cutting Speed	Cutting Speed Head	Length of Grass
1	5	1,800	3.5
2	5	1,500	5.7
3	15	1,500	6.8 *not complete cutting
4	10	1,500	6.5
5	10	1,800	4.2
6	5	1,500	5.5
7	5	2,000	2.5
8	15	2,000	2.3
9	10	2,000	3.5
10	15	2,000	2.8
11	5	2,000	2.5
12	15	1,800	3.7
13	10	1,500	6.4
14	5	1,500	6
15	5	1,500	6.2
16	15	1,500	7.3 * not complete cutting
17	10	1,800	4.6
18	10	2,000	3.8
19	10	1,500	5.4
20	15	2,000	3
21	10	1,800	4.3
22	5	1,800	4
23	10	2,000	2.7
24	5	1,800	3.6
25	15	1,800	4.7
26	15	1,800	5
27	10	1,500	5.6
28	5	2,000	2.2
29	15	1,800	3.7
30	15	1,500	7.2 * not complete cutting
31	5	1,800	3.9
32	15	1,500	7.4 * not complete cutting
33	10	2,000	2.8
34	5	2,000	2.5
35	15	2,000	3.2
36	10	1,800	4.5

4.5 The Data Analysis

To analyze reliability, there was the testing by setting the statistic hypothesis to exam factors affecting the length of Napier significantly at 0.05 (α = 5%) which hypothesized H_0 and H_1 as follows;

The movement speed

H_0: $\mu_{A1} = \mu_{A2} = \mu_{A3}$

H_1: $\mu_{A1} \neq \mu_{A2} \neq \mu_{A2}$ at least 1 pair

*H_0 = the movement speed without
    affecting the length of grasses

H_1 = the movement speed with affecting
    the length of grasses at least 1 pair

The speed of cutter head

H_0: $\mu_{B1} = \mu_{B2} = \mu_{B3}$

H_1: $\mu_{B1} \neq \mu_{B2} \neq \mu_{B2}$ at least 1 pair

*H_0 = the speed of cutter head without affecting the length of grasses

H_1 = the speed of cutter head with affecting the length of grasses at least 1 pair

Before using the hypothesis, there might be the testing of the results spread regularly which presenting on the graph as figure 8.
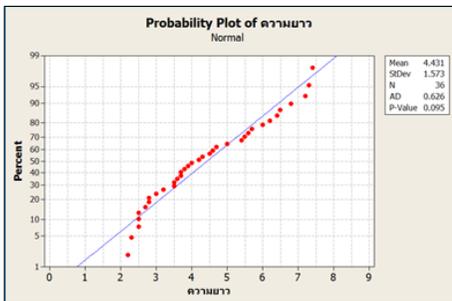

Figure 8 Presenting the Information of Testing

From 36 groups of experiments, the mean was 4.431and P-value at 0.095 which meant P-value here was higher than 0.05 shows that the results were speared regularly as shown in the table. The results were calculated by ANOVA as Table 4.

Table 4 The Statistical Analysis of Factors

Source P	DF	SS	MS	F
Speed of movement 0.000	2	3.536	1.768	10.76
Cutting Speed 0.000	2	75.704	37.852	230.31
Movement Speed*Speed cutting head 0.007	4	2.899	0.725	4.41

From the statistical analysis of factors, the P-value of the movement Speed *Speed of cutting head was < 0.05, so H1 and H0 or Interaction affected the length of grass.
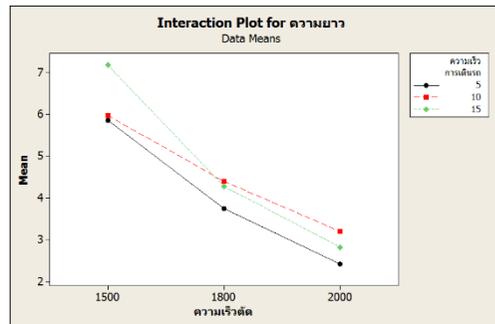

Figure 9 Influencing Factors on the Movement Speed and the Speed of Cutting Head

From the graph shown that the length of grass which were, movement speed at 5 kilometers/hour at the speed of cutting head with 1,800 round/minute could produce the products matched with the needs mostly.

6. Conclusion

The results of the study on factors affecting the efficiency of Nepier mowing through the factorial experiment. There were 2 factors for the experiment; the movement speed and the speed of cutting head. Each factor was studied in 3 levels and 4 times repetitions. From the cutting experiment and analyzing through static, those 2 factors affected the length of grasses significant 0.05. Moreover, the suitable movement speed at 5 kilometers/hour and the speed of cutting head was 1,800 rounds/minute. The results from the assessment of the capacity which using the best result to presented that the model had the capacity at 6.84 tons/hour.

Acknowledgement

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