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Coping with *Rhizopertha dominica*: Navigating the Economic Consequences and Mitigation Strategies in Post-Harvest Wheat

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Authors' contributions

This work was carried out in collaboration between both authors. Author SS collected all the samples, performed monitoring of experiment, find values, noted out and tabulate the data. Author SA sat the laboratory experiment, monitored and fulfilled the required lab conditions, carried out statistical analysis and provided data for tables and graphs. Both authors read and approved the final manuscript.

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ABSTRACT

The present investigation was carried out within the confines of the Department of Zoology at Acharya Narendra Dev Nagar Nigam Mahila Mahavidyalaya in Kanpur, Uttar Pradesh, in the year 2023. The primary objective was to delve into the economic ramifications stemming from the feeding habits of Lesser grain borer, *Rhizopertha dominica*, on wheat the focus of to assessed the resultant damage and subsequent losses incurred during storage. Upon meticulous observation, it became evident that *R. dominica* exacted a substantial toll on the overall quality and quantity of the stored wheat, culminating in significant economic losses. The deleterious impact on the grains after 90 days of storage commencement, revealed a staggering 11.37% loss in weight. Within this

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context, the efficacy of powdered forms of *Cinnamomum verum* and *Syzygium aromaticum* as botanical pesticides was meticulously evaluated in countering the presence of *R. dominica* within post-harvested wheat. The judicious application of 15 grams of powder per 100 grams of wheat grains yielded noteworthy effectiveness in mitigating the ravages and consequential financial setbacks inflicted by *R. dominica*. Both *C. verum* and *S. aromaticum* powders played a pivotal role in curbing weight losses, achieving notable reductions of up to 8.7% and 7.9%, respectively. Remarkably, *C. verum* emerged as the more potent agent compared to *S. aromaticum* in this regard. The utilization of these powdered remedies demonstrates a formidable potential in pest management, particularly in addressing the challenges posed by *R. dominica* infestations in stored wheat. This intervention serves as a robust deterrent against incurring substantial economic losses.

Keywords: Rhizopertha dominica; Cinnamomum verum; Syzygium aromaticum; wheat; botanical pesticides.

1. INTRODUCTION

Cereal grains, including wheat, corn and rice are the primary sources of dietary energy in many countries. However, these grains are vulnerable to infestation by insects that commonly affect stored products, such as the lesser grain borer known as *R.* dominica [1]. Wheat (*Triticum aestivum* L.) belong to family Poaceae and Order Poales is an ancient and extensively cultivated crop that has played a crucial role in the development and advancement of human civilization and are integral parts of its botanical classification. Wheat assumes a paramount role in the realm of nutrition, standing as a quintessential cereal grain replete with vital nourishment. Emanating from its complex carbohydrates is a wellspring of enduring energy, accompanied by a bounty of dietary fiber that not only fosters gastrointestinal well-being but also orchestrates efficacious weight management. These attributes depends on the configuration and interplays of the grain storage proteins [2]. Moreover, wheat bestows an array of proteins, an assortment of pivotal B vitamins, alongside pivotal minerals like iron, magnesium, and zinc, collectively underpinning cardinal facets of energy metabolism, cellular functionality, and immune fortification. Its inherent repository of antioxidants and phytochemicals confers prospective health dividends by mitigating oxidative stress and engendering holistic vitality. Post-harvest losses stemming from the infestation of stored product insects have been gauged at a range of 9% within developed nations, while surging to an alarming 20% or possibly beyond within the context of developing countries [3]. The economic significance of wheat is profound, positioning and a cornerstone crop with multifaceted contributions. Serving as a dietary staple for a substantial global populace, wheat's value reverberates through myriad sectors, that plays a substantial role in addressing the issue of malnutrition [4]. Its pivotal role spans not only ensuring food security but also resonates within the realm of international trade and commercial dynamics. Beyond its nourishing properties, wheat's economic footprint extends to various industries, encompassing food processing, bakery endeavors, and the production of livestock feed. Furthermore, the cultivation and global trade of wheat wield substantial economic prowess, acting as a financial linchpin for farmers, agribusiness entities and entire nations. In summation, the economic eminence of wheat transcends agro-industrial landscapes, weaving itself into the intricate tapestry of global economies. The lesser grain borer, *R. dominica* is widely distributed and known for infesting stored grains worldwide. This species is well-suited to dry environments and is considered a proficient flier, enabling it to easily migrate between storage facilities, leading to the establishment of new infestations [5]. Its presence can lead to significant economic repercussions in post-harvested wheat, stemming from diminished grain quality, quantifiable losses, escalated storage expenses and potential market setbacks. Effective management strategies involve a fusion of preemptive measures, integrated pest management techniques and need based usage of appropriate insecticide helps to minimize these economic implications. The significance of botanical pesticides lies in their role as effective and environmental friendly alternatives than the synthetic chemical pesticides. They often have lower toxicity to non-target organisms and reducing harmful effects on other animals [6]. Additionally, botanical pesticides tend to degrade more rapidly, minimizing residual environmental contamination. Their use can also aid in managing pesticide resistance, as their modes of action differ from synthetic chemicals. Moreover, botanical pesticides align with the growing demand for sustainable agriculture, promoting biodiversity and minimizing the impact on human health and contribute to a more balanced and ecologically sound approach to pest control. [7]. *C. verum*, commonly known as true cinnamon or ceylon cinnamon, holds promise as a botanical pesticide due to its natural compounds that exhibit insecticidal properties. [8]. The essential oil derived from *C. verum* contains active components like cinnamaldehyde, eugenol, and other volatile compounds that have shown insect-repellent and insecticidal effects. When used as a botanical pesticide, *C. verum* extracts or essential oil can deter and control pests by disrupting their feeding, development and reproduction. [9] *S. aromaticum*, commonly known as clove, the most valuable food preservative and used for many medicinal purposes. [10]. It offers potential as a botanical pesticide due to its natural compounds with insecticidal properties. The essential oil extracted from clove buds contains eugenol and other active components that have been found to possess strong insect-repellent and insecticidal effects. [11]. When employed as a botanical pesticide, *S. aromaticum* extracts or essential oil can deter and control pests by disrupting their life cycles and behaviors. This aligns with the increasing interest in sustainable and environmentally friendly approaches to pest management. This investigation underscores the potential efficacy of employing natural plant-derived compounds as an alternative approach to conventional chemical agents focused on the management of *R. dominica* infestations in stored wheat.

2. MATERIALS AND METHODS

The investigation was undertaken at the Department of Zoology, A.N.D.N.N.M. College, situated in Kanpur [Uttar Pradesh, India], during the year 2023.

2.1 Sample Collection

Mature adult male and female *R. dominica* were meticulously gathered from a population exhibiting infestations. After collection, utmost care was taken to ensure that they were kept in their natural state and unaltered. The bark of *C. verum* and the flower buds of *S. aromaticum* were meticulously collected. Subsequent to their collection, a meticulous drying process was employed, succeeded by a fine grinding procedure to yield a fine powder, ready for immediate application. Uncontaminated and intact wheat grains were sourced from the cereal market. Employing a heat sterilization protocol, any concealed infestations were effectively eradicated. Post-sterilization, the disinfected seeds were accurately weighed using a digital balance, and subsequently, they were stored in a cool, dry location, laying the foundation for further research proceedings. This selective sampling strategy allowed for a focused investigation.

2.2 Insect Culture

A controlled laboratory environment was established for the purpose of mass rearing. This environment was maintained at a precisely regulated temperature of 30±2 °C and a relative humidity range of 65±5%. To initiate the experiment, a glass container with a capacity of 1000 ml was employed. Within this container, 500g of meticulously sterilized, healthy wheat grains were placed. Subsequently, a carefully balanced ratio of 50 pairs of adult insects (with a 1:1 male-to-female ratio) was introduced into the container. To ensure adequate airflow, the container's opening was covered with muslin cloth, which was securely fastened using a rubber band. Throughout the duration of the study, meticulous observations were conducted on a regular basis, exercising the utmost caution. This comprehensive monitoring process extended over the entire course of the investigation. Notably, newly emerged adult specimens were designated as the succeeding generation, thus serving as the focal point for subsequent phases of study.

2.3 Experimentation

2.3.1 Effect of protectant on damage and losses

The experimentation was conducted within glass jars, each possessing a volumetric capacity of 300 ml. Within these confined environments, a consistent methodology was upheld. Specifically, 100 grams of grains were placed within each jar. Notably, the experimental setup introduced variations by incorporating differing quantities of protectants powder – specifically, 5 grams, 10 grams and 15 grams,– alongside a controlled treatment. This assortment of powder quantities was thoughtfully designed to discern potential effects on the grains. Upon the culmination of all experimental trials, a systematic process was enacted. Precisely, 50 fresh and 50 impaired grains were selectively extracted from each treatment category, encompassing both protective doses and the control. The evaluation extended beyond mere observation, with the final weight of each sample being meticulously recorded. Subsequently, the percentage weight loss for each distinct treatment was calculated, thereby quantifying the impact of various treatments on the grains. Of paramount significance was the assessment of the control treatment. This evaluation was uniquely structured to ascertain the genuine extent of damage and navigate the economic consequences caused by *R. dominica*. Weight loss percentage was calculated by this formula-

Weight loss (%) = (weight loss of grains / total weight of grains) × 100

2.3.2 Contact toxicity

In the experiment, distinct glass petri-dishes hosted un-infested wheat grains (100g) as the substrate. Within these petri-dishes, diverse dosages of *C. verum* bark powder (5g, 10g, and 15g) were blended with the grains. This was complemented by a control treatment. There was the introduction of 10 pairs of *R. dominica*, in each petri-dish with precautions taken to prevent their escape by securely covering them. Subsequent to a precisely timed interval of 48 hours, close scrutiny ensued to ascertain adult mortality rates, with subsequent enumeration leading to the calculation of mortality percentages. This computation adhered to the established Omotosho and Oso formula from 2004 [12]. Significantly, an analogous experiment was separately conducted, featuring *S. aromaticum* powder as the evaluative element. This approach amplified the research's reliability and depth, offering a comparative perspective on the effects of these botanical agents on *R.dominica* mortality. Collectively, this rigorous methodology and comprehensive design yielded insights into the potential pest management efficacy of these natural substances.

2.4 Statistical Analysis

The data acquired from the laboratory experiments underwent rigorous statistical analysis to derive meaningful insights. The statistical framework employed was that of a Complete Randomized Design (CRD), a well-established approach to experimental design. To facilitate clarity and comparability, the collected data was converted into percentages, reflecting the proportional impact of the various treatments. This transformation allowed for a standardized representation of the results, making it easier to discern patterns and trends. In the pursuit of comprehensive visualization, final tables and graphs were meticulously crafted utilizing the capabilities of Microsoft Office Excel. These visual aids were systematically generated to effectively present the outcomes of the experimentation in a clear and organized manner, aiding in the interpretation and communication of the research findings.

3. RESULTS AND DISCUSSION

The outcomes of the study yielded remarkably significant results concerning the management of *R. dominica*. Two types of plant powders, namely *C. verum* bark and *S. aromaticum* buds, were employed as bio-pesticides to combat *R. dominica* infestation in stored wheat. Various doses of these powders- 5g, 10g, and 15g per 100 grams of wheat grains were meticulously prepared and assessed over a span of 90 days, in addition to a control group. The control treatment exhibited a notable weight loss of 11.37%. In the case of the *C. verum* treatment, when a 5g dose was administered, the weight loss percentage decreased to 8.03%. Similarly, the application of a 10g dose resulted in a weight loss percentage of 4.97%. Most notably, with a 15g dose, the weight loss percentage plummeted to a mere 2.67%. Consequently, the application of a 15g dose of *C. verum* led to a substantial reduction of 8.7% in wheat grain weight loss, as compared to the control treatment. [Table 1 and Chart 1].

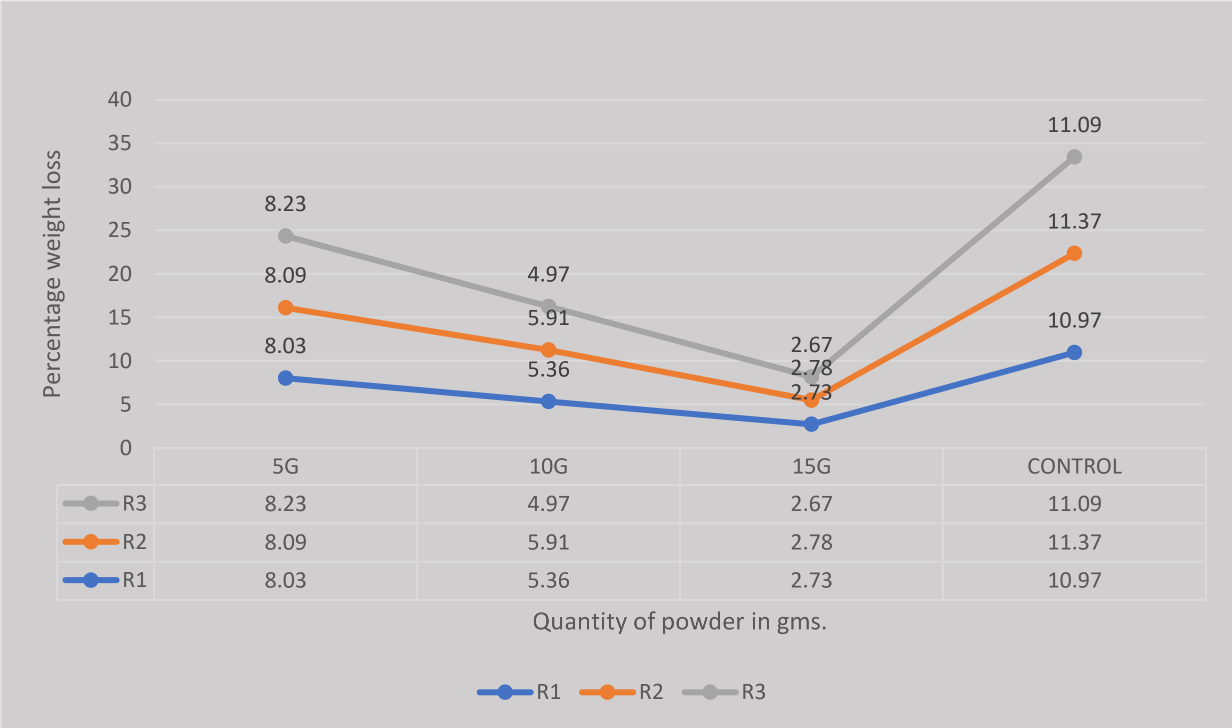
Other treatment involving *S. aromaticum* exhibited diverse outcomes. Its 5g dose led to an 8.2% weight loss, which notably decreased to 6.27% with a 10g dose. The most significant reduction was observed with a 15g dose, resulting in a mere 3.47% weight loss. A significant reduction of 7.9% was observed when contrasted with the control group. Both the botenicals viz., *C. verum* and *S. aromaticum* played a pivotal role in mitigating weight losses, achieving substantial reductions of up to 8.7% and 7.9%, respectively. [Table 2 and Chart 2]. Impressively, *C. verum* emerged as the more potent agent in this regard as compared to *S. aromaticum*.

Table 1. Observations of *Cinnamonum verum*

S.N.	Days of the observation	Grain weight before infestation [in gm.]	Replications	Quantity of leaf powder (in gm.)	Grain weight after infestation [in gm.]	Grain weight loss (%)
			R1	5	91.97	8.03
1.	90	100	**R2**	5	91.91	8.09
			R3	5	91.77	8.23
			R1	10	94.64	5.36
2.	90	100	**R2**	10	94.09	5.91
			R3	10	95.03	4.97
			R1	15	97.27	2.73
3.	90	100	**R2**	15	97.22	2.78
			R3	15	97.33	2.67
			R1	00 (Control)	89.03	10.97
4.	90	100	**R2**	00 (Control)	88.63	11.37
			R3	00 (Control)	88.91	11.09

Table 2. Observations of *Syzygium aromaticum*

S.N.	Days of the observation	Grain weight before infestation [in gm.]	Replications	Quantity of leaf powder (in gm.)	Grain weight after infestation [in gm.]	Grain weight loss (%)
			R1	5	91.52	8.48
1.	90	100	**R2**	5	91.98	8.02
			R3	5	90.79	9.21
			R1	10	93.45	6.55
2.	90	100	**R2**	10	93.73	6.27
			R3	10	93.08	6.92
			R1	15	96.63	3.47
3.	90	100	**R2**	15	95.99	4.01
			R3	15	96.07	3.93
			R1	00 (Control)	89.03	10.97
4.	90	100	**R2**	00 (Control)	88.63	11.37
			R3	00 (Control)	88.91	11.09



	5G	10G	15G	CONTROL
R3	8.23	4.97	2.67	11.09
R2	8.09	5.91	2.78	11.37
R1	8.03	5.36	2.73	10.97

Chart 1. Observations of *Cinnamonum verum*

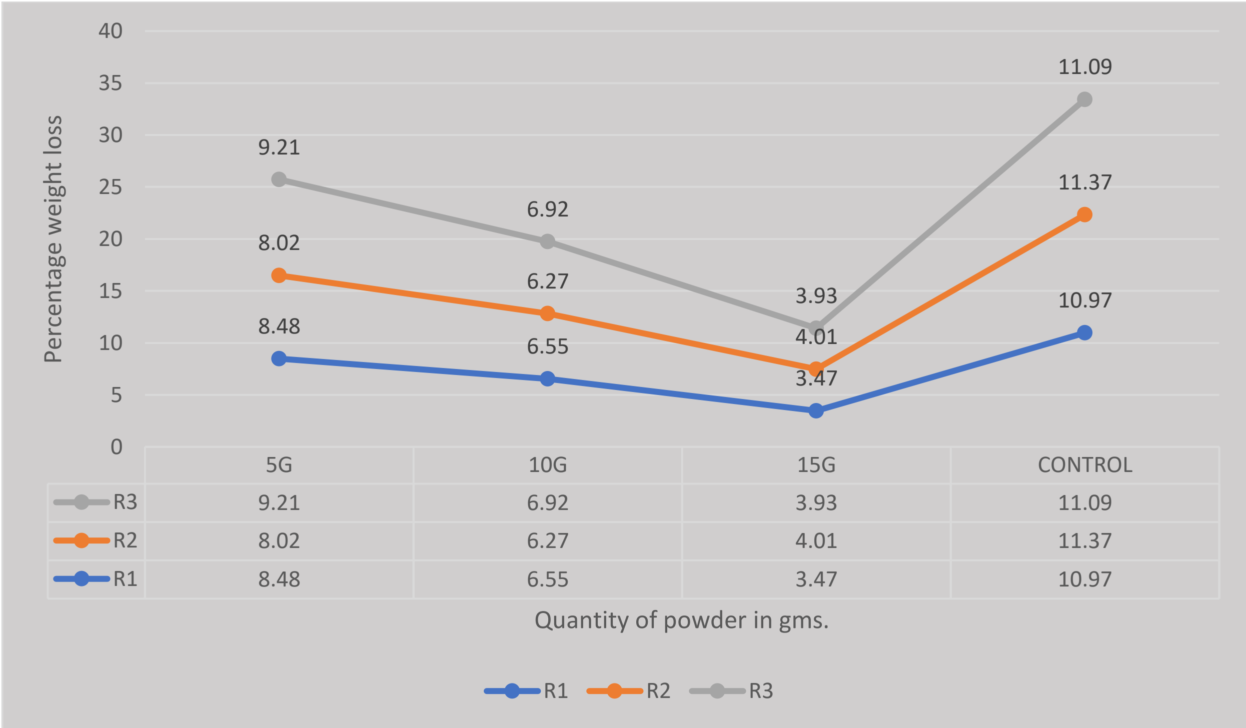


Chart 2. Observations of *Syzygium aromaticum*

Table 3. Percentage contact mortality

S.N.	Quantity of grains (in gm.)	Quantity of powder (in gm.)	% contact mortality [*Cinnamonum verum*]	% contact mortality [*Syzygium aromaticum*]
1.	100	05	10	5
2.	100	10	15	20
3.	100	15	45	40
5.	100	00 (Control)	0.00	0.00

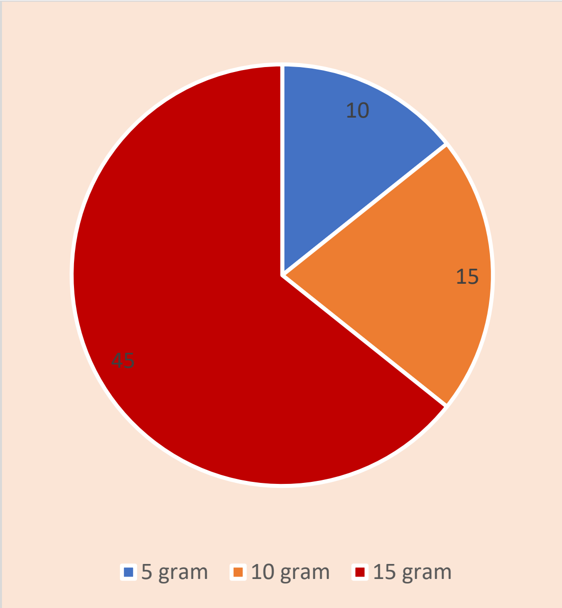


Chart 3. Percentage mortality caused by Cinnamonum verum at different doses

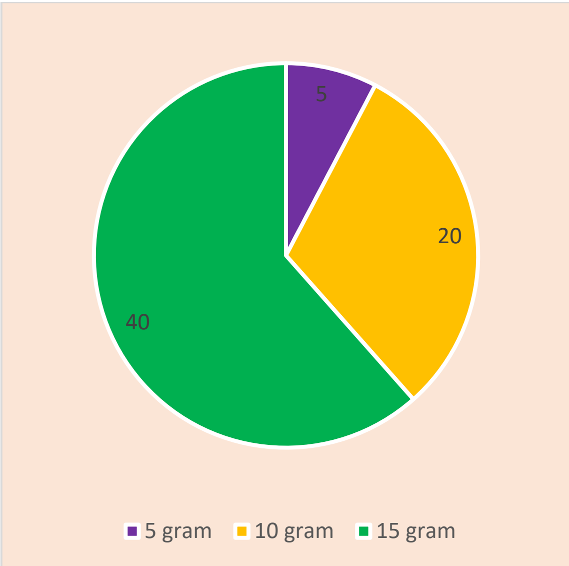


Chart 4. Percentage mortality caused by *Syzygium aromaticum* at different doses

Furthermore, in terms of their contact mortality effects, *C. verum* exhibited the highest rate at 47%, while a similar level of 43% contact mortality was achieved with *S. aromaticum* with 15g doses of both powders. [Table 3 and Charts 3 & 4].

4. CONCLUSION

Botanical pesticides harmonize with the escalating demand for sustainable agriculture, fostering biodiversity, and minimizing repercussions on human health. Their utilization also contributes to the management of pesticide resistance, as their mechanisms of action deviate from synthetic chemicals. This resonates with the growing interest in ecologically sound and environmentally friendly approaches to pest control, effectively deterring substantial economic losses.

AVAILABILITY OF DATA AND MATERIAL

All data and information which used in this work are of high quality and grade, supports the findings of this study are available within this paper provided in Tables 1, 2, 3 and Charts 1, 2, 3, 4.

DECLARATION

I Shraddha Srivastava, declare that the submitted research paper is my original work and no part of it has been published anywhere else in the past. I take full responsibility, that if in future, the paper is found invalid according to basic rules, the last decision will be of the authorities concerned.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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