"Effect of Biochemical parameters in Traditional varieties of rice against *Sitophilus oryzae* (L.) infestation"

Abstract

The management of rice weevil infestations in traditional rice varieties presents unique challenges. Traditional storage practices and methods may not always align with contemporary insect pest management strategies furthermore, the genetic diversity of traditional rice varieties means that insect pest management solutions need to be tailored to specific varieties and local conditions. Twelve rice genotypes were procured from different Farmers of Telangana State. The selected genotypes, after procurement, were thoroughly cleaned by removing physical impurities if any and thereafter they were kept in an incubator at a temperature of 55ºC for four hours to kill the immature stages of insects if any without affecting the viability of the seeds. In this study, the reduced adult emergence in moderately resistant varieties could be linked to their elevated ash content. This high ash content in the seeds may deter insects due to potential toxicity, rendering these varieties less preferred for feeding, growth, and emergence by the grub.

Keywords: storage practices, physical impurities, rice weevil infestations, pest management

1. INTRODUCTION

Rice (*Oryza sativa* L.) is one of the most staple food globally, providing sustainability for more than half of the world's population, making it the most crucial crop globally. In Telangana it is cultivated nearly area 3186.40 lakh hectares, production 10217.13 lakh tons and productivity 3206 kg per hectare during 2020-2021. Among districts of Telangana, in area Nalgonda ranks first whereas in production Nizamabad ranks first (Agri stat info, 2022). Rice ranks as the world's second most essential cereal crop and serves as a fundamental food source in India. It has influenced the cultures, diets, and economies of billions globally. Central to national well-being and food security, rice holds a critical position in India. Following China, India stands as the top producer and a leading exporter of rice worldwide (Viraktamath *et al*., 2011).

Despite technological advancements boosting food grain production, significant losses occur due to poor storage practices. It is estimated that 60-70% of the nation's food grain is kept in traditional household storage methods, including bamboo baskets, mud structures, gunny sacks, and modern bins (Navin *et al*., 2015). India faces post-harvest losses of 12 to 16 million metric tons of food grains annually, a volume the World Bank estimates could feed one-third of the nation's poor. These losses are valued at over Rs. 50,000 crores per year (Singh, 2010). In India, insect pests are estimated to damage 6.5 % of the total stored grains (Raju, 1984).

Traditional rice varieties, cultivated for centuries are integral to the cultural and agricultural heritage of many regions. These varieties often exhibit unique traits such as resilence to local environment conditions and resistance to certain pest and diseases. Despite their benefits, the susceptibility of these varieties to storage insect pests like the rice weevil has not been thoroughly investigated.

The management of rice weevil infestations in traditional rice varieties presents unique challenges. Traditional storage practices and methods may not always align with contemporary insect pest management strategies furthermore, the genetic diversity of traditional rice varieties means that insect pest management solutions need to be tailored to specific varieties and local conditions. Identifying and utilizing resistant traditional varieties can provide an environmentally friendly alternative to chemical pest control preserving both agricultural biodiversity and traditional farming practices.

2. MATERIALS AND METHODS

Twelve rice genotypes were procured from different Farmers of Telangana State. The selected genotypes, after procurement, were thoroughly cleaned by removing physical impurities if any and thereafter they were kept in an incubator at a temperature of 55ºC for four hours to kill the immature stages of insects if any without affecting the viability of the seeds (Singh, 1989). Thereafter moisture content of the test genotypes was standardized to near equilibrium by keeping the genotypes in the desiccator containing saturated solution of KOH for 21 days (Solomon, 1951). This pre-conditioned seed material was used in the experiment.

2.1 Sexing and mass multiplication

The test insect was mass multiplied on paddy BPT 5204 and freshly emerged seven days old adults were used forscreening studies. The male and female sexes of the weevils were recognized according to the characters described by Halstead (1963) i.e weevils having relatively long rostrum with narrow punctures along the rostrum arranged in regular rows and not touching each other were characterized as females. Whereas, males are characterized by having short rostrum with wide punctures along the rostrum. These are large and irregular, not in a row and often touching eachother.

2.2 Screening

Ten grams of seed was taken and placed in small plastic tubes (7.5 cm x 5 cm) with tiny punctures on the lid (under three replications). The test insects (eight females and four males) were introduced into each tube to infest ten grams seeds of each test genotype (Gbaye and Ajiye, 2016). They were incubated at a temperature and relative humidity of 26±2ºC and 70±5 per cent, respectively. The weevils were allowed to oviposit in the seeds for two weeks and then removed. The plastic tubes were kept back in incubator till the F1 adults emerge.

2.3 Mean adult emergence

The number of adults that emerged from each replication of the treatments were counted daily and discarded from the respective tubes until they cease to emerge. The mean adult emergence was worked out by pooling the data.

2.4 Mean development period:

The mean development period of test insect was worked out as per Howe (1971)

$$D = \frac{\sum (A \times B)}{C}$$

A = Number of adults emerged on n^{th} day B = 'n' days required for their emergence C = Total number of adults emerged during experimental period D = Mean developmental period (days).

2.5 Per cent seed damage

The number of damaged seeds by the weevil in each replication of the treatments was counted at the end of the experiment and converted into per cent damaged seeds.

2.6 Ash content (per cent)

The ash content of the test genotypes was calculated as per AOAC (1984) and expressed in percentage. In this analysis, 5g of finely ground sample of test genotypes was taken and initially charred in the silica crucible. After complete charring, the crucibles were kept in a muffle furnace at 600^0C for 2 hours. Thereafter, the final weight of the sample was deducted from the initial weight and converted into percentage.

$$\text{Ash (per cent)} = \frac{\text{Weight of the ash}}{\text{Initial weight of the sample}} \times 100.$$

2.7 Nitrogen and Crude protein content

Initially Nitrogen content of grain samples was determined as per micro-kjeldahl method as suggested by AOAC (1995) using Kelplus auto analyser. Initially, 0.2g of sample was digested in presence of 2g of catalyst mixture (copper sulphate and potassium sulphate in 1:5 ratio) and 10 ml of conc. sulphuric acid at 420ºC for 2 hours. After cooling, the distillation was carried out in auto distillation system (loaded with 4% boric acid and 40% sodium hydroxide). The distillate obtained was titrated against 0.1N HCL till appearance the of pink colour. The per cent nitrogen was calculated as follows.

$$N2\ (\%) = \frac{\text{(Titre value of sample - Titre value of blank)} \times 14 \times \text{Normality of HCl (0.1)} \times 100}{\text{Weight of sample} \times 1000}$$

The crude protein content was calculated by multiplying the nitrogen percent obtained with the factor 6.25 (Mariotti *et al*., 2008) and expressed in percentage.

2.8 Statistical analysis

The data obtained was analyzed for ANOVA (5% probability level) following completely randomized design by using INDOSTAT statistical software. Percentage data obtained was subjected to angular transformation.

3 RESULTS AND DISCUSSIONS

3.1 Mean adult emergence

The mean number of adults emerged from various test varieties ranged from 3.3 to 26.0 . Significantly less number of adults had emerged from MTU 1010 (3.3) followed by Kabirajsal (8.3), BPT 5204 (8.7), Rajamudi (9.7) Karupukavuni (14.3) which is on par with Rajbhog (16.0). Whereas, significantly highest number of adults had emerged from Navara (26.0) followed by Kalabati (24.7) which is on par with Manipuriblack (22.0), Chittimutyalu (21.7) and Ambemohar (20.0) which is on par with Bahurupi (17.3).

3.2 Mean development period (days)

The mean development period of S. oryzae recorded in various treatments ranged from 32.3 to 45.6 days. Shortest mean development period was observed in Navara (32.3 days) followed by Kalabati (34.3 days) which was on par with BPT 5204 (34.0 days) Manipuriblack (35.3), Chittimuthyalu (37.3), Ambemohar (36.6), Bahurupi (38.6) and Rajbhog (41.0) . While, it took maximum time for the adults to emerge in MTU 1010 (39.6 days) which was on par with Kabirajsal (45.6 days), Rajamudi (43.3 days), and Karupukavuni (42.0 days).

3.3 Seed damage (per cent)

Seed damage in rice varieties ranged from 1.3 to 11 per cent (Table 1). Lowest seed damage was recorded in Kabirajsal (1.3 %) followed by MTU 1010 (3.3), Rajamudi (3.7%), Kavuni (4.3 %) which was on par with Rajbhog (4.7) Bahurupi (6.0), and BPT 5204 (7.0) which was on par with Ambemohar (7.7).While, seed damage was significantly highest in Navara (11.0%) followed by Kalabati (9.3%) and Manipuriblack (7.7) and Chittimuthyalu (8.0).

3.4 Ash (per cent)

The ash content of various test varieties ranged from 0.04 to 1.44 per cent. minimum ash content was recorded in Navara (0.04 %),Bahurupi (0.07%) which was on par with Manipuriblack (0.09 %) karupukavuni (0.12%) Chittimuthyalu (0.17 %) Rajbhog (0.27) which was on par with Rajamudi (0.28%) Ambemohar (0.33%) Kalabati (0.45%) and Kabirajsal (0.57).

From the results it was evident that varieties with less adult emergence ,less seed damage and high mean development period recorded good amount of ash *viz.,* Kabirajsal (0.57), Kalabati (0.45%), Ambemohar (0.33%) Rajamudi (0.28%) and Rajbhog (0.27). Elevated ash content in grains may exert toxic effects on insects, disrupting their digestion and rendering the variety unsuitable for feeding, development, and adult emergence (Padmasri, 2018). Similarly, Ramakrishna (2002) It has been identified that ash content in maize exhibits a significant negative correlation with the adult emergence of S. oryzae. Conversely, the highly infested variety BPT 5204, despite having a substantial ash content (1.27%), likely experiences greater infestation due to other factors, such as elevated levels of crude protein, total and reducing sugars.

3.5 Nitrogen and protein (per cent)

Nitrogen and protein per cent was significantly lowest in Kabirajsal (1.09% and 6.83 %) followed by MTU 1010 (1.09% and 6.83%) which was on par with Rajamudi (1.04% and 6.52%), Karupukavuni (1.1% and 7.0%), Rajbhog (1.17% and 7.31%), Bahurupi (1.11% and 6.91 %) and Chittimuthyalu (1.15% and 7.20%). While, highest nitrogen and protein content was identified in BPT 5204 (1.3% and 7.4 %) which was on par with Navara (1.15 % and 7.18 %), Kalabati (1.20 % and 7.53 %) and Manipuriblack (1.06% and 6.65%) and Ambemohar (1.18% and 7.35 %).

The varieties BPT 5204 (with nitrogen and protein contents of 1.3% and 7.4 %, respectively) and Navara (with 1.15% and 7.18% respectively) demonstrated comparatively higher levels of nitrogen and protein. These elevated levels likely rendered these varieties particularly favorable for the growth and development of rice weevils, consequently leading to increased adult emergence, seed damage, and weight loss , while opposite was true for the least preferred varieties, namely Kabirajsal (1.09% and 6.83%), MTU 1010 (1.09% and 6.83 %), Rajamudi (1.04% and 6.52 %), Karupukavuni (1.1% and 7.0%), Rajbhog (1.17% and 7.31%), Bahurupi (1.11% and 6.91 %), and Chittimuthyalu (1.15% and 7.20 %), despite their elevated nitrogen and protein content, their lower preference can likely be attributed to other factors such as high phenol and ash content. Similar findings were reported Mebarkia *et al.,* (2010) discovered that wheat variety Arz, which has a lower protein content (9.27%), experienced a smaller percentage of weight loss due to *Sitophilus* infestation. Conversely, the susceptible variety Siete Ceros, with a higher protein content (16.63%), recorded a comparatively greater percentage of weight loss.

Table 1. **Adult emergence and Seed damage efficacy in various treatments**

Treatments	Name of the treatment	Mean adult emergence	Mean development period	Seed damage (per cent)
T1	Kalabati	24.7	34.3	9.3(17.7)
T2	Manipuriblack	22.0	35.3	7.7(16.06)
T3	Karuppukavuni	14.3	42.0	4.3(11.5)
T4	Navara	26.0	32.3	11.0(18.4)
T5	Rajamudi	9.7	43.3	3.7(11.5)
T6	Ambemohar	20.0	36.6	7.7(16.0)
T7	Chittimuthyalu	21.7	37.3	8.0(17.1)
T8	Rajbhog	16.0	41.0	4.7(11.5)
T9	Kabirajsal	8.3	45.6	1.3(6.5)
T10	Bahurupi	17.3	38.6	6.0(14.1)
T11	MTU 1010	3.3	39.6	3.3(10.4)
T12	BPT 5204	8.7	34.0	7.0(16.4)
	SEm±	0.36	0.40	0.34
	CD (P= 0.05)	1.05	1.19	0.99
	CV (%)	3.87	1.84	4.22
	*Resistant check			
	**Susceptible check			

Figures in parentheses are angular transformed values

Rizwana *et al.,* (2011) identified positive correlations between protein content in rice and both progeny emergence and grain weight loss caused by *S. cerealella.* Similarly, Murad and Batool (2017) observed that wheat varieties with elevated protein levels were more susceptible to *S. cerealella*, as these varieties exhibited a significantly higher number of emerged adults, along with increased seed damage and percentage weight loss.

The present findings was also found with Kiran *et al.,* (2020) the variety JGL 17004 showed highest crude protein of (8.62 %) and lowest found crude protein in variety JGL 11470 (6.93 %). Majid Marani *et al.,* (2023) identified positive correlations between protein content in rice and both adult emergence and weight loss caused by *S. oryzae.*

4. Correlation studies

4.1 Ash content (%)

Treatments	Name of the treatment	Ash content (per cent)	Nitrogen (per cent)	Crude protein (per cent)
T1	Kalabati	0.45	1.20	7.53
T2	Manipuriblack	0.09	1.06	6.65
T3	Karuppukavuni	0.12	1.1	7.0
T4	Navara	0.04	1.15	7.18
T5	Rajamudi	0.28	1.04	6.52
T6	Ambemohar	0.33	1.18	7.35
T7	Chittimuthyalu	0.17	1.15	7.20
T8	Rajbhog	0.27	1.17	7.31
T9	Kabirajsal	0.57	1.09	6.83
T10	Bahurupi	0.07	1.11	6.91
T11	*MTU 1010	1.44	1.09	6.83
T12	**BPT 5204	1.27	1.3	7.4
	SEm±	0.0088	0.0043	0.0265
	CD (P= 0.05)	0.0124	0.0125	0.0775
	CV (%)	3.5	0.655	0.6513
	*Resistant check			
	**Susceptible check			

Table 2. **Ash content (%) in different treatments**

Ash content had significant positive relationship with mean development (0.03). While, it had significant negative relationship with adult emergence (-0.69), susceptibility index (-0.17), weight loss (-0.47) and seed damage (-0.28)

In this study, the reduced adult emergence in moderately resistant varieties could be linked to their elevated ash content. This high ash content in the seeds may deter insects due to potential toxicity, rendering these varieties less preferred for feeding, growth, and emergence by the grub (Padmasri, 2018).

Similarly, Vishwamitra (2011) documented a notable negative correlation between ash content and adult emergence, seed damage, and percent weight loss due to *C. chinensis* in red gram varieties.

4.2 Protein and nitrogen content (%)

Protein and nitrogen had non-significant and negative correlation with mean development period (-0.55) and (-0.54). Whereas, they had non significant positive relationship with adult emergence (0.39) and (0.12), seed damage (0.54) and (0.42).

The results align with the findings of Murthy (1974), indicating a positive correlation between the protein content of sorghum varieties and the emergence of adult *S. oryzae*. Yadav (2017) also noted that protein content exhibited a positive relationship with grain damage and percentage weight loss in wheat. Kiran (2020) also noted that protein and nitrogen had non-significant and negative correlation with mean development period (-0.28).

Fig.1. **Ash content in Traditional varieties of rice**

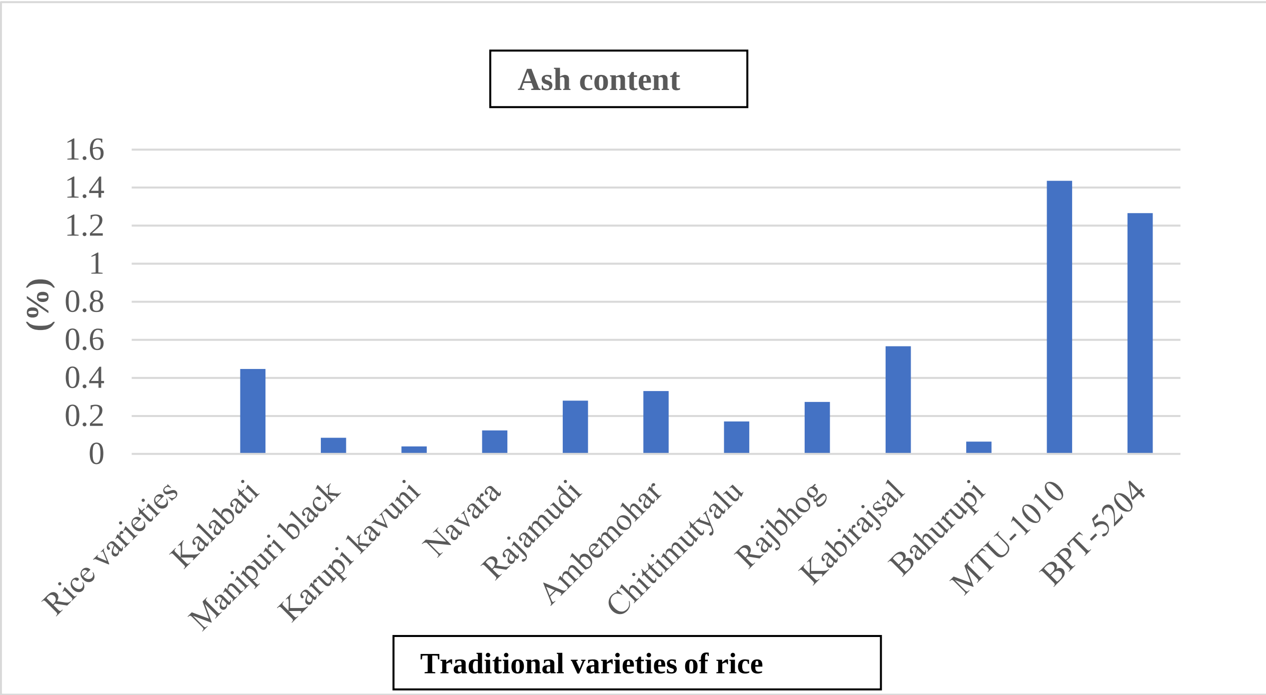

Fig. 2. **Crude protein content in Traditional varieties of rice**

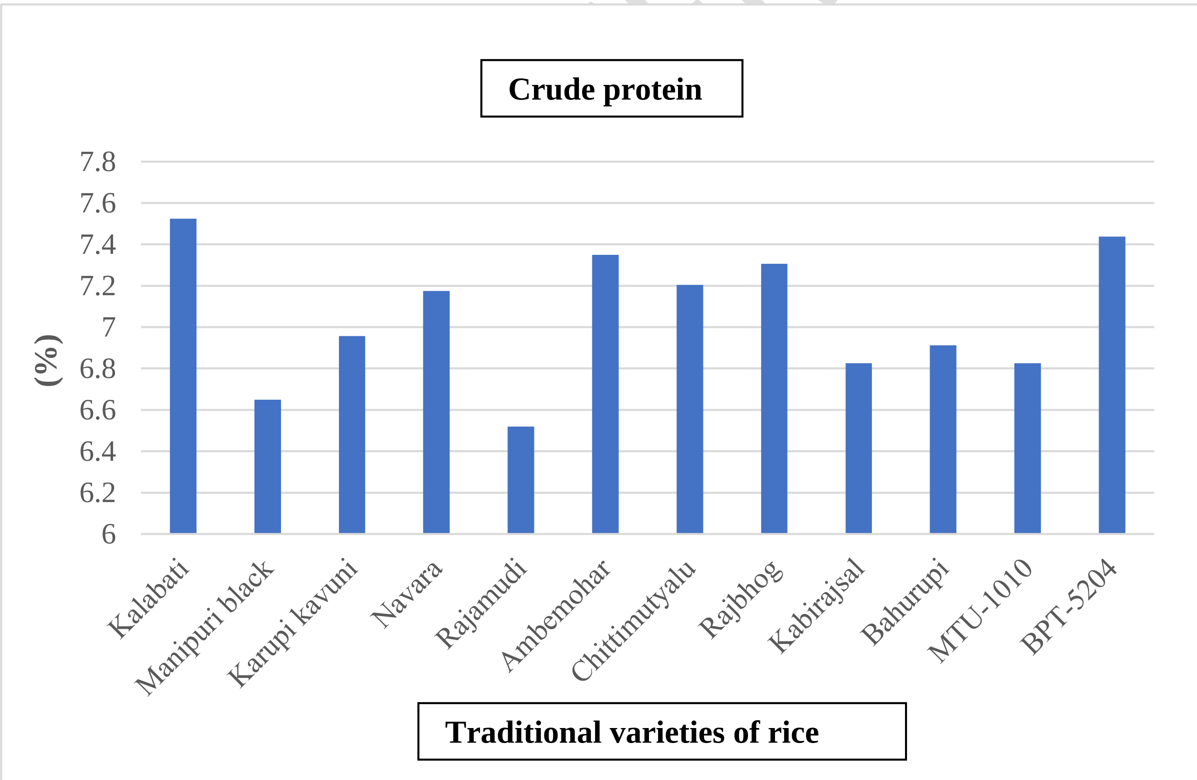

Fig. 3. **Nitrogen content in Traditional varieties of rice**

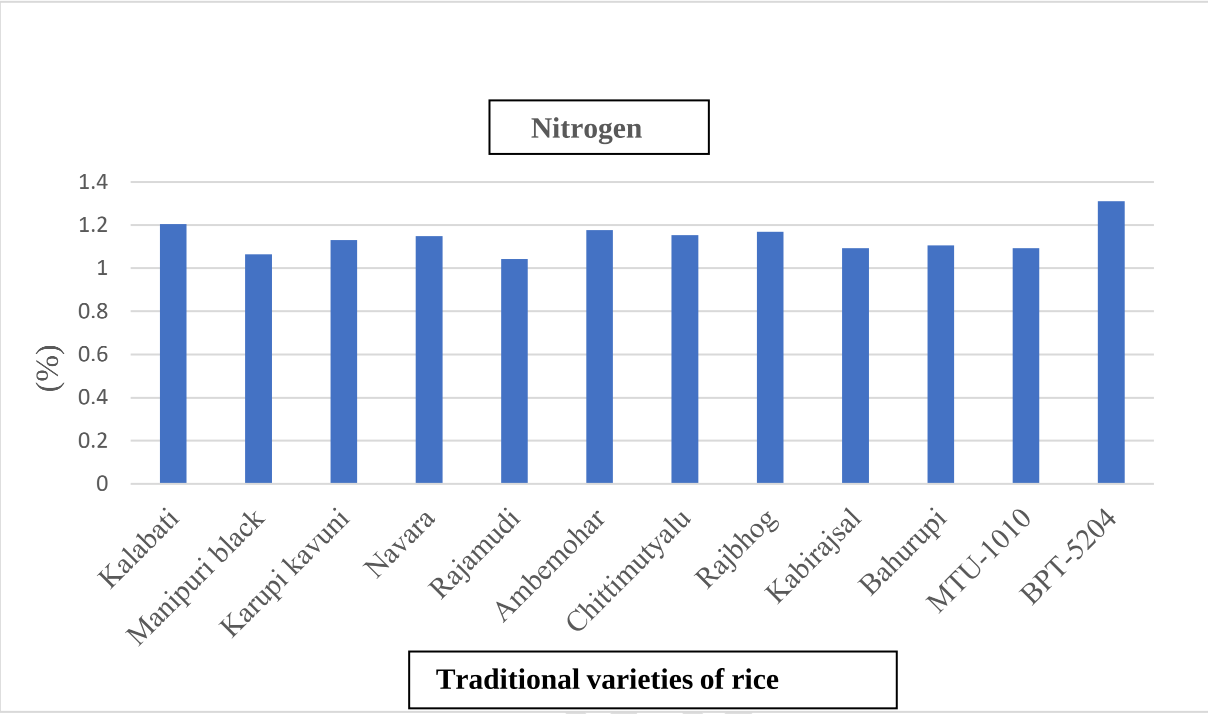

Table 3. Biological parameters for Adult emergence and Seed damage

Biological Parameters / Physico - chemical traits	Adult emergence (number)	Mean development period (days)	Seed damage (per cent)
Ash content (per cent)	-0.69*	0.03	-0.28
Nitrogen (per cent)	0.12	-0.54	0.42
Crude protein (per cent)	0.39	-0.55	0.54

*Significance at 5% level

**Significance at 1% level

5. Conclusion

The varieties containing good amount of ash or less amount of nitrogen and protein viz., MTU 1010, Kabirajsal, Rajamudi Rajbhog and Ambemohar can further be exploited for other traits and best traits can be incorporated in the breeding research to obtain resistant varieties.

REFERENCES

A.O.A.C. 1984. Official Methods of Analysis, 14th edition. Association of Official Analytical Chemists, Washington, D.C.

A.O.A.C. 1995. Official Methods of Analysis, 16th edition. Association of Official Analytical Chemists, Washington, D.C.

Agri stat info, 2022. Area, production and productivity of rice in india.

Gbaye, O.A and Ajiye, O.B. 2016. Susceptibility of some Nigerian hybrid and local rice varieties to *S. oryzae* L. (Coleoptera: Curcilionidae). *International Journal of Entomology Research*. 1 (2): 10-13.

Halstead, D.G.H. 1963. External sex differences in stored products Coleoptera. *Bulletin of Entomological Research*. 54: 119-134.

Howe, R.W. 1971. A parameter for expressing the suitability of an environment for insect development. *Journal of Stored Products Research*. 7: 63-65.

Kiran, S.A., Padmasri, A., Kumar, B.A. and Madhavi, M., 2020. Varietal preference of different rice varieties by rice weevil *Sitophilus oryzae* (L.). *Journal of Entomology and Zoology studies.* 20 ;8(4):54-61

Majid-Marani, S., Naseri, B., Hassanpour, M., Razmjou, J. and Jalaeian, M., 2023. Life history and population growth parameters of the rice weevil, *Sitophilus oryzae* L.(Coleoptera: Curculionidae) fed on 10 rice cultivars and lines. *Journal of Reserch Square*. 5 (2): 16-31

Mariotti, F., Tome, D and Mirand, P.P. 2008. Converting nitrogen into protein- Beyond 6.25 and Jones factors. *Critical Reviews in Food Science and Nutrition*. 48:177- 184.

Mebarkia, A., Rabbe, Y., Guechi, A., Bouras, A and Makhlouf, M. 2010. Susceptibility of twelve soft wheat varieties (*Triticum aestivum*) to *Sitophilus granarius* (L.) (Coleoptera: Curculionidae). *Agriculture and Biology Journal of North America.* 1 (4): 571-578.

Murad, M.S and Batool, Z. 2017. Relative biochemical basis of susceptibility in commercial wheat varieties against angoumois grain moth, *Sitotroga cerealella* (Olivier) and construction of its life table. *Journal of Biometrics and Biostatistics.* 8: 333.

Murthy, S.K. 1974. Effect of some characters of different sorghum varieties and hybrids on oviposition and development of rice weevil, *S. oryzae* (L.). M.Sc. (Ag.) Thesis. Andhra Pradesh Agricultural University, Hyderabad.

Navin, K., Ajeet K.P and Mishra, S.P. 2015. Indigenous technology to protect the storage life of seed. *International Journal of Innovative Science, Engineering & Technology*. 2 (6): 607-612.

Padmasri. A. 2018. Survey and management of rice weevil [*S. oryzae* (Linnaeus)] in maize. Ph.D (Ag.) Thesis. Professor Jayashankar Telangana State Agricultural University, Hyderabad.

Raju, P. 1984. The staggering storage losses-causes and extent. Pesticides.18 (1): 35-37.

Ramakrishna, D. 2002. Evaluation of maize varieties to *S. oryzae* in storage and its management. M.Sc. (Ag.) Thesis. Andhra Pradesh Agricultural University, Hyderabad.

Rizwana, S., Hamed, M., Naheed, A and Afghan, A. 2011. Resistance in stored rice varieties against angoumois grain moth, *Sitotroga cerealella* (Olivier) (Lepidoptera: Gelechiidae). *Pakistan journal of Zoology*. 43 (2): 343-348.

Singh, P.K. 2010. A decentralized and holistic approach for grain management in India. *Current Science*. 99: 1179-1180.

Singh, R.K. 1989. Effect of different rice varieties on the growth and development of S. *oryzae* Linn. Ph. D (Zoology.) Thesis. Kanpur University, Kanpur.

Solomon, M. E. 1951. Control of humidity with potassium hydroxide, sulphuric acid, or other solutions. *Bulletin of Entomological Research*. 42: 543-554.

Viraktamath, B.C., Bentur, J.S., Rao, K.V and Mangal, S. 2011. Vision 2030. Directorate of Rice Research (DRR), Rajendranagar, Hyderabad.

Vishwamitra,V. 2011. Varietal preference and eco-friendly management of *Callosobruchus chinensis* L. in pigeonpea. M. Sc. (Ag.) Thesis. Acharya N.G. Ranga Agricultural University, Hyderabad.

Yadav, M.K. 2017. Bio-ecological studies of rice weevil, *S. oryzae* (L.) on wheat and its management. Ph. D (Ag.) Thesis. S.K.N. Agriculture University, Jobner.