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Development of a Motor-Driven Tiger Grass Depollinator with Dust Cyclone Vortex Separator

Regina L. Bongcato[1], Ernesto B. Bausel Jr.[2], Dale Mark N. Bristol[2], Jeanelyn R. Tominez[2], Larry P. Remolazo[2]

[1]*Student, Department of Mechanical Engineering, Nueva Vizcaya State University - Bambang Campus, 3702 Bambang, Nueva Vizcaya, Philippines*

[2]*Faculty, Department of Mechanical Engineering, Nueva Vizcaya State University - Bambang Campus, 3702 Bambang, Nueva Vizcaya, Philippines*

Corresponding Author: Toyang12393@gmail.com

Abstract*: The soft broom-making industry in Nueva Vizcaya relies heavily on the utilization of tiger grass. However, the traditional broom-making process presents several challenges, including the labor-intensive and time-consuming manual process, the need for efficient pollen removal, and the sustainable management of tiger grass. To address these challenges, the researchers aimed to develop a motor-driven tiger grass pollen remover. Through the proposed design, which includes an option for either motorized or manual operation, the machine aimed to expedite the pollen removal process, increase productivity, and reduce manual labor. To evaluate the effectiveness of the proposed machine, computations were performed to compare the time and effort required for pollen removal using traditional manual methods versus the machine-assisted technique. Results showed that the motor-driven pollen remover significantly reduced the time and effort required for pollen removal, with an efficiency of around 98% for Class A, B, and C tiger grass. The machine-assisted technique reduced the time required for pollen removal from 10-15 minutes per 100 stalks to only 2-4 minutes per 100 stalks and reduced manual labor. These results demonstrated the potential of the proposed machine to revolutionize the broom-making process, increase production rates, minimize costs, and increase the overall output of high-quality tiger grass brooms. Furthermore, the proposed machine holds promise in preserving cultural heritage and offering long-term benefits to local communities by contributing to sustainable livelihoods and rural development. Overall, the development of a motor-driven tiger grass pollen remover represents a significant advancement in the soft broom-making industry and offers innovative solutions to sustain the industry and address its challenges.

***Keywords*: Dust cyclone, motor-driven depollinator, tiger grass, soft broom industry, vortex.**

1. Introduction

Thysanolaena maxima, commonly known as tiger grass or "tambo" in Tagalog, is a grass species that resembles sugarcane and bamboo. It serves as a vital resource for the soft broom-making industry and plays a vital role in the economic development of upland communities. The upper portion of the Tiger Grass flower, specifically the drooping panicle, harvested during late January and February, is a primary material for broom production [1, 2].

The soft broom-making industry, reliant on tiger Grass, contributes to sustainable livelihoods and rural development. Harvesting Tiger Grass for broom production generates income but also fosters community-based initiatives and entrepreneurship, particularly in regions abundant with tiger grass [3]. The economic opportunities created by the utilization of this natural resource help preserve cultural heritage and offer long-term benefits to local communities. The soft broom-making industry in Nueva Vizcaya, particularly in Calitlitan, Aritao, has been a significant source of livelihood for residents, with "walis tambo" being a traditional craft deeply embedded in the community. However, various challenges have surfaced, including the labor-intensive and time-consuming manual process, the need for efficient pollen removal, and the sustainable management of tiger grass.

According to Fadriquel (2016), efficiency and speed are paramount challenges in the traditional broom-making process, with manual methods demanding meticulous attention and repetitive handwork. Pollen removal from Tiger Grass, a critical step, is time-consuming, taking 10-15 minutes per 100 stalks when done manually. Additionally, the sustainability of Tiger Grass is a concern, necessitating responsible harvesting practices to prevent overharvesting and ensure its long-term availability [4].

The broom-making industry in Nueva Vizcaya has received support from the Department of Trade and Industry (DTI), the Department of Social Welfare and Development (DSWD), and the Local Government Unit (LGU) of Aritao. These entities facilitated connections with institutional buyers, creating market linkages and helping broom makers profit from product sales. A skills training on soft broom production in

Calitlitan, Aritao, further emphasized the commitment to enhancing the industry.

Interviews with the experienced walis tambo makers and farmers shed light on the challenges faced by the community. Despite difficulties like depollinating the Tiger Grass using the traditional way, the demand for "walis tambo" remains significant, highlighting the need for innovative solutions to sustain the industry and preserve cultural heritage. Recognizing the need for innovation, the researchers aimed to develop an effective machine-assisted pollen removal technique. This advancement, specifically designed for tiger grass, sought to address the challenges of efficiency and pollen removal. The machine aims to expedite the process, increase productivity, and reduce manual labor, thereby contributing to the sustained growth of the broom-making industry.

The proposed implementation of an advanced machine-assisted pollen removal machine holds the potential to transform the broom-making process. Automation and streamlining of pollen removal can significantly reduce time and effort compared to traditional methods, revolutionizing production rates, minimizing costs, and increasing the overall output of high-quality tiger grass brooms.

2. Materials and Methodology

A. *Tiger grass stalks*

Tiger grass stalks, as shown in Fig. 1, are used for a variety of purposes, particularly when making soft brooms. These bamboo-like stalks, which may reach 10 feet tall, are strong but lightweight, making them excellent for broom handles [5]. Based on their quality and usefulness for creating brooms, tiger grass stalks are divided into three primary grades: Class A, B, and C. Class A stalks are the highest grade because they are straight, uniformly thick, and long-lasting, making them perfect for high-end, soft brooms. Even though Class B stalks are a little less polished and have little flaws, like tiny bends or unequal thickness, they are nonetheless frequently used to make regular brooms. Lastly, Class C stalks are the lowest grade; they are usually used as supplemental materials or for less demanding tasks. They are also frequently thinner or more irregular. While satisfying a range of consumer expectations, these classifications aid in ensuring the effective use of tiger grass resources.

Fig. 1. Dried tiger grass samples

B. *Motor-driven tiger grass depollinator design*

The design of the motor-driven tiger grass depollinator, as shown in Fig. 2, is created to aid in the tiger grass broom production, making it more efficient and faster in meeting the demand for production. A 1-hp motor is used to operate the prototype. This motor was connected to the cyclone separator blower and the thresher with the use of four differently sized pulleys. Instead of using a worm gear speed reducer, an alternate size of pulleys was used to meet the desired speed to lessen the damaged stalks that may be encountered during the operation. The first pulley directly connected to the motor is a 2.75-inch pulley. The second is a double-layered pulley, in which the first pulley connected from the motor pulley is 3 inches, while the second is 3.5 inches. In the next section, the pulley from the thresher also had a two-layered pulley with the same size of 3 inches. The last pulley connected to the thresher has a 12-inch diameter. Wherein the input rpm, which is 1740 rpm, is reduced to an output of 1595 rpm for the blower and 465 rpm for the thresher.

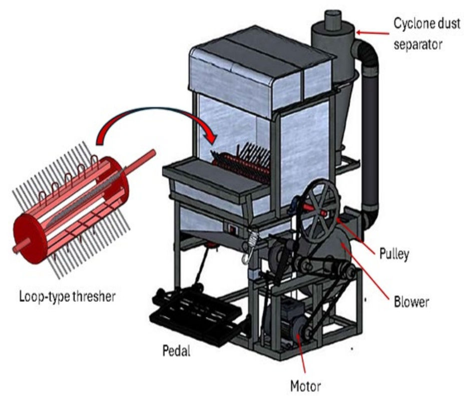
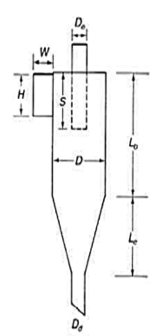


Fig. 2. Design of motor-driven depollinator prototype

C. *Cyclone dust separator design*

The design of the cyclone separator of the machine is based on the sizing stated in the study by Taiwo et al. (2020) as shown in Fig. 3. The cyclone separator is responsible for collecting the removed pollen from the tiger trass using vortex separation to remove the pollen from the hopper and into a collection bag behind the machine [6].

	Cyclone Type					
	High Efficiency		Conventional		High Throughput	
	(1)	(2)	(3)	(4)	(5)	(6)
Body Diameter, D/D	1.0	1.0	1.0	1.0	1.0	1.0
Height of Inlet, H/D	0.5	0.44	0.5	0.5	0.75	0.8
Width of Inlet, W/D	0.2	0.21	0.25	0.25	0.375	0.35
Diameter of Gas Exit, D_e/D	0.5	0.4	0.5	0.5	0.75	0.75
Length of Vortex Finder, S/D	0.5	0.5	0.625	0.6	0.875	0.85
Length of Body, L_b/D	1.5	1.4	2.0	1.75	1.5	1.7
Length of Cone, L_c/D	2.5	2.5	2.0	2.0	2.5	2.0
Diameter of Dust Outlet, D_d/D	0.375	0.4	0.25	0.4	0.375	0.4



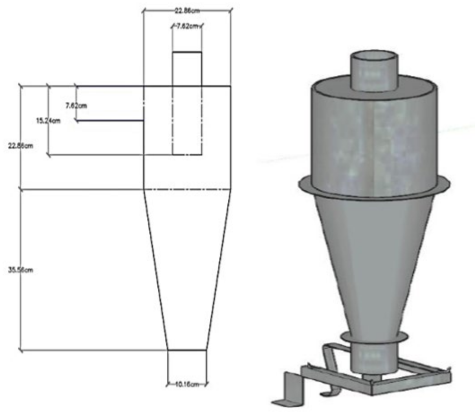


Fig. 3. Dust cyclone standard specifications and set-up

3. Results and Discussion

A. Efficiency of pollen removal in various grades of tiger grass stalks

The researchers collected different parameters on the three classes of tiger grass to solve the efficiency in terms of removing pollen and damaged stalks, and the speed of depollination per class was also gathered. To get the efficiency of pollen removal, the formula for efficiency, as stated by Banton (2023), is derived, which is rewritten as [7]:

$$e_{removed} = \frac{Tiger\ grass\ pollen\ removed}{Tiger\ grass\ pollen\ input} \text{ x } 100\%$$

$$e_{damaged\ stalks} = \frac{Non-damaged\ stalks}{Input\ stalk} \text{ x } 100\%$$

Table 1
Pollen removal efficiency of various tiger grass grades

No. of trials	**Grades of tiger grass stalks**		
Trial No.	**Class A**	**Class B**	**Class C**
1	98.71%	98%	98.92%
2	98.53%	98.53%	98.73%
3	99.07%	98.55%	98.86%
Total Average	**98.77%**	**98.36%**	**98.84%**

Table 2
Damaged stalks efficiency of various tiger grass grades

No. of trials	**Grades of tiger grass stalks**		
Trial No.	**Class A**	**Class B**	**Class C**
1	98%	95%	96%
2	97 %	97%	93%
3	99%	97%	94%
Total Average	**98%**	**96.33%**	**94.33%**

Table 3
Pollen removal time in various tiger grass grades

No. of trials	**Grades of tiger grass stalks**		
Trial No.	**Class A**	**Class B**	**Class C**
1	1.37 min	2.32 min	0.53 min
2	1.73 min	2.0 min	1.06 min
3	1.02 min	2.25 min	0.54 min
Total Average	**1.20 mins**	**2.19 min**	**0.71 min**

The study conducted several trials, as shown in Tables 1, 2, and 3, each consisting of 100 stalks, and the efficiency of pollen removal was measured in terms of quality, time, and the number of damaged stalks of different dryness levels. The results showed that in Class A, which represents dry tiger grass stalks, the total average efficiency of pollen removal is 98.77%, with 98% efficiency in terms of damaged stalks. The time taken for pollen removal varied between 1:02 to 1:34 minutes. In Class B, which represents moderately dry tiger grass stalks, the total average efficiency of pollen removal was 98.36%, with 96.33% efficiency in terms of damaged stalks. The time taken for pollen removal varied between 2:00 to 2:32 minutes. In Class C, which represents overly-dried tiger grass stalks, the total average efficiency of pollen removal was 98.84%, with a total of 94.33% efficiency in terms of damaged stalks. The time taken for pollen removal varied between 0.53 to 1:06 minutes.

B. Effectiveness of pollen removal in various grades of tiger grass stalks

A comparison is made between manual and motor-driven tiger grass depollination, as shown in Tables 4 and 5, respectively. This comparison is based on the removal time of pollens, the number of damaged stalks, and the number of stalks left after depollination, which are the parameters of interest in evaluating the effectiveness of pollen removal on tiger grass.

Table 4
Manual pollen removal efficiency of tiger grass

Respondent	**Number of stalks**	**Time (mins)**	**Number of damaged stalks**	**Number of stalks left**
1	100	20	10	90
2	100	20	12	88
3	100	15	15	85
4	100	20	15	85
5	100	20	15	85
6	100	15	18	82
7	100	18	10	90
8	100	18	15	85
9	100	20	10	90
10	100	15	15	85
Total Average	**100**	**18.1**	**13.5 ≈ 14**	**86.5 ≈ 87**

$$\boldsymbol{Capacity\ (manual)} = \frac{87\ Stalks}{18.1\ minutes} = \mathbf{4.81} \approx \mathbf{5}\ \frac{\boldsymbol{stalks}}{\boldsymbol{minute}}$$

Table 5
Motor-driven pollen removal efficiency of tiger grass

Grades of tiger grass stalks	Number of stalks	Average time (mins)	Number of damaged stalks	Number of stalks left
A	100	1.20	2	98
B	100	2.19	4	96
C	100	0.71	5	95
Total Average	**100**	**1.37**	**3.66 ≈ 4**	**96.33≈ 96**

$$\boldsymbol{Capacity\ (prototype)} = \frac{96\ Stalks}{1.37\ minutes} = \mathbf{70.07} \approx \mathbf{70}\ \frac{\boldsymbol{stalks}}{\boldsymbol{minute}}$$

The above results depict the efficiency of two methods for the removal of pollen from dry tiger grass stalks in terms of quantity. The first method involves a manual or human labor approach, while the second method is a machine-based approach. The results from the tests show that the machine-based approach is significantly more efficient than the manual approach. The machine was able to remove pollen from 100 stalks in an average time of 3.58 minutes, with only one stalk being damaged in the process. In contrast, the manual approach required an average time of 18.1 minutes to remove pollen from 100 stalks, with an average of 13.5 stalks being damaged in the process.

These results suggest that the machine-based approach is the more efficient method for pollen removal in terms of quantity. The machine's capacity of 70 stalks per minute is significantly higher than the manual capacity of only 5 stalks per minute. This means that the machine can produce a larger quantity of pollen-free tiger grass stalks in a shorter amount of time, which could potentially increase productivity and save costs.

4. Conclusion

In conclusion, the motor-driven tiger grass depollinator design has incorporated a loop-type thresher cylinder/drum incorporated with nylon strings, a shrouded radial blade centrifugal impeller blower, and a cyclone dust separator. The researchers performed three tests, namely, Class A (Dry), Class B (Moderately Dry), and Class C (Over-Dry). Each test consisted of 3 trials, each with 100 stalks, as needed by the study. On the tabulated data obtained from the stated results, the prototype presented a high level of efficiency and speed in removing tiger grass pollens regardless of the grades. Based on the results obtained from the efficiency tests of the motorized-driven tiger grass de-pollinator, it can be concluded that the machine is highly effective in terms of both quality and quantity. The machine has the average efficiency rate in removing pollen of 98.66% and for the damaged stalks is 96.22 % efficiency rate. In terms of quantity, the machine's capacity is significantly higher than the manual operation, with a capacity of 70 stalks/minute compared to 5 stalks/minute for manual operation. Therefore, the motorized-driven Tiger Grass de-pollinator is an efficient and effective tool for the removal of tiger grass pollen.

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