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Effect of operating parameters on groundnut thresher performance

[1] Sourabh Kumar Dewangan, [2] RK Naik, [3] Gajendra Singh, [4] Geeta Patel and [5] HS Tuteja

[1] Ph.D. Scholar, Department of Farm Machinery and Power Engineering (FMPE), SVCAET & RS, Indira Gandhi Krishi Vishwavidyalaya (IGKV), Raipur, Chhattisgarh, India

[2] Professor & Head, Department of Farm Machinery and Power Engineering (FMPE), Principal Investigator, AICRP on Farm Implements and Machinery (FIM), SVCAET & RS, Indira Gandhi Krishi Vishwavidyalaya (IGKV), Raipur, Chhattisgarh, India

[3] Ph.D. Scholar, Department of Farm Machinery and Power Engineering (FMPE), SVCAET & RS, Indira Gandhi Krishi Vishwavidyalaya (IGKV), Raipur, Chhattisgarh, India

[4] Guest Teacher, Department of Farm Machinery and Power Engineering (FMPE), College of Agriculture (COA&RS), Indira Gandhi Krishi Vishwavidyalaya (IGKV), Raigarh, Chhattisgarh, India

[5] Senior Research Fellow (SRF), Central Institute of Agricultural Engineering (CIAE), Bhopal, Madhya Pradesh, India

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Corresponding Author: Sourabh Kumar Dewangan

Abstract

India is the world's second-largest producer of groundnut (*Arachis hypogaea* L.), accounting for 31.81% of the country's oilseed production. Despite advances in mechanization, threshing remains a labor-intensive process, requiring 160-200 man-hours per hectare. To address this, a power-operated groundnut thresher was developed and evaluated at SVCAET&RS, IGKV, Raipur. The study examined the effects of three operational parameters cylinder peripheral speed (23.5-31.5 m/s), feed rate (7700-7900 kg/h), and concave clearance (15-25 mm) on threshing efficiency, cleaning efficiency, broken pod percentage, and un-threshed pod loss. Experiments followed a three-factor factorial randomized block design (FRBD) with three replications, ensuring statistical reliability. Standard testing procedures (IS: 11234-1985 and IS: 6284-1985) were used for performance evaluation. Results demonstrated that optimized combinations of speed, feed rate, and clearance significantly enhanced threshing and cleaning efficiency while minimizing losses, highlighting the thresher's potential to reduce drudgery and improve post-harvest efficiency in groundnut cultivation.

Key words: Broken pod, blown pod, Concave clearance, feed rate

Introduction

India is the second largest producer of groundnut after China. Groundnut (*Arachis hypogaea* L.) is the major oilseed in India in terms of production. On an average it accounts for 31.81% of the oilseeds. The annual production of seed and oil are 5.8 and 1.5 million tonnes, respectively. About 80% of the total groundnut produced in India undergoes processing so that it can be utilized as oil and cake. Around 75% of the crop is produced during *kharif* season in June-September) and remaining 25 percent during *rabi* season in November-March (Senthilkumar *et al.*, 2017) [18]. Groundnut serves as edible oil in a large part of India, and edible oil constitutes 72.1% of the total agricultural imports. Though machines for planting and digging groundnut crops have been developed, threshing in India is still performed manually, requiring approximately 160-200 man-hours per hectare (Kalkat and Verma, 1972; Singh *et al.*, 2009; Reddy *et al.*, 2013) [12, 17]. It is recognized that threshing is an extremely labor-intensive process that requires a great deal of human drudgery (Naik *et al.*, 2010) [13]. Due to a number of causes, Chhattisgarh farmers have historically placed a higher priority on paddy agriculture, which has resulted in a decreased interest in groundnut growing. Although recent data show that groundnut production is becoming more popular in different districts. Growing groundnuts can be more costly and time-consuming than growing paddy, especially for small-scale farmers. One of the most important aspects of post-harvest activities that influence the caliber and volume of crop production is threshing. Groundnut threshing can be labor-intensive, but it is also made more challenging by the absence of widespread and affordable mechanization these regions need power operated groundnut thresher. Singh *et al*, 2009 studied effect of 3 levels of operational parameters, i.e. feed rate (600, 800 and 1,000 kg/hr), cylinder peripheral speed (5.8, 6.4, 7.1 m/s) and concave clearance (30, 36, 42 mm) was studied on various performance parameters of thresher to find best combination of operational parameters. These parameters were selected based on preliminary trials conducted on the thresher. Samples were collected from all outlet of the machine for 30 sec. to compute threshing efficiency, cleaning efficiency, output capacity and pod loss of the machine. The average arithmetic mean diameter of groundnut pod was 17.77 mm, and the geometric mean diameter of groundnut pod was 16.39 mm. Other properties included a sphericity of 0.58, a bulk density of 246.45

kg/m³, a true density of 438.79 kg/m³ and an angle of repose of 26.73°. The rupture forces were 31.24 N when applied longitudinally and 245.41 N when applied vertically. These values are crucial for designing efficient post-harvest systems for threshing and helps reduce losses (Dewangan, *et al.* 2025) [5].

Material and methods

An experimental setup and a prototype were developed to study various design parameters of the machine. It consisted of threshing drum, concave unit, feeding unit and cleaning. It was fabricated at the SV College of Agricultural Engineering Technology and Research Station workshop, IGKV, Raipur, and at M/s Chandrakar Agrinext, Durg. The variables selected for investigation included three different peripheral speeds of the threshing cylinder, ranging from 23.5 m/s to 31.5 m/s, three different feed rates between 7700 kg/h and 7900 kg/h, and three different concave clearance varying from 15 to 25 mm. The study focused on several performance parameters such as: threshing efficiency, percentage of broken grains, cleaning efficiency, blown pod percentage and un-threshed pod percentage (Table A). A three-factor factorial randomized block design was employed to analyze the collected data.

The experimental data collected for the various independent parameters were replicated three times to ensure accuracy and reliability. Measurements were systematically recorded during each replication. The data's collection, a statistical analysis were using a Factorial Randomized Block Design (FRBD) to evaluate the effects of the independent variables on the measured outcomes. This method allowed for effective control of variability among experimental units and provided a more precise understanding of the influence of each factor under investigation. Standard methods for testing groundnut power threshers, as prescribed by IS: 11234-1985, were utilized to evaluate their performance. Concurrently, terminology related to threshing operations and equipment from IS: 6284-1985 was referenced. These standards were then employed to calculate dependent parameters during the experiment.

Table 1: Study parameters: feed rate, moisture, and threshing cylinder speed

S. No.	Independent Parameters		Dependent Parameters
	Variables	Levels	
1.	Feed rate, kg/h	7700 7800 7900	Threshing Efficiency, % Broken pod, % Cleaning efficiency, % Blown pod, % Un-threshed pod, %
2.	Cylinder speed, m/s	23.5 27.5 31.5	
3.	Concave clearance, mm	15 (CC1) 20 (CC2) 25 (CC3)	

Results and Discussion

In essence, this preliminary experiment served as a foundational research step to gather empirical data, ensuring the subsequent design and development of the groundnut thresher would be well-informed, efficient, and capable of delivering optimal performance. Concave clearance, material feed rate, and the threshing cylinder's peripheral speed are the most crucial parameters directly impacting a thresher's performance. Experimenting with these variables helps pinpoint the ideal combination to maximize threshing efficiency (separating pods from vines), minimize broken pod percentage, prevent pods from being blown out or left unthreshed, and optimize energy efficiency.

Effect of Concave clearance, feed rate and cylinder speed on cleaning efficiency (%): The interaction between concave clearance, feed rate, and cylinder speed (Fig.1) significantly influenced (0.01%) cleaning efficiency. Cleaning efficiency increased with increased cylinder speed but decreased with increasing feed rate and concave clearance. The highest cleaning efficiency of 98.40% was observed as cylinder speed of 31.5 m/s, feed rate of 7700 kg/h and 25 mm concave clearance, while the lowest efficiency of 95.40% occurred with 21.5 m/s cylinder speed, 7900 kg/h feed rate and 15 mm clearance. The higher efficiency at increased cylinder speeds is likely due to an enhanced blower air flow rate and more effective straw size reduction, improving separation. These findings align with research by Pralhad (2007), Parmanand and Verma (2015), Humphred (2017) and Aboegela *et al.* (2021) [1, 9, 15, 16].

Effect of concave clearance, feed rate and cylinder speed broken pod percentage: The lowest broken pods percentage was found to be 0.70% when feed rate, concave clearance and cylinder speed were 7900 kg/h, 15 mm and 23.5 m/s, respectively. The highest broken pod percentage recorded was 2.60%, occurring with a feed rate of 7700 kg/h, a cylinder speed of 31.5 m/s, and a 15 mm concave clearance (Fig.2). In essence, the lowest breakage scenario balances effective threshing with gentle forces and a protective buffer of crop material. Conversely, the highest breakage scenario combines high-impact forces with intense rubbing and a lack of cushioning, creating conditions highly conducive to pod damage. These interactive effects and their impact on pod breakage are consistent with findings reported by Dhananchezhiyan *et al.* (2013) [7]. As concave clearance increased, pod damage decreased. This happens because a larger gap allows the crop to flow more smoothly, reducing the intense compression, impact, and friction forces acting on the pods. This finding is consistent with research by Wacker (2003), Saeidirad and Javadi (2011), and Saeidirad *et al.* (2013) [24, 25, 26]. Conversely, higher cylinder speeds resulted in increased pod damage. This is due to the stronger impacts, greater friction, and intensified rubbing forces generated during threshing at higher speeds, leading to more extensive breakage. This trend aligns with findings from Singhal and Thierstein (1987), Asokan (1997), Dogra *et al.* (2014) [3, 8, 20], and Sudjan *et al.* (2002) [22], all of whom indicate that increased cylinder speed, and often feed rates, lead to greater seed damage.

Effect of concave clearance, feed rate and cylinder speed blown pod percentage: The blown pod percentage increased with higher cylinder speeds and decreased with larger concave clearances (Fig.3). Specifically, at the lowest cylinder speed (23.5 m/s), the blown pod percentage ranged from 1.26% (15 mm clearance, 7700 kg/h feed rate) down to a minimal 0.06% (25 mm clearance, 7900 kg/h feed rate). As cylinder speed increased to 27.5 m/s and 31.5 m/s, the blown pod percentage rose proportionally across all tested feed rates and concave clearances. The highest recorded value was 2.05%, observed at the maximum cylinder speed (31.5 m/s), smallest concave clearance (15 mm), and lowest feed rate (7700 kg/h).

Blown pod percentage is primarily governed by the interplay of mechanical forces and aerodynamics. Higher cylinder speeds increase blown pods by generating more broken pods (due to stronger impacts) which have lower terminal velocities, and by creating stronger internal airflow that expels these lighter fragments. Conversely, larger concave clearances reduce blown pods by causing less aggressive threshing and thus fewer broken pods. Additionally, higher feed rates can paradoxically decrease blown pods due to a cushioning effect and reduced effective airflow velocity, preventing lighter pods from escaping. Ultimately, blown pod percentage reflects the balance between broken pod generation (cylinder speed, concave clearance) and the aerodynamic forces within the thresher (cylinder speed, feed rate). Similar finding were also observed by Dhananchezhiyan *et al.* (2013) and Dewangan *et al.* (2025) [5, 7].

Effect of concave clearance, feed rate and cylinder speed un-threshed pod

Unthreshed pod percentage consistently decreased with increased cylinder speed, reaching its lowest (0.30%) at the highest speed (31.5 m/s), smallest concave clearance (15 mm), and moderate feed rate (7800 kg/h). Conversely, increasing concave clearance directly raised the unthreshed pod percentage (Fig.4). This is because higher cylinder speeds generate stronger impact and rubbing forces, efficiently detaching pods, while a wider concave clearance reduces these critical forces, allowing pods to pass unthreshed. The data suggests a moderate feed rate (7800 kg/h) is optimal, as very low rates might lack sufficient material for effective interaction, and very high rates could overload the system. In essence, achieving the lowest unthreshed pod percentage requires a precise balance: high cylinder speeds for effective separation, low concave clearances for vigorous interaction, and moderate feed rates to ensure consistent processing without overload or inadequate engagement. The findings of the study were consistent with those reported by Sinha *et al.* (2009), Singh *et al.* (2009), Zaalouk (2009), Osueke (2011), Bawatharani *et al.* (2012), Ahmad *et al.* (2013) [2, 4, 14, 21, 23].

Conclusion

The results from testing the groundnut thresher demonstrate its high effectiveness, with an exceptional average threshing efficiency of 99%. It was discovered to be the most variable characteristic, indicating its sensitivity to operational parameters, even if the average cleaning efficiency was likewise high. The concave clearance and peripheral speed might be adjusted to boost the thresher's robust average output capacity of 2000 kg/h. There was a cost associated with this output boost, too, as cleaning effectiveness decreased as input rates increased. Overall, the thresher was a very effective machine for post-harvest processing, with low losses and little pod damage.

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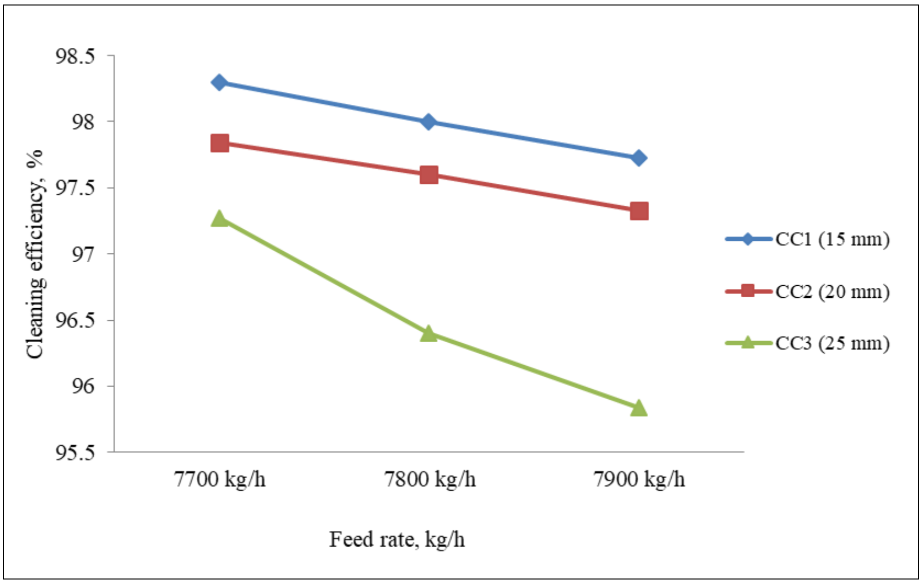


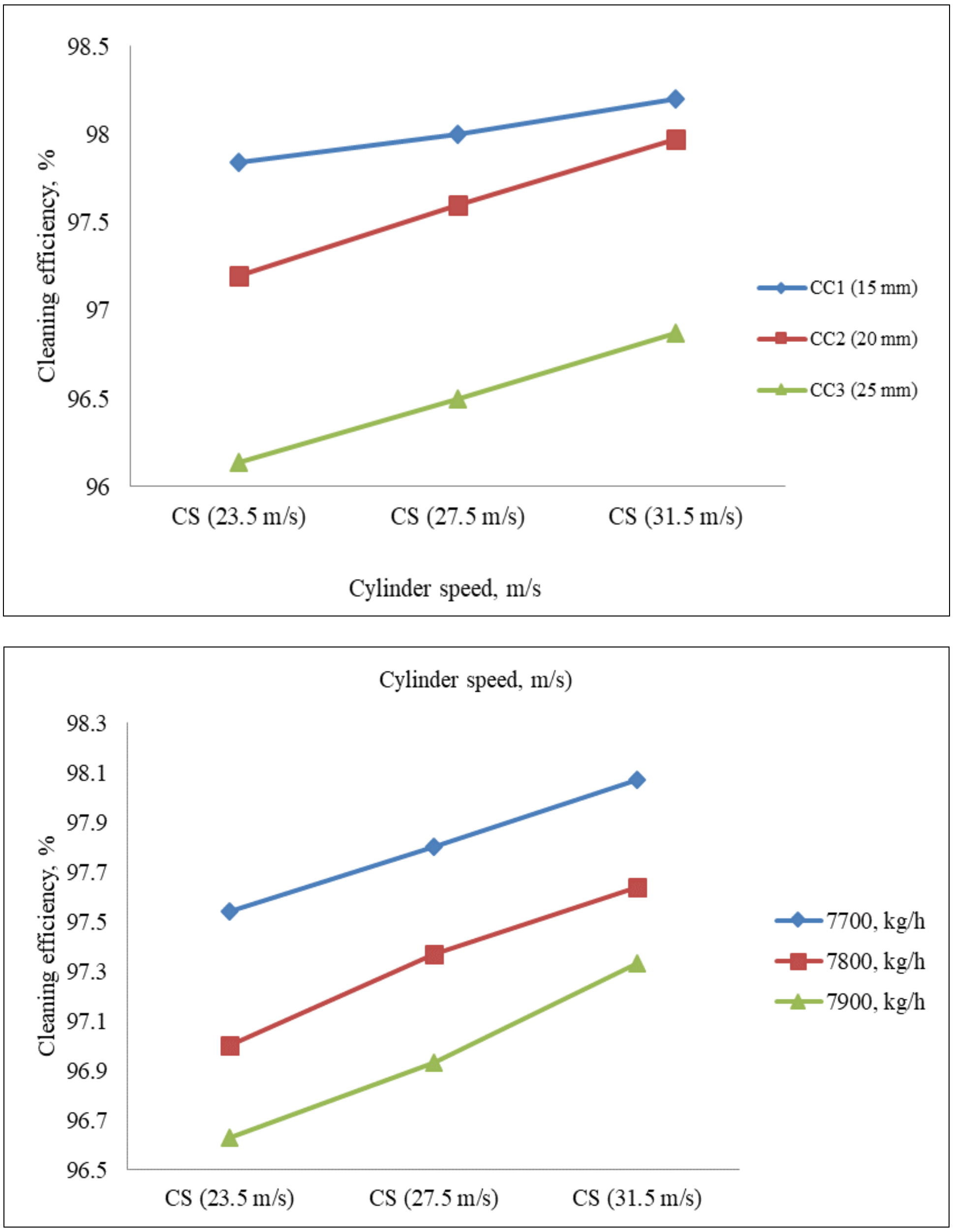
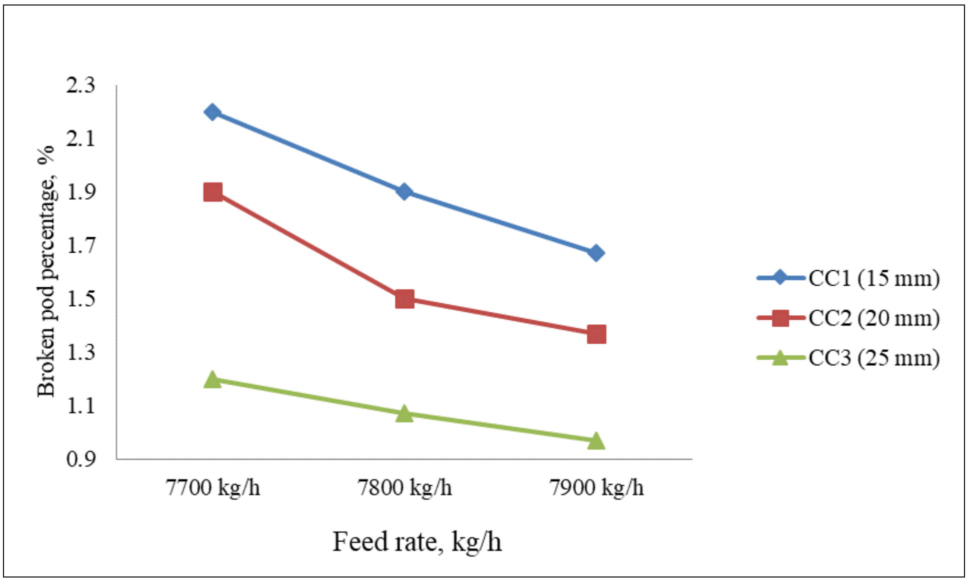
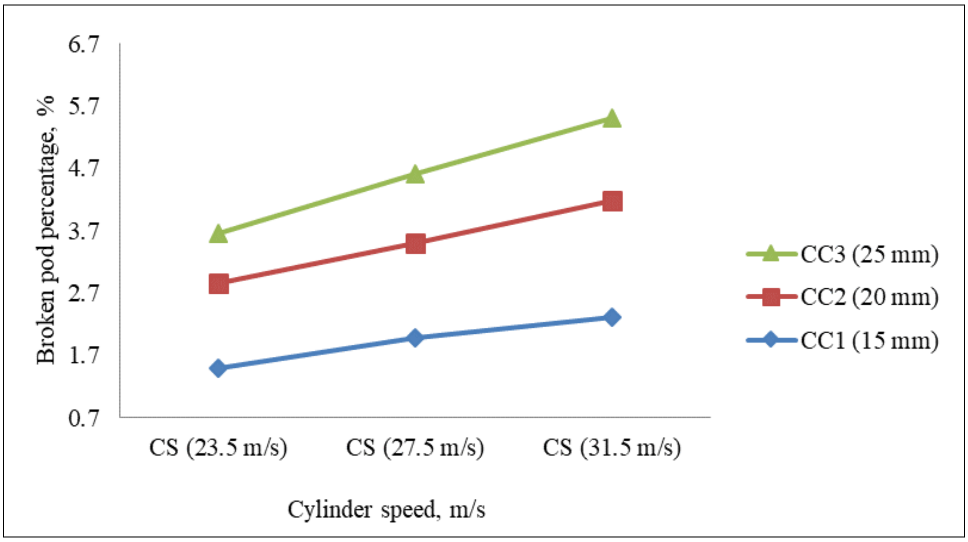


Fig 1: Effect of Concave clearance, feed rate and cylinder speed on cleaning efficiency (%)





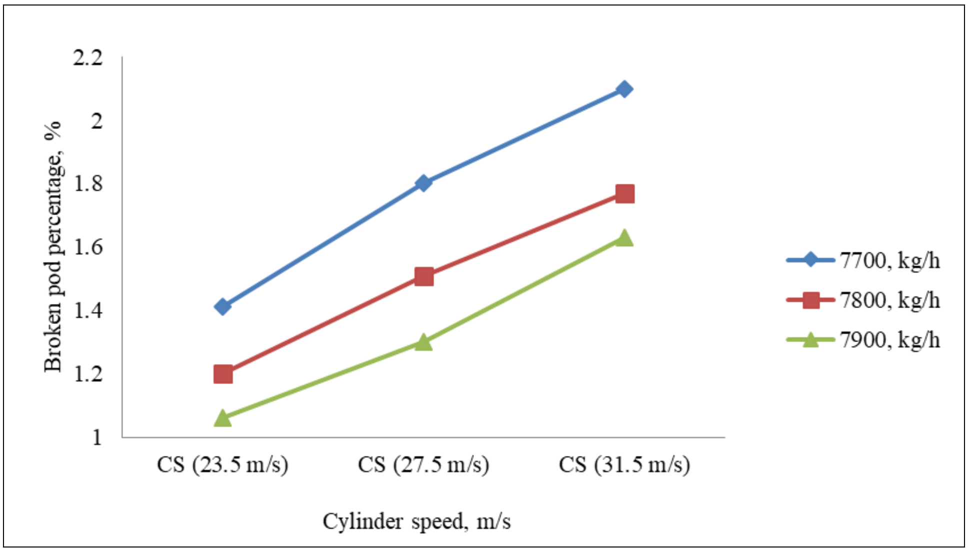
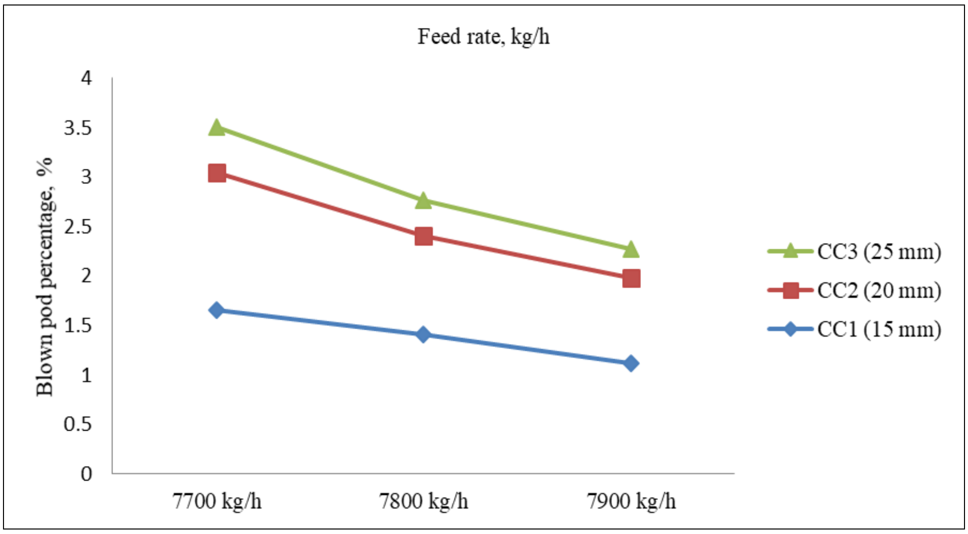
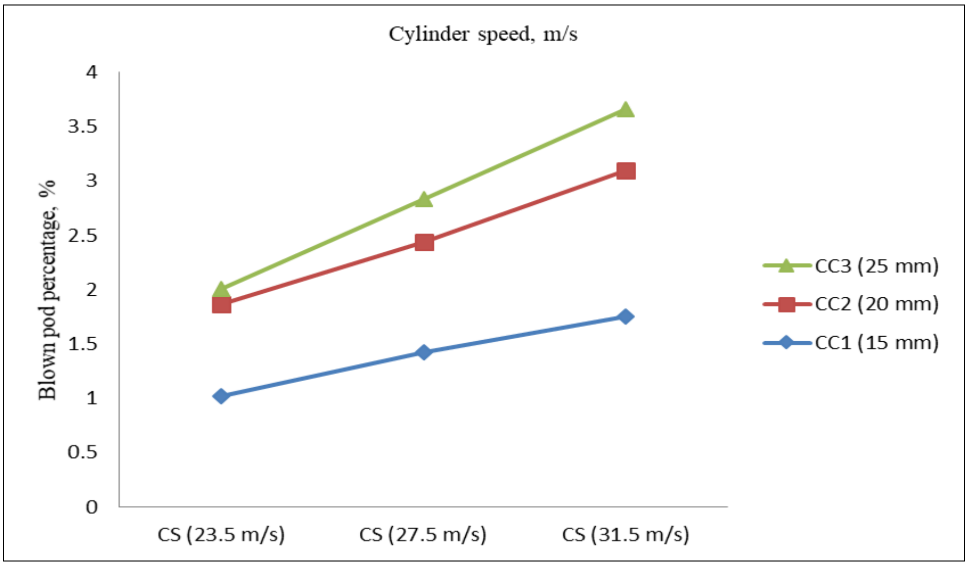


Fig 2: Effect of Concave clearance, feed rate and cylinder speed on broken pod (%)





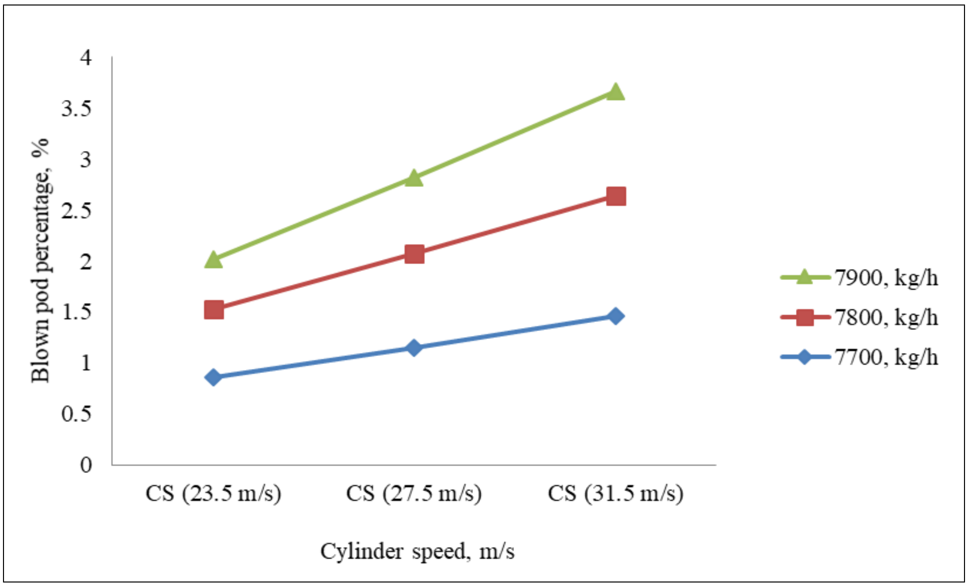
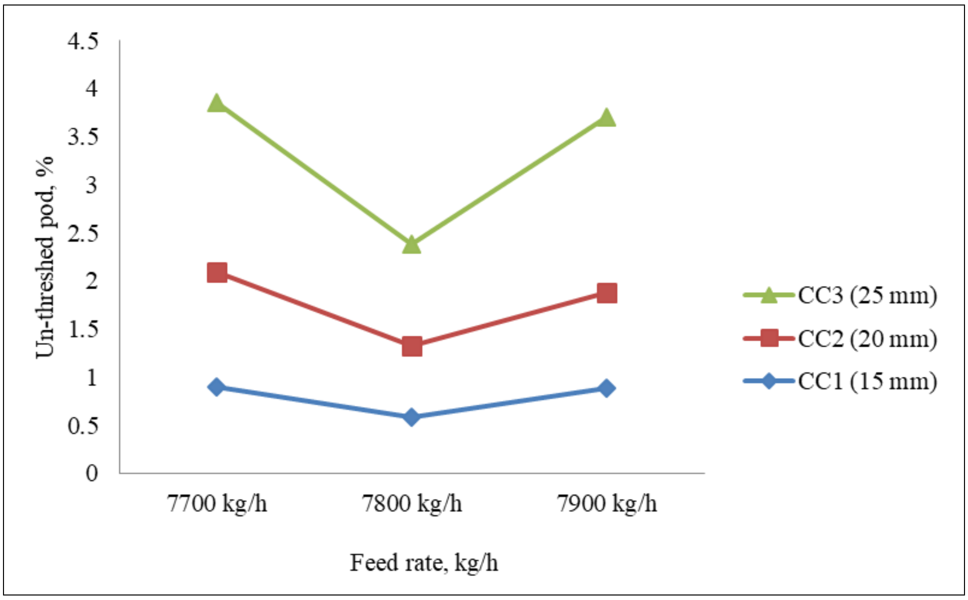


Fig 3: Effect of Concave clearance, feed rate and cylinder speed on blown pod (%)



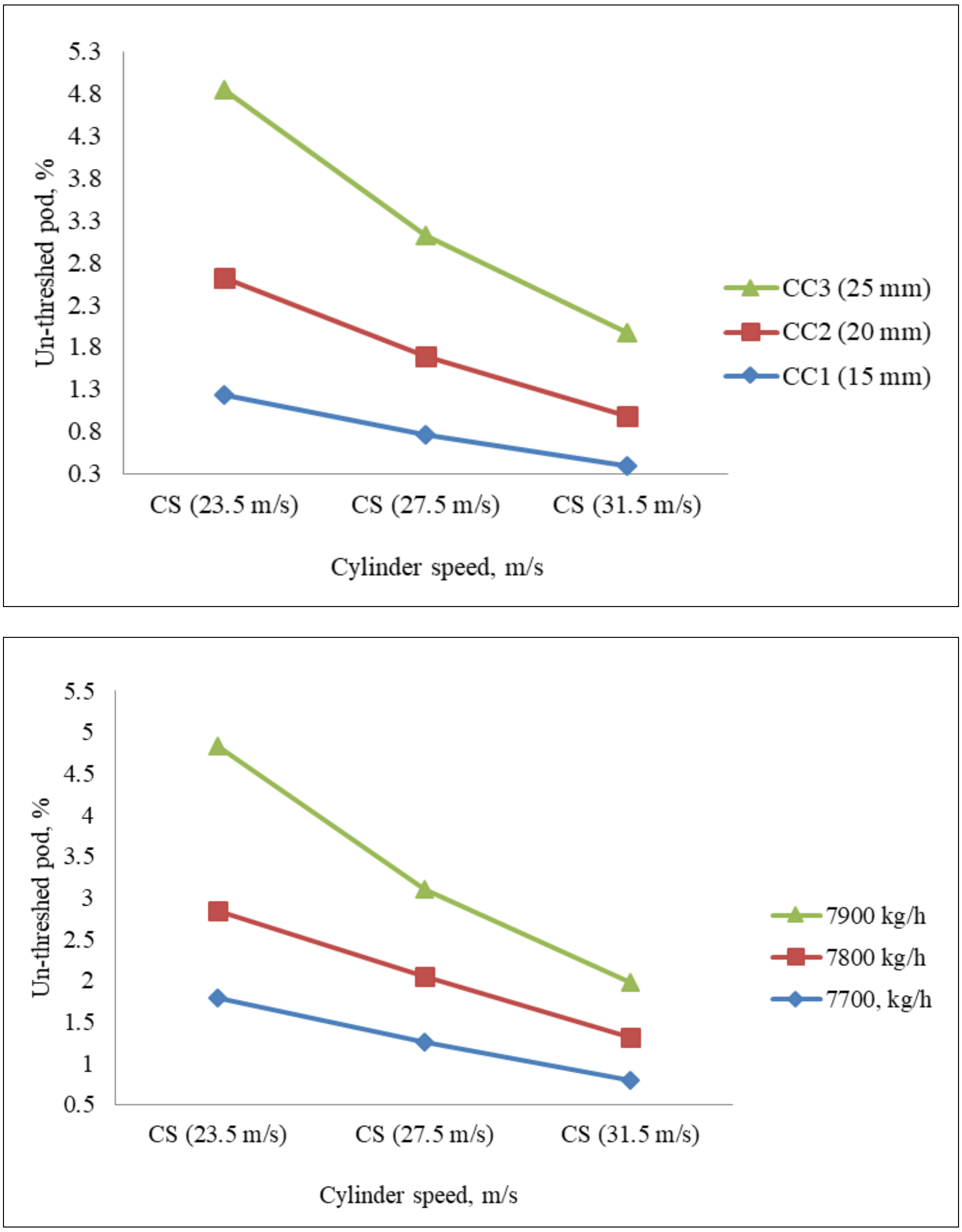


Fig 4: Effect of Concave clearance, feed rate and cylinder speed on unthreshed pod (%)

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