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Influence of Rice Grain Physico-Chemical Traits on Infestation of *Sitotroga cerealella* (Olivier)

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***Abstract*:** Experiment was conducted to observe the influence of grain physical and biochemical parameters against Angoumois grain moth, *Sitotroga cerealella* at Department of Entomology, Agricultural College, Bapatla. A total of 15 pre-released and released rice genotypes were evaluated to analyze their physical and biochemical characteristics. The grain hardness, grain length, grain breadth, husk thickness of rice genotypes ranged from 55.59 to 102.02 N, 7.52 to 9.56 mm, 1.96 to 2.86 mm, 0.09 to 0.23 mm, respectively. The percent protein, total soluble sugars, amylose, ash and silica contents of uninfested rice genotypes ranged from 6.13 to 9.03, 70.44 to 78.67, 20.87 to 35.37, 7.13 to 11.84, 2.91 to 6.18, respectively. Significant positive correlation was observed between grain damage and weight loss due to *S. cerealella* with regard to total soluble sugars, protein and ash content of rice genotypes, whereas, negative correlation was with regard to amylose and silica content of rice genotypes. The infestation of *S. cerealella* on rice genotypes showed significant increase in protein and ash contents after three months of storage.

***Keywords*:** Angoumois grain moth, Genotypes, Grain hardness, Husk thickness, Physiochemical properties

Rice (*Oryza sativa* L.) is a crucial staple for much of the world's population, supplying over one−fifth of daily calories globally. India, with its diverse agro-ecological zones, stands as the second largest producer of rice. Despite advances in cultivation, one of the persistent challenges is post−harvest loss during storage. Storage pests can inflict losses of 20% or more in developing countries, undermining food security and farmers' livelihoods.

Among stored−grain pests, the Angoumois grain moth (*Sitotroga cerealella* (Olivier)) is particularly destructive in rice, as well as in other cereals such as wheat, maize, sorghum, oats and barley. The larvae of *S. cerealella* bore into grains and consume large portions of the endosperm, leading to reductions in germination capacity, development of off−odours and deterioration in appearance and seed quality. Because new rice genotypes are continually released to meet yield, quality, and climate adaptability goals, there is a pressing need to assess how resistant these varieties are to storage pests (Ashamo 2010). Physical traits such as grain hardness, husk or outer layer thickness, grain size, shape, and moisture content may affect the ability of *S. cerealella* to infest, develop and damage grains. Biochemical traits such as protein, starch, fat or lipid content, or other enzymes/metabolites may also play a role in resistance or susceptibility (Demissie et al., 2015). In this study, aim to examine the physico−chemical properties of several rice genotypes and their relationship with infestation, development, and damage by *Sitotroga cerealella*.

MATERIAL AND METHODS

Fifteen rice genotypes were procured from three different Rice Research Stations in Andhra Pradesh. The selected genotypes were disinfested to eliminate any live insect stages present by keeping them in a hot air oven at 60°C for 5 hours and then equilibrated to a moisture content of 12-13%.

Mass rearing of *S. cerealella*: *Sitotroga cerealella* was mass reared on disinfested rice grains of commercial genotype BPT 5204 under controlled laboratory conditions. Stock culture was started by placing 20 adults of *S. cerealella* in culture jar containing 500 g of rice grains. Honey solution (1:10, Honey: water) was provided as adult food for egg laying. The adults of *S. cerealella* were removed after five days and the jars were incubated. Fresh batch of moths started emerging out in about 3-4 weeks after incubation. Newly emerged adults were collected into required number of jars with rice grains. Parent moths were allowed to lay eggs on the grains and jars were kept undisturbed for three weeks. Emerging moths were collected and transferred to the fresh medium and this process was repeated to maintain the culture.

Screening: Fifty grams of disinfested healthy grains of each rice genotype were taken in individual plastic container of 250 ml size and five pairs of one-day-old (0-24h) healthy adults of *S. cerealella* were released and removed once they died. Experiment was conducted under laboratory conditions (28±2°C and 65±5% RH) with three replications. After twenty days, the jars were examined *daily* for per cent grain *damage*.

Percent grain damage: A sample of 5g was taken from each treatment in which total number of grains and number of damaged grains were counted.

Determination of physical characteristics: The physical properties of genotypes *viz.*, size of the grain, surface texture, grain hardiness and thickness of husk were estimated. Grain size and thickness of husk was measured by using screw gauge. The texture of grains was assessed based on visual observation. The grain hardiness of each genotype was tested by using grain hardness tester (Kiya Seisa Kusho Ltd. Japan).

Biochemical analysis for qualitative/nutritional losses: Total soluble sugars (Yemm and Willis 1954), amylose (McCready et al., 1950), protein (Lowry et al., 1951), ash (AOAC 2000) and silica (Kamath and Proctor, 1998) were determined according to the standard protocols.

Statistical analysis: The influence of physical properties *was* correlated with per cent grain damage of genotypes by *S. cerealella*. The influence of per cent protein, total soluble sugars, amylose, ash and silica contents were correlated with per cent weight loss and grain damage of varieties by *S. cerealella.*

RESULTS AND DISCUSSION

Physical parameters of rice genotypes: The grain hardness of rice genotypes indicated that a minimum of 55.59 Newton force was required to break the grains of MTU 1166 genotype followed by BPT 5204 genotype, *which required 58.86 N*. Highest force of 102.02 Newton was needed to break down the grains of MTU 7029 genotype. *Thus,* MTU 7029 *was* the hardest among all genotypes and MTU 1166 was the most fragile. The grain length and width among rice genotypes ranged between 7.52 and 9.56 mm and 1.96 and 2.86 mm, respectively. Highest grain length was observed in MTU 1290 genotype with 9.56 mm, while the lowest grain length was recorded in NLR 9674 (7.52 mm). Highest grain width was recorded in genotype MTU 3626 (2.94 mm), whereas the lowest grain width was observed in BPT 5204 (1.96 mm). L/B ratio was calculated and it ranged between 2.64 and 4.23. Based on L/B ratio, genotypes were classified as long slender (LS) and medium slender (MS) (Table 1). Husk thickness of rice genotypes ranged between 0.09 and 0.23 mm. More thickness was observed in BPT 1235 (0.23 mm), while the least was observed in MTU 1187 (0.09 mm) (Table 1). The results are in conformity with Aruna and Ratnasudhakar (2009) who evaluated fifteen genotypes of rice against *S. cerealella*. Among the physical parameters grain texture, hardness and husk thickness contributed *resistance* against *S. cerealella*.

Correlation between physical parameters and grain damage: Correlation studies between physical parameters and grain damage are presented in Table 2. Per cent grain damage was significantly negatively correlated with grain hardness (-0.654) and grain length (-0.332), but was negatively and *non-significantly* correlated with grain width. Husk thickness was significantly negatively correlated with per cent damage (-0.0658). Gopala Swamy et al. (2019)

Table 1. Physical parameters of rice genotypes

Genotypes	Grain damage (%)	Length (mm)	Breadth (mm)	Hardness (N)	Husk thickness (mm)	Texture	L/B	Grain type
BPT 5204	10.67	7.78	1.96	58.86	0.11	Super fine grain	3.97	LS
BPT 2846	5.00	8.06	2.06	84.37	0.12	Coarse grain	3.91	LS
BPT 1235	7.33	8.58	2.20	79.79	0.23	Fine grain	3.90	LS
BPT 2295	9.67	8.02	2.02	79.79	0.12	Fine grain	3.97	LS
MTU 7029	5.33	7.56	2.18	102.02	0.10	Coarse grain	3.47	LS
MTU 3626	5.67	8.62	2.94	70.63	0.12	Fine grain	2.93	MS
MTU 1217	6.00	7.56	2.86	96.14	0.21	Fine grain	2.64	MS
MTU 1187	9.33	8.66	2.30	79.79	0.09	Coarse grain	3.77	LS
MTU 1166	12.33	7.56	2.04	55.59	0.11	Coarse grain	3.71	LS
MTU 1290	1.67	9.56	2.26	89.60	0.12	Fine grain	4.23	LS
NLR-9674	7.67	7.52	2.74	87.96	0.10	Fine grain	2.74	MS
NLR 40058	3.33	8.02	2.30	92.87	0.12	Fine grain	3.49	LS
NLR 28523	4.67	7.64	2.68	89.60	0.11	Fine grain	2.85	MS
NLR 34449	5.67	7.82	2.08	74.56	0.12	Fine grain	3.76	LS
NLR 30491	4.33	7.74	2.44	74.56	0.11	Coarse grain	3.17	LS
CD (p=0.05)		0.40	0.15	4.08	NS			

Source of Genotypes: The rice genotypes used in this study were procured from Agricultural Research Station (ARS) Bapatla (BPT 5204, BPT 2486, BPT 1235, BPT 2295) Agricultural Research Station (ARS) Nellore (NLR 9674, NLR 40058, NLR 28523, NLR 34449, NLR 30491) and Regional Agricultural Research Station (RARS) Maruteru (MTU 7029, MTU 3626, MTU 1217, MTU 1187, MTU 1166, MTU 1290)
LS= Long Slender, MS=Medium Slender , Mean of 5 grains

aloes reported that bold varieties with thicker husk were less prone to Angoumois grain moth infestation than the varieties having fine grain with thinner husk.

Biochemical analysis: The uninfested rice genotypes exhibited significant variation in their biochemical composition. Total soluble sugars averaged 74.35%, ranging from 70.44% to 78.67%, with the highest content observed in BPT 5204, followed by MTU 1187, BPT 2846, BPT 1235, and MTU 1166. Protein content varied from 6.13 to 9.03%, with an average of 7.32%; the highest was in MTU 1166, while MTU 1290 showed the lowest. Amylose content ranged from 20.87 to 35.37%, with an average of 26.03%, and the maximum was in NLR 34449. Ash content showed range of 7.13 to 11.84%, with NLR 34449 recording the highest and NLR 40058, the lowest. Silica content varied between 2.91 and 6.18%, averaging 5.11%, with the highest in NLR 40058 and the lowest in MTU 1166.

Protein content of rice genotypes *was* positively correlated with the per cent damage and per cent weight loss due to the infestation ~~of~~ *by S. cerealella* on rice grains (Table 4). This finding is in conformity with Muthukumar (2014) and Rizwana et al. (2011) where positive correlation between protein content of the rice genotypes and per cent weight loss caused by *S. cerealella*. Swamy et al. (2022) alsoo reported a positive correlation between protein content and adult emergence of *S. cerealella*.

The significant positive correlation was observed between total soluble sugars and the percentage of damage caused by *S, cerealella*, indicating that higher sugar content may enhance susceptibility to infestation. Similarly, ash content showed a significant positive correlation with both

Table 2. Correlation studies between physical parameters of rice genotypes and per cent grain damage by *Sitotroga cerealella*

Variable	Correlation Co-efficient	
Grain damage Vs Grain hardness	-0.654**	Significant at 5% level
Grain damage Vs Grain length	-0.332*	Significant at 1% level
Grain damage Vs Grain width	-0.333	Non-significant
Grain damage Vs Husk thickness	-0.0658	Non-significant

*, **Correlation significant at the 0.05 and 0.01 level (2 tailed)

Table 4. Correlation between biochemical parameters of rice grains and damage by *S. cerealella* after three months of storage

Variable	Correlation coefficient	
Biochemical parameters	Per cent weight loss	Per cent damage
Total Soluble Sugars	0.156*	0.004*
Protein	0.9207*	0.066*
Amylose	-0.169	-0.183
Ash	0.812***	0.891***
Silica	-0.745**	-0.752**

***, **, * Correlation is significant at 0.001 , 0.01 and 0.05 level

Table 3. Bio-chemical composition of uninfested rice genotypes during storage

Genotypes	Uninfested grain				
	TSS (%)	Protein (%)	Amylose (%)	Ash (%)	Silica (%)
BPT 5204	78.67	8.14	25.01	10.09	4.70
BPT 2846	78.29	7.39	27.20	8.18	5.58
BPT 1235	77.41	7.57	22.30	9.60	3.54
BPT 2295	72.09	8.02	30.34	9.93	5.16
MTU 7029	73.36	6.80	24.06	8.07	5.54
MTU 3626	75.14	7.40	24.99	8.97	4.62
MTU 1217	74.36	7.50	26.80	9.49	5.60
MTU 1187	78.38	7.99	28.06	10.29	5.04
MTU 1166	76.36	9.03	20.93	11.84	2.91
MTU 1290	70.44	6.13	24.11	7.38	6.09
NLR 9674	71.30	7.53	20.87	8.43	4.61
NLR 40058	72.15	6.34	31.86	7.13	6.18
NLR 28523	73.32	6.67	27.55	7.50	5.74
NLR 34449	73.04	7.08	35.37	9.77	5.91
NLR 30491	71.03	6.24	21.00	8.10	5.43
CD (p=0.05)	1.80	0.37	1.62	0.36	0.33

Table 5. Effect of *S. cerealella* infestation on biochemical characteristics of rice genotypes during storage

Genotypes	Infested grain				
	TSS (%)	Protein (%)	Amylose (%)	Ash (%)	Silica (%)
BPT 5204	73.16	8.32	23.82	10.40	3.85
BPT 2846	74.60	7.41	24.67	8.61	5.29
BPT 1235	71.87	7.60	20.95	10.01	3.11
BPT 2295	67.27	8.14	28.83	10.29	3.80
MTU 7029	68.74	6.90	23.41	8.20	4.88
MTU 3626	70.04	7.49	23.83	9.50	3.97
MTU 1217	69.04	7.53	25.09	9.83	4.02
MTU 1187	73.98	8.03	26.96	10.44	4.69
MTU 1166	67.01	9.28	20.72	12.08	2.01
MTU 1290	68.23	6.15	23.04	7.43	5.88
NLR 9674	67.30	7.59	20.27	8.61	3.59
NLR 40058	70.2	6.38	30.68	7.61	4.84
NLR 28523	70.17	6.70	24.85	7.88	3.81
NLR 34449	66.39	7.13	32.94	9.93	5.56
NLR 30491	69.90	6.29	20.83	8.10	4.36
CD (p=0.05)	1.742	0.167	0.868	0.468	0.308

damage and weight loss, which is consistent with the findings of Rizwana et al. (2011) and Kiran and Kumar (2020). In contrast, silica content exhibited a negative correlation with damage and weight loss, with lower silica levels recorded in highly susceptible genotypes. Higher silica content is believed to enhance grain hardness, thereby creating a physical barrier that delays or prevents larval penetration, thereby conferring resistance. Amylose content was also negatively correlated with damage and weight loss, as lower amylose levels are often associated with higher chalkiness and reduced grain hardness, which may facilitate easier infestation by *S. cerealella*.

Nutritional changes in rice genotypes due to infestation by *S. cerealella* after three months of storage: The protein and ash content increased significantly in rice genotypes following *S. cerealella* infestation, particularly in highly susceptible varieties such as MTU 1166 and BPT 5204 (Table 5). This rise in protein and ash is attributed to the accumulation of insect body fragments, cast skins and metabolic residues within the grain, rather than an actual improvement in nutritional quality (Nisar et al*.,* 2020, Kishore et al*.,* 2024). In contrast, the least susceptible genotype, MTU 1290, showed a smaller increase in protein content, indicating that reduced insect infestation limits these biochemical alterations. Additionally, a significant reduction in total soluble sugars, amylose, and silica contents was observed in infested grains, with more pronounced decreases in susceptible genotypes. This finding aligns with recent research indicating that stored grain pests consume carbohydrates, which serve as their primary energy source, leading to a depletion of total soluble sugars and starch components such as amylose (Zote and Shukla 2025). The decrease in silica content, which is known to strengthen grain husks and act as a natural barrier to pest, further supports the role of physical grain traits in resistance to *S. cerealella* infestation.

CONCLUSION

This study highlights the significant role of grain physical and biochemical parameters influencing rice genotypes susceptibility to *S. cerealella*. Physical parameters such as grain hardness, size and husk thickness were negatively associated with infestation, indicating their importance in pest resistance. Biochemical factors like higher protein, sugars and ash *were associated with* increased infestation, while higher amylose and silica contributed to resistance. The findings suggest that no single trait can predict resistance, but a combination of characteristics *should* be considered. Despite the threat posed by storage pests, breeding efforts have so far focused mainly on field pests. These results provide a valuable foundation for developing resistant rice varieties, offering a sustainable and eco-friendly approach to managing *S. cerealella* in storage.

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AUTHORS CONTRIBUTION

All authors contributed significantly to the development of this work Raja Mallika A conducted the experiment, collected data, performed statistical analysis and interpreted the results. Madhumathi T provided overall guidance, supervision and critical review of the manuscript. Naik R.B.M. contributed to the compilation and interpretation of relevant literature. Swapna M assisted in biochemical analysis and laboratory work. All authors reviewed, edited and approved the final version of the manuscript.

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