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Organic Grain Protectants for Enhancing Storability of Rice Seeds

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

An experiment was conducted at the Department of Seed Science and Technology, College of Agriculture, Vellayani to study the influence of organic grain protectants in enhancing storage life of rice seeds. The experiment consists of six treatments with different organic grain protectants *viz* Arka (*Calotropis gigantea*) leaf powder, Neem (*Azadirachta indica*) leaf powder, Pongamia (*Pongamia pinnata*) leaf powder, Sweet flag (*Acorus calamus*) rhizome powder, Arappu (*Albizia amara*) leaf powder and control. All the treatments were effective in control of storage pest and

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mycoflora infestation without any seed damage and weight loss compared to control with 62.33,16.25 per cent seed damage and weight loss. The treatment T_4 [Sweet flag (*Acorus calamus*) rhizome powder] recorded superior among all treatments, germination percentage (82.00%), germination energy (81.00%), seedling vigour index (1029.20), seedling shoot length (13.03 cm), seedling root length (12.40 cm). However, among all treatments T_4 [Sweet flag (*Acorus calamus*) rhizome powder] recorded least Seed damage percentage, seed weight loss percentage, total number of adult insects and mycoflora infestation compared to control.

Keywords: Rice seeds; organic grain protectants; seed storage; storage pest; mycoflora infestation; seed germination.

1. INTRODUCTION

Seed is the fertilized, matured ovule and a carrier of genetic potential for sustainable crop production. It is the basic and crucial input of agriculture around which all other input acts. Rice (*Oryza sativa)* is a staple food for half of the world's population but it is severely threatened by diseases. The population may meet the requirements of only 60% of the population (FAO, 2018). "China is the leading producer of rice (142.3 million tonnes) followed by India (110.4million tonnes, thereby plays a major role in meeting the rice demand. Seed storage is an essential segment of seed industry. In storage, viability and vigour of the seeds is regulated by many physico-chemical factors like moisture content of the seed atmospheric humidity, temperature, initial seed quality, physical and chemical composition of seed, gaseous exchange, storage structure and packaging materials. The production and supply of quality seed is one of the important factors responsible for the increased productivity and production of any crop. The highest quality of the seed is attained under that complex of conditions evoking the most favourable interactions Storage pest infestation, Seed germination and mycoflora between genetic makeup of a seed and the environment under which it is produced, harvested, processed and stored. The seed potentiation is mainly achieved by treating the seeds with various chemicals and botanicals can reduce the infestation and maintain the quality of the seed in term of viability and vigour for longer period in storage. Maintenance of seed quality during storage period is important not only for successful crop production but also for maintaining the quality and integrity of the seed that are inconstant threat of genetic erosion. The use of naturally occurring seed protectants and usage of bio-control agents is powerful alternative. Use of locally available plant materials to protect seeds from insect pests is a common age-old practice and the extracts from different plants have been known to possess insecticidal properties against wide range of pests" (Isman 2008). "Standardize of seed treatment with organic grain protectants would be of great advantage to reduce the problems in maintenance of seed quality during storage. Leaf and fruit powders of herbal plants are widely used for seed treatment" (Bashyam 1999). "The performance of dry seed treatment with crude plant materials in powder form have been found to significantly slow down the deterioration of seeds under various ageing conditions" (De et al*.* 2004 in wheat; Rudrapal and Basu, 2004 in French bean; Sengupta et al. 2005 in onion; Kundagrami et al*.* 2008 in rice). The pest-controlling efficacy of many plant derivatives has already been proved against several storage pests and they can improve seed quality. A number of synthetic and natural components have been suggested as potential candidate for seed treatment. The almost non-existent and therefore could be beneficial to our agricultural sector. However, their efficiency as well as effect on seed quality remains to be observed (Kumar 2017).

2. MATERIALS AND METHODS

The experiment was conducted in Department of Seed Science and Technology, College of Agriculture, Vellayani, Thiruvananthapuram to study the effects of organic grain protectants in enhancing storage life of rice seeds. The experiment consists of six treatments viz T_1: Arka (*Calotropis gigantea*) leaf powder @ 12.5g, T_2: Neem (*Azadirachta indica*) leaf powder @ 12.5g, T_3: Pongamia (*Pongamia pinnata*) leaf powder @ 12.5g, T_4: Sweet flag (*Acorus calamus*) rhizome powder @ 5g, T_5: Arappu (*Albizia amara*) leaf powder @ 12.5g, T_6: Control. The experiment was conducted in Completely Randomized Block Design (CRD) in three replications.500 grams of seed was used in each replication and packed in cloth bags stored for ten months at room temperature. The bimonthly observations on

various parameters were carried out and statistically analysed. The percentage seed damage was determined by collecting a sample of 100 seeds from each three replications of each treatment at bimonthly intervals proposed by Adams and Schulten (Adams et al. 1978). Seed weight loss percentage was calculated from number of damaged and undamaged seeds, weight of damaged and undamaged seeds as given by Adams and Schulten (Adams et al. 1978). Total number of adult insects was also calculated at bimonthly intervals. Mycoflora infestation was assessed by agar plate method. The germination test was carried out with 100 seeds in four replications with rolled paper towel method for 8 days (ISTA 2013). Normal healthy seeds were taken for germination test. Other germination parameters like germination energy, seedling shoot and root length, Seedling vigour index (Abdul-Baki 1973) was calculated at bimonthly intervals.

Seed damage percentage =

$$\frac{Number\ of\ damaged\ seeds}{Total\ number\ of\ seeds\ taken} \times 100$$

Seed weight loss percentage

$$= \frac{U\ (Nd) - D\ (Nu)}{U\ (Nu + Nd)} \times 100$$

Nd- Number of damaged seeds
Nu- Number of undamaged seeds
D- Weight of damaged seeds
U- Weight of undamaged seeds

Germination percentage =

$$\frac{\text{Number of seeds germinated}}{\text{Total number of seeds taken}} \times 100$$

Germination energy =

$$\frac{\text{Number of seeds germinated on day 4 count}}{\text{Total number of seeds tested}} \times 100$$

Seedling vigour index = Per cent seed germination x Seedling length

3. RESULTS AND DISCUSSION

3.1 Storage Pest Infestation Assessment

Among the different treatments all the organic grain protectants used were significantly superior to control. Seed damage was not observed in treatments T_1 [*Calotropis gigantea* leaf powder @ 12.5g/500g], T_2 [*Azadirachta indica* leaf powder @ 12.5g/500g], T_3 [*Pongamia pinnata* leaf powder @ 12.5g/500g] for up to four months of storage and T_5 [*Albizia amara* leaf powder @ 12.5g/500g] for up to two months of storage. No seed damage and weight loss were observed in T_4 [*Acorus calamus* rhizome powder @ 5g/500g] for up to six months of storage. In contrast, seed infestation was observed from initial month up to ten months in control. At the end of storage period, seed damage percentage was highest in control (62.33%) which was then followed by T_5 (20.33%), T_2 (13.33%), T_1 (12.33%). Treatment T_4 recorded damage percentage 5.667% which was on par with T_3 (8.667%). Seed weight loss was highest in control (16.25%) lowest in T_4 (7.53%). The results were in agreement the findings of Shukla et al. 2002 concluded that the dose of 5mg rhizome powder of *Acorus calamus* per gram proved fatal, causing 100 per cent mortality of *C. chinensis* in chickpea and completely inhibiting F_1 emergence. In the study, three major storage pests were found infesting the seeds. various treatments were lesser grain borer (*Rhyzopertha dominica*), rice weevil (*Sitophilus oryzae*) and Angoumois grain moth (*Sitotroga cerealella*) during different periods of storage. In control lesser grain borer (*Rhyzopertha dominica*), rice weevil (*Sitophilus oryzae*) and Angoumois grain moth (*Sitotroga cerealella*) was observed from two, four and six months of storage. Where as in T_4 adult insects were observed from sixth month- lesser grain borer (*Rhyzopertha dominica*) and rice weevil (*Sitophilus oryzae*) from eighth month of storage onwards. No incidence of Angoumois grain moth (*Sitotroga cerealella*) throughout the storage period. The total number of adult insects at the end of ten months storage in control was lesser grain borer (*Rhyzopertha dominica*) with 7.66%, rice weevil (*Sitophilus oryzae*) with 7.33% and Angoumois grain moth (*Sitotroga cerealella*) with 2.333%. In contrast in T_4 lesser grain borer (*Rhyzopertha dominica*) with 1.66%, rice weevil (*Sitophilus oryzae*) with 0.66%. Paul et al. 1965 and Jillani and Haq, 1984 reported that *Acorus calamus* rhizome powder repelled the population of *S. oryzae* and *R. dominica*. Similarly, in another test conducted against Angoumois grain moth, (*Sitotroga cerealella* O.), it was found that 100% mortality was resulted when rhizome dust of *A. calamus* was used at 10g/kg of rice grain (Timsina et al. 2007). The results of the present findings are agreement with the results of Kudachi and Balikai 2009 who reported that *A. calamus* rhizome powder @ 1 percent recorded percent adult mortality of *R. dominica* with zero percent seed damage, minimum percent seed weight loss of zero percent.

Table 1. Effect of Organic grain protectants on seed damage percentage and seed weight loss percentage

Treatment	Seed damage percentage			Seed weight loss percentage		
	2 MAS	6 MAS	10 MAS	2 MAS	6 MAS	10 MAS
T_1 *Calotropis gigantea* leaf powder @ 12.5g/500g	0.00	1.33	12.33	0.00	2.37	10.99
T_2 *Azadirachta indica* leaf powder @ 12.5g/500g	0.00	1.66	13.33	0.00	2.33	10.32
T_3 *Pongamia pinnata* leaf powder @ 12.5g/500g	0.00	1.00	8.66	0.00	2.32	10.03
T_4 *Acorus calamus* rhizome powder @ 5g/500g	0.00	0.33	5.66	0.00	1.03	7.53
T_5 *Albizia amara* leaf powder @ 12.5g/500g	0.33	2.33	20.33	0.33	3.03	11.21
T_6 Control	1.33	13.66	62.33	3.00	9.46	16.25
SE (m)	0.19	0.87	2.76	0.43	0.58	0.81
CD (5%)	NS	2.685	8.532	NS	1.809	2.500

MAS-Months After Storage

Table 2. Effect of organic grain protectants on total number of adult insects

Treatment	Lesser grain borer (*Rhyzopertha dominica*)			Rice weevil (*Sitophilus oryzae*)			Angoumois grain moth (*Sitotroga cerealella*)		
	2 MAS	6 MAS	10 MAS	2 MAS	6 MAS	10 MAS	2 MAS	6 MAS	10 MAS
T_1 *Calotropis gigantea* leaf powder @ 12.5g/500g	0.000	0.66	3.33	0.00	0.33	4.33	0.00	0.00	0.66
T_2 *Azadirachta indica* leaf powder @ 12.5g/500g	0.000	0.66	2.66	0.00	0.00	3.33	0.00	0.00	0.00
T_3 *Pongamia pinnata* leaf powder @ 12.5g/500g	0.000	0.33	1.66	0.00	0.00	1.33	0.00	0.00	0.00
T *Albizia amara* leaf powder @ 12.5g/500g	0.000	0.33	1.66	0.00	0.00	0.66	0.00	0.00	0.00
T_5 *Albizia amara* leaf powder @ 12.5g/500g	0.000	1.33	6.33	0.00	0.66	5.33	0.00	0.00	1.33
T_6 Control	0.667	4.33	7.66	0.00	1.66	7.33	0.00	0.66	2.33
SE (m)	0.27	0.62	1.24	0.00	0.40	1.20	0.00	0.13	0.62
CD (5%)	NS	1.922	3.843	NS	NS	3.703	NS	NS	NS

Table 3. Effect of organic grain protectants on mycoflora infestation

Treatment	Mycoflora infestation in seeds (%)		
	2 MAS	6 MAS	10 MAS
T_1 *Calotropis gigantea* leaf powder @ 12.5g/500g	0.00	6.67	20.00
T_2 *Azadirachta indica* leaf powder @ 12.5g/500g	0.00	2.67	25.12
T_3 *Pongamia pinnata* leaf powder @ 12.5g/500g	0.00	2.67	17.13
T_4 *Acorus calamus* rhizome powder @ 5g/500g	0.00	0.00	10.16
T_5 *Albizia amara* leaf powder @ 12.5g/500g	0.00	4.66	37.13
T_6 Control	0.00	42.66	69.33
SE (m)	0.00	2.09	5.86
CD (5%)	NS	6.442	18.065

Table 4. Effect of organic grain protectants on germination parameters

Treatment	Germination percentage			Germination energy		
	2 MAS	6 MAS	10 MAS	2 MAS	6 MAS	10 MAS
T_1 *Calotropis gigantea* leaf powder @ 12.5g/500g	95.33	89.66	79.66	86.67	82.33	77.33
T_2 *Azadirachta indica* leaf powder @ 12.5g/500g	96.33	89.00	80.67	88.67	83.00	77.00
T_3 *Pongamia pinnata* leaf powder @ 12.5g/500g	96.00	89.66	80.00	89.00	84.00	78.67
T_4 *Acorus calamus* rhizome powder @ 5g/500g	97.66	91.00	82.00	89.67	86.00	81.00
T_5 *Albizia amara* leaf powder @ 12.5g/500g	96.00	89.33	79.66	88.00	82.67	77.67
T_6 Control	95.33	87.60	74.00	87.66	82.00	75.33
SE (m)	0.72	0.79	0.94	0.79	1.21	0.86
CD (5%)	NS	2.445	2.905	NS	NS	2.652

Table 5. Effect of organic grain protectants on seedling vigour index, seedling shoot length and seedling root length

Treatment	Seedling vigour index			Seedling shoot length			Seedling root length		
	2 MAS	6 MAS	10 MAS	2 MAS	6 MAS	10 MAS	2 MAS	6 MAS	10 MAS
T_1 *Calotropis gigantea* leaf powder @ 12.5g/500g	1218.3	1144.2	959.7	12.33	11.73	10.93	12.66	12.63	11.90
T_2 *Azadirachta indica* leaf powder @ 12.5g/500g	1207.0	1152.2	991.4	11.63	11.70	10.30	12.40	12.80	12.16
T_3 *Pongamia pinnata* leaf powder @ 12.5g/500g	1349.7	1178.1	988.0	13.50	12.93	12.00	13.93	13.00	12.20
T_4 *Acorus calamus* rhizome powder @ 5g/500g	1381.2	1221.2	1029.0	14.06	13.66	13.03	14.00	13.26	12.40
T_5 *Albizia amara* leaf powder @ 12.5g/500g	1184.6	1130.4	961.0	11.40	11.66	10.33	12.23	12.53	11.90
T_6 Control	1341.7	1100.0	942.00	12.53	11.66	10.20	13.90	12.40	11.80
SE (m)	83.45	91.61	58.64	0.28	0.30	0.26	0.90	0.99	0.68
CD (5%)	NS	282.28	180.70	0.887	0.934	0.812	NS	NS	2.112

3.2 Mycoflora Infestation Assessment

In the assessment of mycoflora infestation was highest in control (69.33%) and least in T_4 (10.16%) which was recorded from eighth month of storage onwards, whereas in control from fourth month onwards. The infested mycoflora in storage was *Aspergillus flavus*. *A. calamus* shows growth inhibitory effect against *Aspergillus flavus* and *Aspergillus niger*. Since the plant is easily available to farmers, it could serve as an alternate approach to chemical fungicides which are costly and highly toxic (Bisht et al. 2011).

3.3 Seed Germination Parameters

Organic grain protectants improved the seed germination parameters compared to control. After ten months of storage seed treated with T_4 Sweet flag (*Acorus calamus*) rhizome powder recorded highest in seed germination percentage, vigour index and seedling parameters. The results were in accordance with (Anandi R, 2001 -cowpea; Parameswari, 2002 - pigeon pea) seed treated with *Acorus calamus* rhizome powder excelled other botanicals in the seed quality maintenance. At the end of ten months of storage period T_4 recorded highest germination per cent (82.00%) which was on par with T_3 (80.00%). Also, T_6 recorded the lowest germination per cent (79.00%) among all treatments. Satisfactory germination (80%) as per the Indian minimum seed certification standards for rice was maintained for 12 months and even more period with sweet flag rhizome powder seed treatment. With respect to sweet flag rhizome powder, higher germination noticed may be related to its antioxidant property of β asarone which acts as a scavenger of free radicals and inhibit seed deterioration. These results are in accord with the findings of Bhargude et al. 2021 in sorghum. The treatment T_4 recorded maximum germination energy, seedling vigour index, seedling shoot and root length among all treatments with 81.00%, 1020.20,13.03 cm and 12.40 cm. In contrast control was recorded lowest germination energy, seedling vigour index, seedling shoot and root length with 75.33%, 942.00, 10.26cm and 11.80 cm.

The increased rate of imbibition, where the tiny particles in the coating act as a "wick" or moisture-attracting material, or possibly to improve germination, was the cause of the seed treated with *Acorus calamus* rhizome powder's improved vigour metrics (Renugadevi et al. 2006). Gadewar et al. 2017 observed sorghum seeds treated with sweet flag powder (2.5 per cent) showed significantly higher 100 seed weight, germination percentage, seedling vigour, field emergence percentage compared to other seed treatment and control during storage. Regarding seed treatments, the seeds treated with sweet flag rhizome powder at a rate of 20 g kg^{-1} had the greatest root length (13.40 cm), shoot (8.98 cm), seedling length (22.39 cm), and seedling vigour index I (2037) after 12 months of storage (Radha et al. 2024). Improved germination rates are a result of maintaining seed integrity and reducing insect infestation (Latha 2015). The powder contains bio active compounds that can stimulate seed metabolism and enhance the overall vigour of the seeds. Treatment with sweet flag rhizome powder helps maintain seed viability during storage by reducing seed damage and preserving seed quality. The powder may also improve the availability of essential nutrients to the seeds, promoting better germination and early seedling growth.

4. CONCLUSION

Out of all the organic grain protectants used in this investigation, Acorus calamus was able to sustain germination above IMSCS and provided total seed protection by inhibiting Sitophilus oryzae-induced seed damage. A. calamus has a well-established insecticidal effect on a variety of insect pests. The current study suggests using Acorus calamus rhizomes to suppress weevils. Because A. calamus products are used as medications all over the world, they may be less dangerous to people than the majority of traditional pesticides. Herbal plants that are readily available and virtually harmless to the environment and human health are used as organic grain protectants. We agree that some traditionally used botanicals can be an excellent alternative to chemical pesticides in stored grains if used in the correct dose and method. The ease in availability and simplicity in these botanicals are most likely to be accepted and adopted by the farmers.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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