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Development of Rotary Sieve for Preparation of Casing Soil Required in Mushroom Cultivation

ANARASE DATTATRAY ARJUN* and **BRIJ LAL ATTRI**

ICAR – Directorate of Mushroom Research, Solan, India.

Abstract

Preparation of casing material is an important and crucial step in button mushroom cultivation. Decomposed farmyard manure (FYM) is one of the major ingredients used in the casing mixture and it needs to be sieved for the separation of undesirable impurities. The conventional practice of sieving raw FYM is time consuming, crude and causes drudgery to the human labors. The study aims to develop a rotary sieve to be used for sieving of raw FYM before its use in casing mixture. While fabrication, sieve performance was evaluated by carrying out 15 experimental trials formulated using the Box-Behnken design of response surface methodology. Maximum sieve effectiveness (0.952) and throughput capacity (61crates/h) were estimated at the rotational speed of 33.2 rpm, sieve inclination of 9.8% and 0.49 inch sieve aperture. Labor, time and human drudgery were seen to be significantly reduced by using rotary sieve in casing material preparation.

Article History

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Keywords

Casing; FYM; Mushroom Cultivation; Rotary Sieve; Response Surface Methodology.

Introduction

In India, contribution of white button mushroom is 73% of total mushroom production and it is the most popular mushroom in the country.[1] In the process of button mushroom cultivation, firstly inoculated compost is incubated at 25˚C for up to 15 days. Once the compost is colonized, it has to be covered with the casing mixture containing farmyard manure and coir pith.[2] Casing is an important step in the cultivation cycle of button mushroom and without it mushrooms do not appear. It is the 4-5 cm thick layer of soil applied on the top surface of spawn run compost. This layer facilitates the availability of water and aeration for the growth of mushrooms. A mixture of 2-3 years old farmyard manure with garden soil in the ratio of 1:1 is prepared. If coir pith is available then it can also be used as 1:1:1. The casing material should be having high porosity, water holding capacity with a pH range between 7-7.5. Besides animal droppings, decomposed raw farmyard manure also contains unwanted impurities such as stones, plastic waste, hard trash etc. Therefore, before mixing with other ingredients of casing soil, decomposed farmyard manure needs to be

CONTACT Anarase Dattatray Arjun d.anarase@gmail.com ICAR – Directorate of Mushroom Research, Solan, India.

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sieved to separate larger impurities from it. Sieving of such farmyard manure before mixing with casing mixture is labor and time intensive task. The sieving of farmyard manure in most of the time is done by using a simple sieve either by keeping the sieve inclined to the ground or directly keeping it on the crates in which undersize material is collected. This method requires a large number of laborers and also causes drudgery to them. For solving this problem on mushroom farm, hand operated rotary sieve was developed.

Previous workers have reported the design and development of a warm sieving machine for the production of vermicompost.[3] Fabrication of rotary sieve for segregating solid waste in the Ambad city has been reported.[4] However, no report on availability of such type of mechanical device for preparation of casing material was found. In this work, the objective of developing this sieve was to reduce the time requirement, labor and to separate the raw farmyard manure into two fractions such as undersized material of uniform particle size to be used as a casing ingredient and oversized material (impurities).

Materials and Methods

A rotary sieve for screening raw farmyard manure (FYM) has been developed at ICAR- Directorate of Mushroom Research, Solan (H.P.). It consists of a mild steel cylindrical sieve mounted on a rectangular frame with the help of a central shaft of diameter 5 cm and bearings on the feeding and discharge end. Two numbers of rims along with four spokes at a distance of 900 mm were welded on the central shaft for supporting the rotary sieve on load bearings. The handle is fitted on the discharge side of the machine. The cylindrical sieve consists of a wire mesh drum 135 cm in length and 78 cm in diameter. The overall dimensions of the supporting frame of the sieving machine are 5 × 3.5 × 2.5 feet. Guard plate is fitted on one of the side of supporting frame to prevent the separated fine material to fall out of crates. The supporting frame of this machine is fabricated using mild steel and the rotary sieve is made of galvanized iron. The weight of supporting frame was kept heavy in order to provide stability during the operation. Firstly to provide the structural support and stability to the sieve, a framework of hollow mild steel rectangular channels was made using a welding process. The rotary cylindrical sieve was attached to the shaft by using rims and spokes. Rotary sieve along with the shaft and bearings is attached parallel to the rectangular supporting frame. The handle is attached to the discharge end of the machine (Fig.1) .While the fabrication of the rotary sieve was in progress, three sieve design parameters such as rotational speed, sieve inclination or slope and sieve aperture were optimized through experimentation.

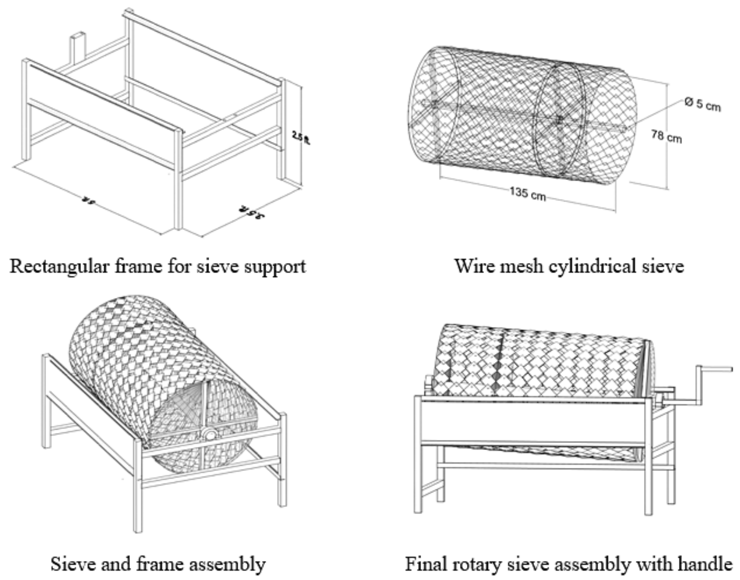


Fig. 1: Fabrication of rotary sieve

Testing and Optimization of Sieve Performance

Sieving tests were performed with the fabricated rotary sieve. Before the start of the sieving operation, the sieve was placed on the horizontal surface where raw farmyard manure is piled (Fig. 2). Feeding end of the sieve was slightly lifted by using bricks or suitable blocks up to the height of 15-20 cm. A total of eight crates were placed under the sieve for collecting the uniform sized FYM and one at the discharge end for collecting impurities. During operation, rotary sieve was kept rotating firstly by rotating the handle provided on discharge end. While the sieve was under rotation, raw farmyard manure was fed from the other end of the sieve by using a gardening spade. Three persons (two for feeding and one for sieve rotation) performed this task during testing trials. Parameters such as sieve effectiveness and throughput capacity were determined to evaluate the performance of the developed rotary sieve. Sieve parameters viz. rotational speed (rpm), sieve inclination (%) and sieve aperture (inch) were optimized by using Box-Behnken experimental design of response surface methodology. In total 15 experimental trials of rotary sieve were performed with three sieve parameters (Rotational speed (15-45 rpm), sieve inclination (5-15%) and sieve aperture (0.25-0.75 inch). Sieve effectiveness and throughput capacity of rotary sieve were estimated for each experimental run.

Fig. 2: Farmyard manure sieve a) Rotary sieve in use b) Separated undersize and oversize material from raw FYM

Throughput Capacity

The throughput capacity of the rotary sieve was determined by dividing the number of crates sieved by total time required for sieving.[5,8]

$$\text{Throughput capacity}=Nc/T \quad ...(1)$$

Where Nc is number of crates sieved and T is total time of sieving (h).

Sieve effectiveness

In sieving, feed material (F) having size larger than sieve aperture remains over the inner periphery of sieve and move along the length of sieve is called as oversize material. Feed material which passes through the sieve opening and collected separately is termed as undersize material.[5] Sieve effectiveness was determined as the measure of how effective the sieve was to separate the desired portion from the feed mixture. Following expression (2) was used for calculating sieve effectiveness (E).

$$E=m_o (1-m_u)(m_o-m_f)(m_f-m_u))/(m_f (1-m_f) (m_o-m_u)^2 \quad ...(2)$$

Where, m_o is mass fraction of desired material in overflow, m_u is mass fraction of desired material in underflow and mf is mass fraction of desired material in feed material.[7]

Results and Discussion

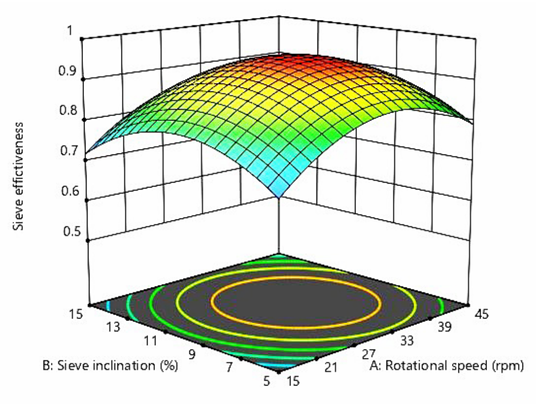
During the operation, raw decomposed farmyard manure was fed manually from one end of the cylindrical sieve and simultaneously sieve was kept rotating by means of handle provided on other end of the sieve. The rotary motion of the sieve causes FYM material to move on the inner periphery of the sieve. This rotary motion causes undersize desirable material to fall through sieve openings and oversize material like stones and larger impurities to move along the length. Oversize and undesirable material is then collected at the other end of the rotary sieve (Fig. 2). Results of 15 sieve testing trials are presented in Table 1.

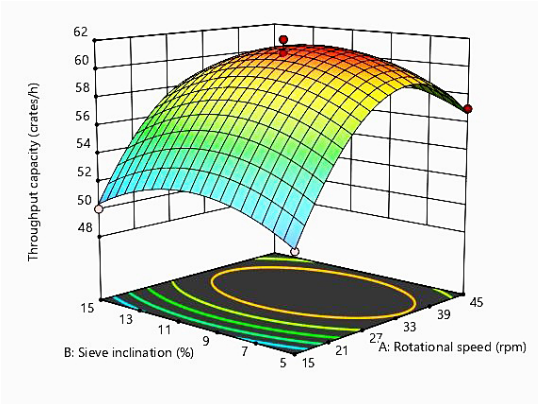
Table 1 Performance evaluation of rotary sieve

Sieve operating parameters			Responses	
Rotational speed, rpm	Sieve inclination, %	Sieve aperture, inches	Sieve effectiveness	Throughput capacity, Crates/h
30	5	0.25	0.8	53
15	10	0.75	0.72	49
30	10	0.5	0.95	60
30	10	0.5	0.96	61
45	5	0.5	0.78	57
30	5	0.75	0.76	57
45	15	0.5	0.8	56
45	10	0.75	0.78	54
15	15	0.5	0.73	50
30	10	0.5	0.94	62
30	15	0.25	0.75	55
30	15	0.75	0.73	55
45	10	0.25	0.78	55
15	10	0.25	0.73	49
15	5	0.5	0.7	50

Effect of Operating Parameters on Sieve Performance

From the surface plot depicted in Fig. 3, the maximum effectiveness of the rotary sieve in separating desired material from raw FYM and throughput capacity has been recorded at a sieve inclination of 10% and rotational speed of 30 rpm approximately. Extreme rotational speeds and sieve inclination resulted in declined sieve performance in terms of separation effectiveness and throughput capacity.





(a) (b)

Fig. 3: (a) Sieve effectiveness and (b) Throughput capacity of rotary sieve at fixed sieve aperture of 0.5 inch

Optimized Sieve Performance

The optimum performance of the rotary sieve was determined with respect to the desirable goals for sieve effectiveness (rpm) and throughput capacity (Crates/h). Optimum values of rotational speed, sieve inclination and sieve aperture were obtained for maximum effectiveness and throughput capacity of the rotary sieve. From numerical optimization, sieve parameters for desired performance of rotary sieve were found to be as a rotational speed of 33.2 rpm, sieve inclination of 9.85% and sieve aperture of 0.499 inches. Under these operating conditions, sieve effectiveness and through capacity were recorded to be 0.952 and 61 crates/h respectively. The mean desirability for target sieve effectiveness and through capacity was estimated to be 0.962 (Fig. 4).

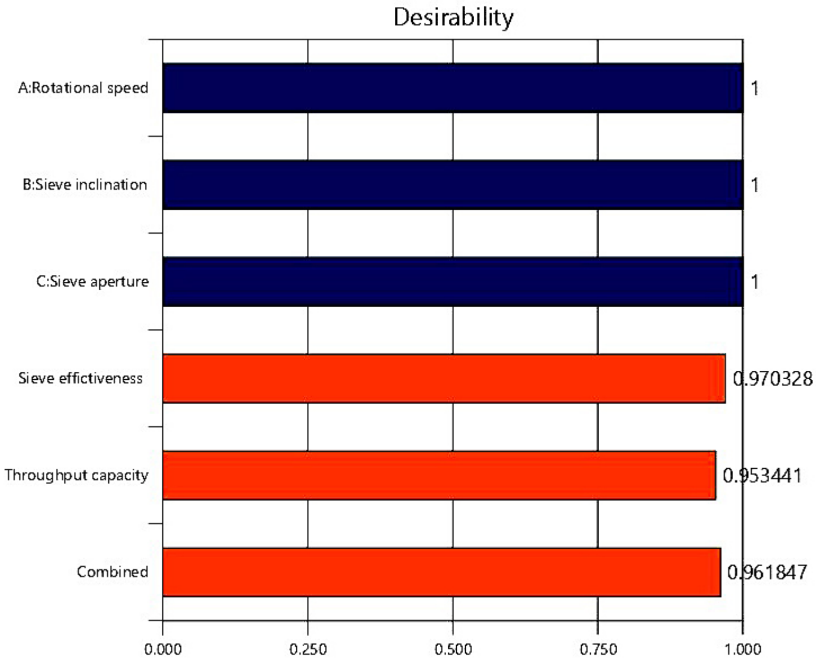


Fig. 4: Desirability of optimized sieve performance

Conclusion

Rotary sieve developed in this work, found to be 95.2% efficient in separating impurities from desired raw farmyard manure to be used in casing mixture. By making the use of developed rotary sieve, more uniform sized farmyard manure required in casing mixture can be prepared. It may be easily moved from one place to another as it is not too heavy. A maximum of three persons (two for feeding and one for sieve rotation) can perform the task. Use of this sieve has significantly minimized number of laborers, time and human drudgery caused in preparation of casing material required in mushroom cultivation.

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Conflict of Interest

Authors declare no conflict of interest.

Data Availability Statement

Not applicable

Ethics Statement

This work does not contain experiments on humans and animals

Authors' Contribution

Anarase Dattatray Arjun- Conceptualization, methodology, writing and editing; Brij Lal Attri-Supervision, editing and review

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