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Control Strategy of Saw-Toothed Grain Beetle, Oryzaephilus Surinamensis(L. 1758)Through A Methyl Bromide Gas Fumigation System on Date Fruits

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ABSTRACT

The application of fumigant Methyl bromide gas on counted (n=20) bags kept under godowns located at Khajoor and Chhuhara mandi region, Sukkur on Aseel semi-dry and dry dates were kept under observation. The (03) treatments were replicated (03) times. The population reduction % data was recorded on the 2nd, 3rd, and 5th day with the dose after application of 100g, 200g, and 300g, in each treatment. The overall maximum reduction % on Aseel semi-dry dates was recorded at 43.25, 38.90, 35.40 in the first year and 63.55, 56.80, 41.55 in the second year of the study. The maximum reduction % observed in the first year than the second year of the observation. Similarly, the reduction % on Aseel dry dates counted at 58.45, 53.20, 44.65 in 1st year and 55.30, 42.45, 40.20 in 2nd year research studies, respectively. It is concluded that the *O. surinamensis* is a destructive insect pest. In Pakistan, it is strictly needed for the management of this pest to protect the highly valuable and commercial date palm industry against insect pest havoc. This study suggests that due to the wide use of insecticides, we are unable to export. Therefore, we should have to introduce eco-friendly control measures against the saw-toothed grain beetle, due to this we will not only save our date fruits from pest infestation but also save the quality and quantity of date fruit. In this context, the IPM techniques and laboratory-based scientific study would be an authentic and supportable tool for date fruit protection.

Keywords: Aseel variety; Fumigation, Methyl bromide, *Oryzaephilus surinamensis.*

INTRODUCTION

The Date palm history is as old as man and is considered the oldest tree on the earth, the accurate date palm origin is unknown, but it is believed those have occurred naturally in the region of the Persian bay (Lee, 1963). In Pakistan, dates are marketed in the whole country with high appreciated crop and confectionery products which use peaks during the Ramadan feast by Muslims and the celebration of Diwali by Hindus, and this fruit has cultural, nutritional, social, medicinal, industrial, and religious value. The Khairpur district is the main date-producing area in Pakistan, where *P. dactylifera* is regarded as a cash crop with a high

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economic value of this area due to its most energetic and nutritive value supplement (Kousar et al.,2022).The name *Oryzaephilus surinamensis* was coined by (Carl Linnaeus, 1758) and is a little concerned with the superfamily, Cucujoidea, which was described in 1767 from Surinam, hence named as *Surinamensis*. It is a key pest of stored grain (Guo et al., 2019). This pest insect frequently feeds on dry and semi-dry dates, flours, cereals, dried meat, bran, dough, tobacco, sugar, and several other human consumption products, millet, confectionaries, oilseeds, they are secondary feeders and infest grains by forming mechanical lesions and minor cracks and their adults and larvae causing dates ravages, reducing the capability of germination(Sahito et al., 2017).Generally, the larvae stages of the insect pest are voracious feeders (Mangrio et al., 2019; 2021), serving as a destructive agent to their host species frequently loweringthe fruit's nutritional value (Mangrio & Sahito, 2022).

The application of residual insecticides and fumigants today is mainly for pest control in stored grains (Heaps, 2006). The organophosphates, phosphine, and pyrethroids are conventional insecticides used to control pest insects that are harming stored products, but for decades extensive use of fumigants including resistance power in insects caused health and environmental hazards (Pimentel et al., 2010). Spinosad belongs to bio-insecticides, which are beneficial in IPM strategies and have been successfully evaluated against several insect species on several commodities (Hertlein et al., 2011). Phosphine, the most effective and highly toxic, is commonly used in the fumigation process to combat pests in stored products, but the indiscriminate and continuous application of phosphine enhances the resistance power of pests (Lorini et al., 2007). *O. surinamensis* are small-sized insects, that engage in digging tunnels between the rind cause injuries to date fruit, and can hide in food storage products it is difficult to control through insecticides and develop resistance as insecticide resistance power (Wallbank & Collins, 2003).

For the controlling of pests in stored foodstuff bromide methyl is considered highly effective, for date disinfestations, a common alternative is heat treatment (Belarbi et al., 2001). The phosphine fumigation creates lethal exposure and leads to the phosphine resistance power in pest insects of stored productsand it is a challenge to constant application of phosphine (Gautam et al., 2020). The use of CO_2 and phosphine gas, each alone and mixed, in controlling *O. surinamensis* (L.) and *P. interpunctella* (Hubner), which infest stored date fruits (El-Shafei, 2020).The bioassays of seven important beetle species of stored grains viz., *Tribolium confusum Jacquelin* (duVal), *Prostephanus truncates* (Horn), *Cryptolestes ferruginous* (Stephens), *O. surinamensis*, *R. Dominica*, *Sitophilus oryzae* L., and *Sitophilus granaries* (L.) were observed to assess the insecticidal value of thiamethoxam, a neonicotinoid and suggested that thiamethoxam recommended for its efficacy at the rate of 10ppm and 14 days could be used for the control of all insects and their progeny (Tsaganouet al., 2021). The *O. surinamensis*performs is a primaryfunction in lowering the content and quality of dried fruits (Hashem *et al*., 2021).Keeping in view prevention from pests of store products is of dominantposition.

MATERIALS AND METHODS

Study area

The Methyl bromide gas was purchased and imported from China to use against the pest, saw-toothed beetle, *O. surinamensis* containing date fruits of dry and semi-dry dates at Khajoor and Chuhanra Mandi, region Sukkur, 2019-20. This mandi is known as a top-sellingto export throughout the world. Mostly the neighboring country India, where the dry

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and semi-dry date fruits are exported to use in sacred religions, Islam for the month of Ramzan for fasting and dry date fruits for the Hinduism religion for Parsad, sweat purpose. Thus; it is necessary to cross the fruits from the fumigation system as international law to get rid of this vigorous pest. Hence; the trials were conducted at the exporting date factories to check the efficacy of Methyl bromide under control shades under the dates godowns. The first dose was given to the 20 gunny bags of dry and semi-dry dates of each which were coved with a plastic sheet or tarp and kept for the 10 days to be purified from pests. Latter. The second dose was given into the fully sealed iron-made container which possesses the single whole from which the Methyl bromide gas was crossed after it was also sealed to reach the prescribed destination and opened there smoothly. Further, the dose and description are given according to the treatment, thus the results were obtained so far.

Application of Methyl bromide gas

The population of the pest, *O. surinamensis* was counted before the application of the Methyl bromide gas application on infested semi-dry and dry date fruits. The infested samples were taken from every (n=20) gunny bag by taking samples of 250g from each gunny bag for each treatment. Thus, there were 100 bags for every treatment. This method of the application of the methyl bromide was replicated five times on different doses such as; T_1= 100g, T_2= 200, T_3= 300, T_4= control for each gunny bag of date fruits, and the weight of each bag comprises 50kg. Thus, the effect of the bromide methyl gas was observed through these applications.

Sampling and data collection

The data of the pest population was taken after the 2^{nd} day, 3^{rd} day, and 5^{th} daybefore the transporting in containers to send abroad. Latter those containers were also fumigated in sealed containers to open astheyreached their actual destination. Because the methyl bromide has an ability of high oxygen repellent that is used for the purpose to kill and repellent the pest population. After the different dose applications, the mortality percentage was evaluated through Abbott, Handerson, and Tilton given formula:

$$\text{Corrected (\%)} = \left(1 - \frac{\text{The population of insects after treatment}}{\text{Population of insects in control after treatment}}\right) x100$$

Statistical analysis methods

The ANOVA was done through Randomized Complete Block Design for pest population and parasite prevalence on five prominent varieties in consequent months of both years.The least significant difference was observed at a 5% probability level, compared with different treatments. The statistical analysis was done through student package statistics software GraphPad Prism 5 version.

RESULTS

Methyl bromide gas against Saw-toothed grain beetle, on dry and semi-dry date godowns at Sukkur

The application of fumigant was used to control the population of the Saw-toothed grain beetle. In this context methyl bromide, an effective insecticide, and odorless and colorless gas

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were applied against insect pests. A total of 100g were used in three-time intervals at various date palm godowns of located at godowns of region Sukkur during, 2019-20.

The overall pooled mean reduction % of STGB after the application of Methyl bromide on semi-dry dates of Aseel variety during, 2019-20

The overall mean maximum to minimum reduction % of pooled data of 2 consequent years, 2019-20 of the pest population, *O. surinamensis* has been recorded on Aseel semi-dry dates of (n=20) gunny bags 55.30, 42.60, 38.20, after 3rd, 5th, 2nd days and ANOVA found in significant difference DF= 2; F= 1360; P= 0.03. Again, in three-time intervals 200g were used against the population reduction of Saw-toothed grain beetle at godowns Khajoor Mandi and the overall maximum mean reduction recorded after 2nd day 45.40, 3rd day 41.55, and 5th day 31.60, and ANOVA found DF= 2; F= 688, P= 0.05. Similarly, 300g in three intervals were applied on semi-dry dates at 42.45 after the 3rd day, 37.60 2nd day, 18.50, on date palm stores, and statistically, the analysis found a significant difference in *O. surinamensis* population reduction DF; 1; F= 1636; P= 001 on 1st day. On 2nd day of the treatment reduction occurred in pest population fluctuations and statistically data analysed found DF= 1; F= 326; P= 0.04, significant difference, 3rd day of the treatment, DF= 2; F= 770; P= 0.05, later on 5th day of the post-treatment DF= 2; F= 707; P= 0.02. In three-time intervals, maximum reduction of the pest population occurred after the fifth day of the application of Methyl bromide gas, and 300g application of Methyl bromide was found more effective against the population reduction of this pest compared to 100g on semi-dry dates. The values of nine replication with their mean ± SE the statistically difference among each treatment. The capital letters are showing the difference in the same time intervals of doses treatments, small letters indicate the difference in treatments and the same letters mean no difference between the time intervals of treatments observed at (P<0.05) after one-way analysis of variance through Tukey's test, bar columns are showing the reduction % in (Fig. 1).

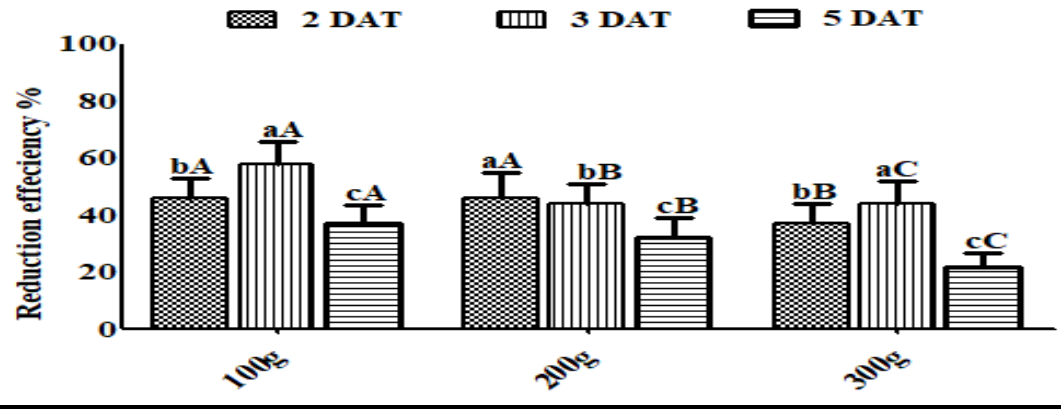

Fig. 1. The overall mean reduction % of STGB after the application of Methyl bromide on semi-dry dates of Aseel variety during, 2019-20

The overall mean reduction % of STGB after the application of Methyl bromide on dry dates of Aseel variety during, 2019-20

The methyl bromide was used as the fumigation, this odorless was applied against the *O. surinamensis* and a total of 100g through three intervals were used on Aseel dry dates of (n=20) gunny bags different godowns of date palms at Khairpur. The overall reduction % of the pest insect was recorded at 72.15 after the 3rd day, 56.35after the 2nd day, 46.35 after 5th

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days, and after the application of methyl bromide when data were subjected to the analysis found DF= 2; F= 824; P= 0.03, with a significant difference, through three-time intervals 200g the overall reduction efficacy recorded 51.45, 48.60, 46.75, after 3rd, 2nd, and 5th days found with significant difference DF= 2; F= 556; P= 0.02, and 300g intervals of three-time with reduction efficacy at 51.45, 48.55, 37.60 after 2nd, 3rd, and 5th days, with DF= 2; F= 964; P= 0.01 in a 1st-day significant difference. The methyl bromide after 2nd the application the ANOVA of pest population recorded with DF= 2; F= 152; P= 0.03, after the passing of 3rd day pest population reduction occurred with DF= 2; F= 1306; P= 0.02, later on, the passing of the 5th day's population of saw-toothed grain beetle reduced with DF= 2; F= 1093; P= 0.02, with a significant difference. The 300g of Methyl bromide with maximum population reduction of STGB compared to 200g and 100g with effectiveness after the fifth day of the application on dry dates, respectively. In all nine replications the capital letters show the statistical difference in different doses time intervals, small are differences in treatments and the same letters mean with a non-significant difference of the same letters at (P< 0.05) after one-way analysis of variance through Tukey's test, further reduction % of this pest justified as in (Fig. 2).

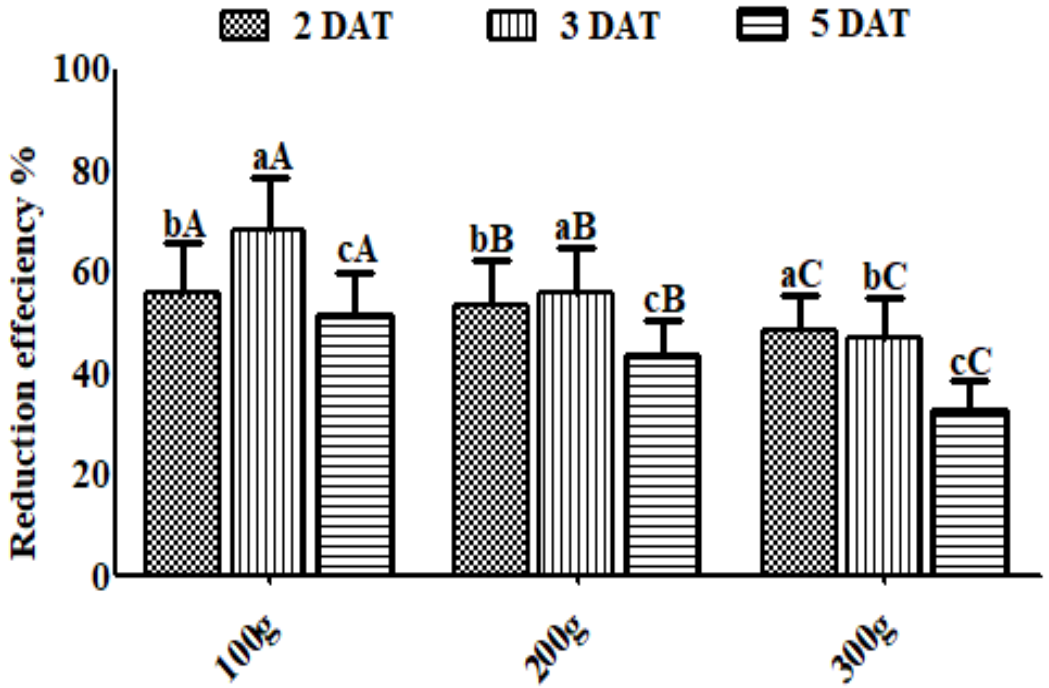

Fig. 2. The overall mean reduction % of STGB after the application of Methyl bromide on dry dates of Aseel variety during, 2019-20

The overall mean reduction % of STGB after Methyl bromide application on semi-dry Aseel variety during, 2019-20

The fumigation methyl bromide was applied against the destructive pest *O. surinamensis* during, 2019-20, and on a three-time interval basis, a total of 100g of this odorless gas was applied on Aseel semi-dry dates of (n= 20) gunny bags at dates store godowns Khairpur. After the application of such an amount of methyl bromide reduction efficacy of the pest and recorded with a maximum to the minimum mean of 65.45 after the 2nd day, 61.60 after 3rd day, 58.40 after 5th days and ANOVA found significant differences at DF= 2; F= 112; P= 0.04, at the amount of 200g at three-time intervals reduction mean counted at 63.55, 57.45, 44.55 after 3rd, 2nd, 5th days and the data was found at significant differences DF= 2; F= 1204;

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P= 0.02, again the application of 300g pest population reduction recorded 46.70, 45.20, and 43.35 after 2nd, 3rd, 5th days and then analyzed and found with a significant difference at DF= 2; F= 144; P= 001. After 2nd day of the bromide application reduction % was counted and found with the significant differences at DF= 2; F= 1220; P= 0.02, on 3rd day at DF= 2; F= 1348; P= 0.02, and after 5th day at DF= 2; 1348; P= 0.00, with significant difference, respectively. The efficacy of Methyl bromide was found more effective at the 300g dose application followed by 200g and 100g. The maximum reduction occurred after the fifth day of the Methyl bromide application and the minimum during the first day on the semi-dry Aseel variety, respectively. The same letters' mean values with the non-significant difference in nine replications at (P< 0.05) Tukey's test after one-way analysis of variance. The capital letters indicate the time intervals statistically difference in doses and small indicate the difference in treatments, the detailed description has been shown in given (Fig. 3).

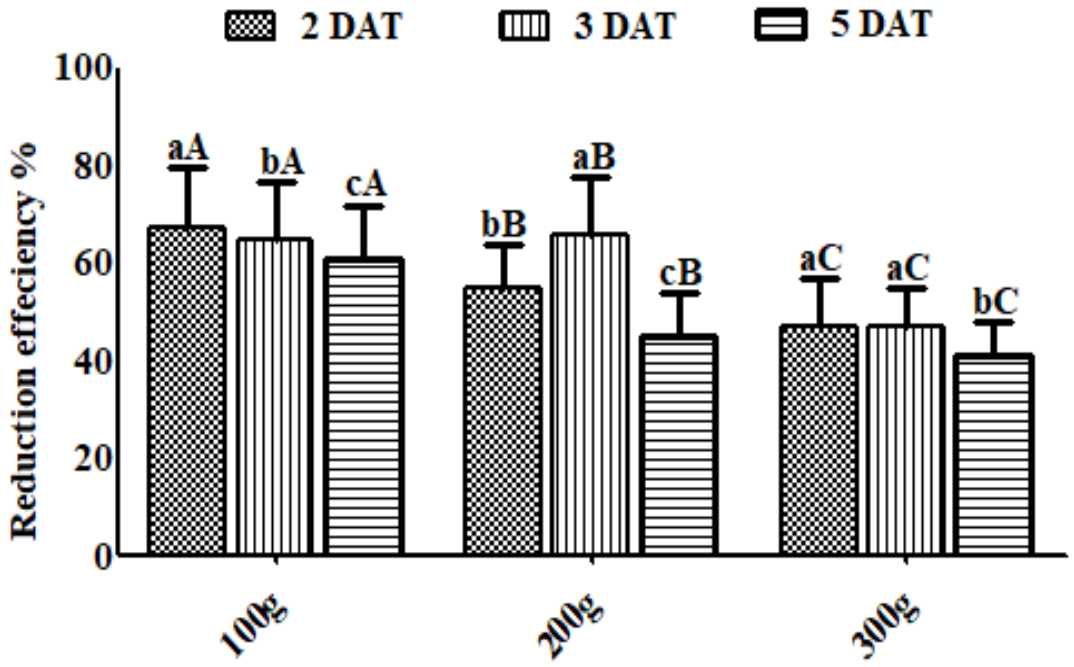

Fig. 3. The overall mean reduction % of STGB after Methyl bromide application on semi-dry Aseel variety during, 2019-20

The overall mean reduction % of STGB after Methyl bromide application on dry dates of Aseel variety during, 2019-20

The date godowns located at District: Khairpur were kept under observation for the use of Methyl bromide application on a prominent dates' variety Aseel dry dates of (n=20) sealed within the gunny bags. through three-time intervals with 100g against the population reduction overall mean 63.60 after 2nd day, 58.45 after 55.35, 43.10 after 5th days of the *O. surinamensis*. After the application of such amount of methyl bromide reduction of the pest were counted and analyzed with significant difference DF= 2; F= 768; P= 0.02, at the application of 200g reduction mean counted 58.40, 52.10, 36.60 after 2nd, 3rd, and 5th days and through ANOVA DF= 2; F= 1708; P= 0.04, at 300g population reduction mean population of the Saw-toothed grain counted 52.35, 42.15, 35.20, after 2nd, 3rd, 5th days through three-time intervals DF= 2; F= 1008; P= 0.02. After the application of 2nd day, population reduction occurred in three-time intervals at DF= 2; F= 684; P= 0.04, after 3rd day analysis found DF= 2; F= 628; P= 0.02, and after 5th day ANOVA found with DF= 2; F=

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916; P= 0.04, significant difference respectively. The Methyl bromide was observed more effective after the fifth day of the application of 300g and less effective during the initial days with 200g and 100g on dry dates of the Aseel variety. The small letters indicate the intervals statistically difference within the treatments and the capital letters difference in doses with nine replications. The same letters' values in their mean were found with no difference between the intervals of treatments through the Tukey's test after a one-way analysis of variance at (P<0.05), the description is given in (Fig. 4).

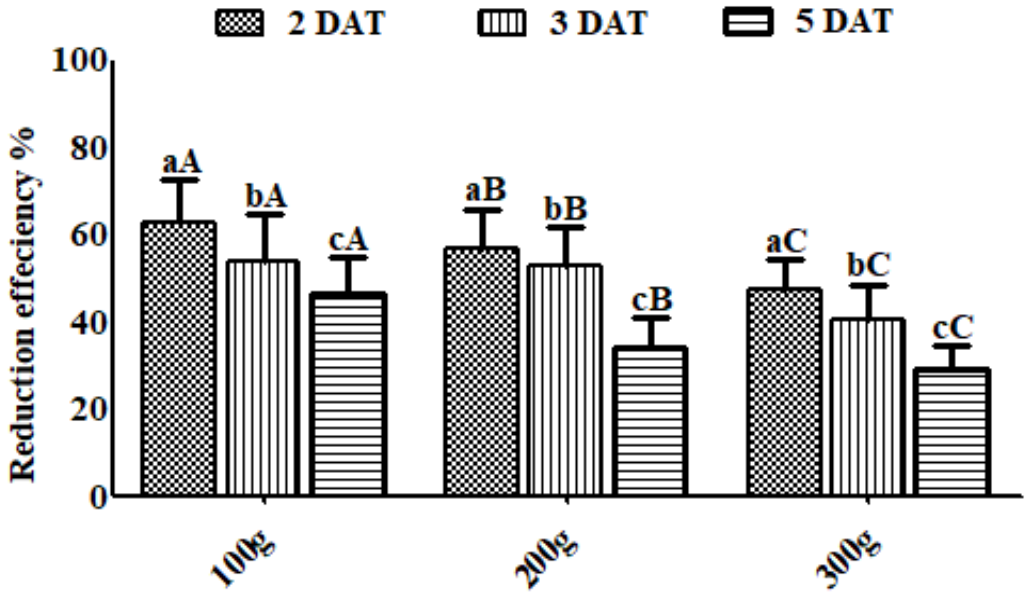

Fig. 4. The overall mean reduction % of STGB after Methyl bromide application on dry dates of Aseel variety during, 2019-20

The overall pooled mean reduction % through Methyl bromide gas against STGB during, 2019-20

For the purpose to control the pest infestation of *O. surinamensis* on semi-dry date fruits the application of Methyl bromide fumigation on semi-dry dates of the Aseel variety was applied in, 2019 and 20 at different date palm godowns of Khairpur. The overall pooled mean population reduction % in different time intervals against STGB with minimum to the maximum mean recorded 35.40, 38.90, 43.25, with the dose application of 300g, 200g, and 100g, respectively during 2019. The overall mean reduction % counted at 41.55, 56.80, 63. 55, with the application of 300g, 200g, 100g, and the overall maximum reduction % of methyl bromide observed in 2019 than 2020. The analysis of variance was found within 2019, DF= 2; F= 294; P= 0.03, significant difference and in 2020, DF= 2; F= 631; P= 0.03 with significant difference. The overall maximum reduction of the Saw-toothed grain beetle occurred after the fifth day at the 300g dose application of Methyl bromide on semi-dry dates. While as; minimum reduction of the pest occurred in the initial days, respectively. Letters indicate the statistical difference in the different doses or treatments of each year through Tukey's test after one-way ANOVA observed at (P< 0.05), values are shown as mean ± SE of 9 replications, justification is shown in (Fig. 5).

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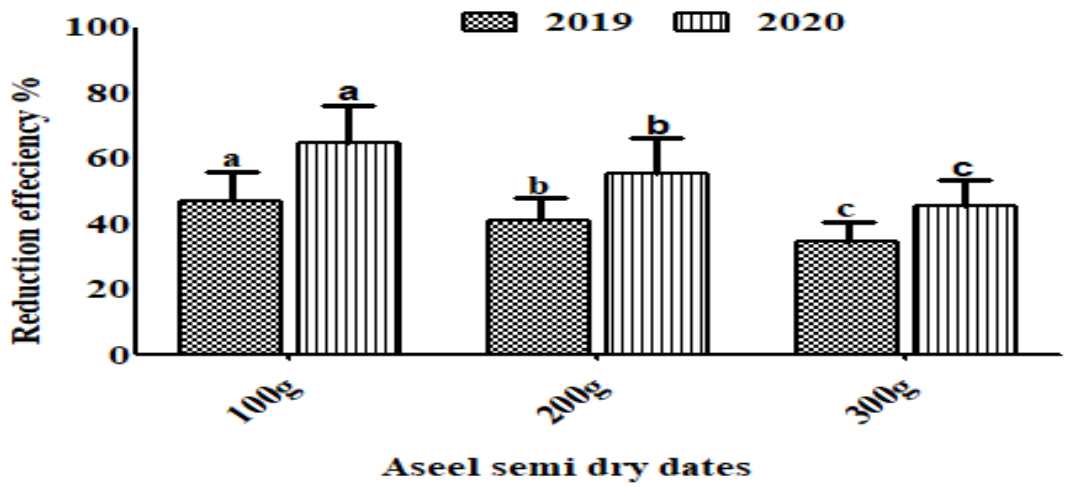

Fig. 5. The overall pooled mean reduction % through Methyl bromide gas against STGB during, 2019-20

The overall pooled mean reduction % through Methyl bromide gas against STGB during, 2019-20

The *O. surinamensis* infestation on dry dates was recorded during, 2019-20, and the overall mean of pooled reduction data of different time intervals against STGB after the application of Methyl bromide fumigation on dry dates of Aseel variety during 2019. The overall minimum to maximum means was recorded at 58.45, 53.20, and 44.65 after the application of 100g, 200g, and 300g methyl bromide at various date palm godowns of district Khairpur Mir's. The reduction % of the methyl bromide during, 2020 was recorded at 55.30, 42.45, and 40.20, after the application of 100g, 200g, and 300g, respectively. When the data of both years was subjected to analysis found within 2019, DF= 2; F= 418; P= 0.03, and in 2020, DF= 2; F= 422; P= 0. 01 with significant difference was found through three-time intervals. Similarly, a minimum reduction of the pest population was found at the dose application of 100g during both years of the study and a maximum at the dose application of 300g after the fifth day of application of Methyl bromide against *O. surinamensis* on Aseel dry fruits. Letters indicate the statistical difference in the different doses or treatments of each year after one-way ANOVA through Tukey's test at ($P< 0.05$), and values are shown as mean ± SE of 9 replications, further variation in homogenous differentiation as given in (Fig. 6).

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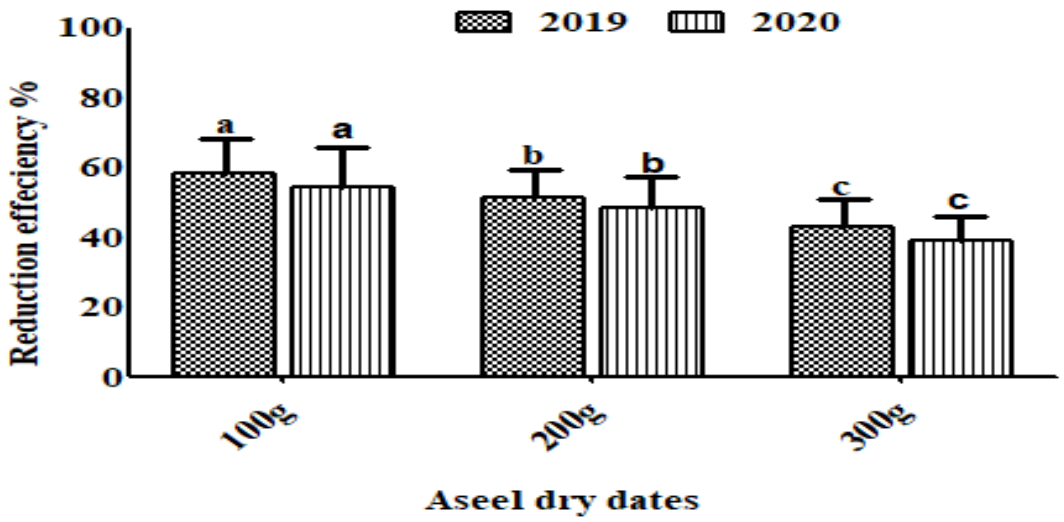

Fig. 6. The overall pooled mean reduction % through Methyl bromide gas against STGB during, 2019-20

DISCUSSIONS

When the semi-dry and dry date fruits are exported to the neighboring country, especially to India, where not only this kind of semi-dry date fruit is used for fasting in Ramzan and dry dates fruit is used for nourishment purposes but also used for the worshiping purpose at the time of Bhagwan Krishna Artee time or Parsaad which is known as sweet for happiness. Therefore, it is necessary to process the fumigation to kill or repellent the pest. The bromide methyl gas was purchased from China and before the application, those bags were sealed and covered with the gunny date fruit-containing bags with the plastic shopper by creating a single hole, from which the methyl bromide was processed, and finally, the hole was once again sealed at once. The odorless and colorless gas methyl bromide 100g, 200g, and 300g were used as fumigation against the population of *O. surinamensis* on semi-dry and dry date fruits. The maximum efficacy was found after the 5^{th} day followed by the 3^{rd} and 2^{nd} day on Aseel semi-dry dates at the application of 300g of bromide methyl gas. Again, the maximum efficacy was recorded after the 5^{th} day at the dose of 300g on Aseel dry dates during, 2019. This work is similar to (Hilton and Banks, 1997), who documented the efficacy power of bromide methyl and suggested the most effective against,*O. surinamensis* control. The pesticide residual efficacy with decreasedthreat is important for techniques on their frequency and use and within pesticides, insects increase regulators, pyriproxyfen inclusive, wereefficiently used to manipulatesaved pests of grains (Yasir et al., 2020). The combined almond oil and spinosad action against the adults of *O. surinamensis* (Coleoptera, Silvanidae), at 28 ±2°C and 65±5% RH and 21 days of exposure during bioassay testsperiods (Mohamed et al., 2020).The insect contamination of stored grain is a major concern for the grain industry but Phosphine is currently the standard fumigant used to control insect pests in stored grain (Harush et al., 2021). However, some species and populations of insects that infest stored grain exhibit resistance to this fumigant and consumers are concerned about pesticide residues.

During, 2020 the maximum efficacy was observed after the 5^{th} day by the bromide application at 300g followed by 200g and 100g on Aseel semi-dry and methyl bromide with maximum efficacy was observed after the 5^{th} day followed by 3^{rd} and 2^{nd} days application.The overall maximum reduction efficacy was found higher during 2019, followed by 2020 on Aseel semi-dry but on Aseel dry the reduction efficacy was found in the reverse

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condition.Date palm is a highly valuable crop of Sindh province that largely grows in the Khaipur district. During the research, it was frequently observed that *O. surinamensis* widely hits the Aseel variety as compared to others this variety is regarded as the queen variety of this region and has main commercial value. Only district Khairpur shares 85% of dates in the country and the climatic condition of this region is fruitful for sufficient growth of novel and most economically valuable date palm verities. Further to our results, findings are agreed with the other scientists of the world who worked on the date palm, *P. dactylifera* tree which is almost certainly the oldest tree cultivated by humans the historical evidence has shown that their fruits were cultivated and used for thousands of years (Tavakolian et al., 2013). In the same way, the carbohydrate content of 9 different varieties was reported to be between 59.6% and 76.8% (Abdul-Hamid et al., 2020).

Thousands of years ago, humans realized their importance, and the inclusion of dates in the diet is currently associated with several positive effects on human physiology, date chemical compositions, post-harvesting diseases, and challenges faced by rural women while date processing industries in District Khairpur, Sindh. Like this work, it is also been reported by other scientists of the world such as; (Colman et al., 2012; Juhaimi et al., 2012; Hamad et al., 2015; Jemni et al., 2015; Mallahet al., 2016; Khalid et al., 2017; Nehdi et al., 2018; Daoud et al., 2019; Kahramanoglu and Usanmaz, 2019; Chaudhary et al., 2020; Hussain et al., 2020, Saqib et al., 2020 and Walsh et al., 2020). Nevertheless, Ozone gas greatly reduced the survival of months larvae and verstylic work was done on date palm and its fruits (Aghdam and Bodbodak, 2013; Al-Hazzani et al., 2014; Abu-Reidah et al., 2017; Al-Ghamdi et al., 2019; Aboryia and Omar, 2020; Abu-Shama et al., 2020; Acharya and Pal, 2020; Kousar et al., 2021). The dates at ripening stages are usually immersed in 3 to 4% of acetic acid or vinegar for astringency removal. Additionally, immature dates can be dipped in hot water or incubated at 32–38^{o}C for a few days to become soft, translucent, and better flavor. Moreover, the hearts and terminal buds of date palm trees are a good additional recipe for a tasty salad (EL-Lakwah et al., 2011; Moustafa et al., 2021; Awad et al., 2022), and their proper management with the benefit-cost ratio (Sarraf et al., 2021). Al-Yahyai and Manickavasagan, 2012), conducted an overview of date palm production. (Azab et al.,2020), reported the joint action of Spinosad and Sweet Almond Oil mixture against the *O. surinamensis* and found better results. (Ata et al.,2012; 2014 and Fatima et al., 2016) described the factures hampering date palm production in Punjab, Pakistan, and the role of date palm in the livelihoods of farmers thus; the socio-economic characterization of this crop and the date circulation chains in Pakistan among growers to the market levels were also highlighted as our results are much agreed with them. Keeping in view, it is direly needed to become aware of the rate of losses of date fruits due to the infestation of *O. surinamensis* and introduce informative and crucial management strategies against this destructive pest insect.

CONCLUSION

It is concluded that the climatic condition of Sindh is in favor of the growth and development of the Saw-toothed grain beetle almost in all types of different date fruit varieties which are locally found here, in which the fumigation was found as an immediate control when the dates were stored or exported.

AUTHORS CONTRIBUTION

T.K:experimented, data collected,wrote the manuscript, H.A.S:supervisedand helped in proofreading, T.J: monitored the research work in the Entomology laboratory at DPRI.

W.M.M: contributed to statistical analysis, B.M: provided technical support, A.H.M: helped in introduction write up, Y.A.J: helped in data collection, F.A.J: provide technical support in the Methyl bromide gas application inside the dates containing bags.

IMPACT STATEMENT

The recommendations benefit of date fruit consumption as exemplified by the Messenger of Allah (S.A.W.) has been proven by many studies. Muslims have adopted the Islamic recommendations of date consumption accordingly on a priority basis to fulfill their spiritual need.

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CONSENT OF THE PUBLICATION

All authors accept responsibility for releasing this material.

CONFLICT OF INTEREST

The authors have declared that there is no conflict of interest for this paper'spublication.

AVAILABILITY OF DATA AND MATERIALS

At the request of the corresponding author, the data and findings are available due to ethical restrictions and privacy.

REFERENCES

1. Abdul-Hamid, N.A., Mustaffer, N.H., Maulidiani, M., Mediani, A., Ismail, I.S., Tham, C.L., Shadid, K. & Abas, F. 2020. Quality evaluation of the physical properties, phytochemicals, biological activities, and proximate analysis of nine Saudi date palm fruit varieties. *Journal of the Saudi Society of Agricultural Sciences* 19: 151-160.
2. Aboryia, M.& Omar, A.S. 2020. Effectiveness of some edible coatings on storage ability of Zaghloul Date Palm Fruits. *Journal of Plant Production* 11: 1477-1485.
3. Abu-Reidah, I.M., Gil-Izquierdo, Á. Medina, S. & Ferreres, F. 2017. Phenolic composition profiling of different edible parts and by-products of date palm (*Phoenix dactylifera* L.) by using HPLC-DAD-ESI/MSn. *Food Research International* 100: 494-500.
4. Abu-Shama, H.S., Abou-Zaid, F.O.F. & El-Sayed, E.Z. 2020. Effect of using edible coatings on fruit quality of Barhi date cultivar. *Scientia Horticulturae* 265: 109262.

5. Acharya, A.& Pal, P.K. 2020. Agriculture nanotechnology: Translating research outcome to field applications by influencing environmental sustainability. *Nano Impact* 100232.
6. Aghdam, M.S.& Bodbodak, S. 2013. Physiological and biochemical mechanisms regulating chilling tolerance in fruits and vegetables under postharvest salicylates and jasmonates treatments. *Scientia Horticulturae* 156: 73-85.
7. Al-Ghamdi, F.L., Bokhari, F.M.& Aly, M.M. 2019. Toxigenic fungi associated with dried Fruits and fruit-based products collected from Jeddah province. *Journal of Pharmacy and Biological Sciences* 14: 10-20.
8. Al-Hazzani, A.A., Shehata, A.I. Rizwana, H. Moubayed, N.M. Alshatwi, A.A. Munshi, A. & Elgaaly, G. 2014. Postharvest fruit spoilage bacteria and fungi associated with date palm (*Phoenix dactylifera* L) from Saudi Arabia. *African Journal of Microbiology Research* 8: 1228-1236.
9. Al-Yahyai, R. & Manickavasagan, A. 2012 An overview of date palm production. In: Manickavasagan A, Essa M, Sukumar E (eds) Dates: production, processing, food, and medicinal values. *CRC Press, Boca Raton, Florida, USA* pp: 312.
10. Ata S, Shahbaz B, Ahmad M, & Khan I.A. 2012. Factors hampering date palm production in the Punjab: a case study of D. G. Khan district. *Pakistan Journal of Agriculture Science* 49:217-220.
11. Ata S, Shahbaz B, Khan I.A, & Iftikhar M. 2014. Role of date palm in livelihoods of farmers of marginal areas: a case study of South Punjab, Pakistan. *Journal of Agriculture Research*52: 453462.
12. Awad, M., Ibrahim E.D.S, Osman E.I. Elmenofy W.H. Mahmoud A.W.M. Atia.& Moustafa M.A.M. 2022. Nano-insecticides against the black cutworm *Agrotis ipsilon* (Lepidoptera: Noctuidae): Toxicity, development, enzyme activity, and DNA mutagenicity. *PLoS ONE* 17: 1-21.
13. Belarbi, A., Aymard, C.H. &Hebert, J.P. 2001. Evolution of Deglet Noor date quality on it heat treatments (color and texture). In: *Proceedings of the 2nd international conference on the date palms, Al-Ain* pp: 86.
14. Chaudhary, S., Kumar, S. Kumar, V. & Sharma, R. 2020. Chitosan nanoemulsions as advanced edible coatings for fruits and vegetables: Composition, fabrication and developments in last decade. *International Journal of Biological Macromolecules* 152: 154170.
15. Colman, S., Spencer, T. Ghamba, P.& Colman, E. 2012. Isolation and identification of fungal species from dried date palm (*Phoenix dactylifera*) fruits sold in Maiduguri metropolis. *African Journal of Biotechnology* 11: 12063-12066.
16. Daoud, A., Malika, D. Bakari, S. Hfaiedh, N. Mnafgui, K. Kadri, A. & Gharsallah, N. 2019. Assessment of polyphenol composition, antioxidant and antimicrobial properties of various extracts of Date Palm Pollen (DPP) from two Tunisian cultivars. *Arabian Journal of Chemistry* 12: 3075-3086.
17. EL-Lakwah, F.A.M., EL-Banna, A.A. ELHosary R.A. & EL-Shafei W.K.M. 2011. Population dynamics of the red palm weevil, *Rhynchophorus ferrugineus* (OLIV.) on date palm plantations in 6th October governorate. *Egypt Journal of Agriculture Research* 89: 1105-1118.
18. El-Shafei, W.K.M. 2020. Comparison between using phosphine and/or carbon dioxide for controlling *Plodia interpunctella* and *Oryzaephilus surinamensis* in stored date fruits. *Middle East Journal of Applied Sciences* 10: 657-664.
19. Fatima, G., Khan, & Buerkert. I.A. 2016. Socio-economic characterisation of date palm (*Phoenix dactylifera* L.) growers and date value chains in Pakistan. *Springerplus* 5: 12-22.

20. Gautam, S.G., Opit, G.P., Konemann, C., Shakya, K. & Hosoda, E. 2020. Phosphine resistance in saw-toothed grain beetle, *Oryzaephilus surinamensis* in the United States. *Journal of Stored Products Research* 89: 1-9.
21. Guo, S.S., Wang, Y., Pang, X., Geng, Z., Cao, J. & Du, S. 2019. Seven herbs against the stored product insect: Toxicity evidence and the active sesquiterpenes from *Atractylodeslancea*. *Ecotoxicalogy and Environental Safety*169: 807-813.
22. Hamad, I., AbdElgawad, H. Al Jaouni, S. Zinta, G. Asard, H. Hassan, S. Hegab, M. Hagagy, N. & Selim, S. 2015. Metabolic analysis of various date palm fruit (*Phoenix dactylifera* L.) cultivars from Saudi Arabia to assess their nutritional quality. *Molecules* 20: 13620-13641.
23. Harush, A., Quinn, E., Trostanetsky, A., Rapaport, A., Kostyukovsky, M. & Gottlieb, D. 2021. Integrated Pest Management for stored grain: Potential natural biological control by a parasitoid wasp community. *Insects*12:10-38.
24. Hashem, M.Y., Khalifa, E.A. & Ahmed, S.S. 2021. The effect of modified atmospheres on the Saw-toothed grain beetle *Oryzaephilus surinamensis* (L.) (Coleoptera: Silvanidae) and the quality of semi-dried dates, *Journal of Stored Products Research* 93: 101850.
25. Heaps, J.W. 2006. Insect Management for Food Storage and Processing. *American Association of Cereal Chemists International, USA*pp: 231.
26. Hertlein, M.B., Thompson, G.D., Subramanyam, B. & Athanassiou, C.G. 2011. Spinosad: A new natural product for stored grain protection. *Journal of Stored Products Research* 47: 131-146.
27. Hilton, S.J. & Banks, H.J. 1997. Methyl bromide sorp-tion and residues on sultanas and raisins. *Journal of Stored Products Research*33: 231-249.
28. Hussain, M. I., Farooq, M.& Syed, Q.A. 2020. Nutritional and biological characteristics of the date palm fruit (*Phoenix dactylifera* L.). A review. *Food Bioscience* 100-509.
29. Jemni, M., Otón, M., Souza, M., Dhouibi, M, Ferchichi, A.& Artés, F. 2015. Ozone gas greatly reduced the survival of carob moth larvae in stored date palm fruit. *Journal of New Sciences* 16: 5670-573.
30. Juhaimi, F.A., Ghafoor, K. & Ozcan, M.M. 2012. Physical and chemical properties, antioxidant activity, total phenol and mineral profile of seeds of seven different date fruit (*Phoenix dactylifera* L.) varieties. *International Journal of Food Sciences and Nutrition*63: 84-89.
31. Kahramanoglu I.& Usanmaz S. 2019. Preharvest and postharvest treatments for increasing the rate of ripening of date palm fruit (*Phoenix dactylifera* L.) cv. *Medjool. Progress in nutrition* 21:215-224.
32. Khalid, S., Khalid, N. Khan, R.S. Ahmed, H. & Ahmad, A. 2017. A review on chemistry and pharmacology of Ajwa date fruit and pit. *Trends in Food Science and Technology* 63: 60-69.
33. Khan, A.L., Al-Harrasi, A., Numan, M., Abdul Kareem, N.M., Mabood, F.& Al-Rawahi, A. 2021. Spectroscopic and molecular methods to differentiate gender in immature Date palm (*Phoenix dactylifera* L.). *Plants* 10:536.
34. Kousar, T., Memon, Z.N., Sahito, H.A., Mangrio, W.M., Jatoi, F.A. & Shah, Z.H. 2021. Biology, morphology, and varietal distribution of Saw-toothed grain beetle, *Oryzaephilus surinamensis* (L) on date palm dry and semi-dry dates at district: Khairpur, Sindh - Pakistan. *Pure & Applied Biology* 10: 539-548.
35. Kousar, T., Memon, Z.N. &Sahito, H.A. 2022. Infestation instability and parasitism of Saw-toothed grain beetle, *Oryzaephilus surinamensis* (L.) on prominent dry and semi-dry date fruits. Annals of R.S.C.B., 26(1): 510–530.

36. Lee, D.R. 1963. Date cultivation in the Choachella valley California. *The Ohio Journal of Science*36(2): 82-87.
37. Lorini, I., Collins, P.J., Daglish, G.J., Nayak, M.K. & Pavic, H. 2007. Detection and characterization of strong resistance to phosphine in Brazilian *Rhyzopertha dominica* (F.) (Coleoptera: Bostrychidae*). Pest Management Science* 63:358-364.
38. Mallah, N.A., Sahito, HA.,Kousar, T., Kubar, WA., Jatoi, FA. & Shah, Z.H. 2016. Susceptibility of different varieties of stored date palm fruits infested by saw tooth grain beetle, *Oryzaephilus surinamensis* (L., 1758) under laboratory conditions. *J. Entomology and Zoology Studies* 4(6): 438-443.
39. Mangrio, W.M., Sahito, H.A., Chandio, N.H., Kousar, T., Shah, Z.H., Khaskheli, N.A. & Jatoi, F.A. 2019. Food and feed consumption of Lemon butterfly, *Papilio demoleus* under laboratory conditions. *Pure and Applied Biology* 9: 340-351.
40. Mangrio, W.M. & Sahito H.A. 2021. Morphometric life stages of Lemon butterfly, *Papilio demoleus* Linnaeus (Lepidoptera: Papilionidae) on *Citrus limon* (L.) Osbeck. *International Journal of Biological Sciences* 5: 188-199.
41. Mangrio, W.M. & Sahito H.A. 2022. Biology, weight measurement and larval time consumption of lemon butterfly, *Papilio demoleus*Linnaeus (1758) on citrus limon leaves under laboratory conditions. Annals of R.S.C.B., 26(1): 282–297.
42. Mohamed, E.S., Ali, A., El-Shirbeny, M., Abutaleb, K. & Shaddad, S.M. 2020. Mapping soil moisture and their correlation with crop pattern using remotely sensed data in arid region.*The Egyptian Journal of Remote Sensing and Space Sciences*23: 347-353.
43. Moustafa, M.A.M., Fouad E.A, Abdel-Mobdy Y, Hamow K.A, Miko´ Z.& Molnar B.P. 2021. Toxicity and sublethal effects of chlorantraniliprole and indoxacarb on *Spodoptera littoralis* (Lepidoptera: Noctuidae). *Applied Entomology and Zoology* 56: 115-124.
44. Nehdi, I.A., Sbihi, H.M. Tan, C.P. Rashid, U. & Al-Resayes, S.I. 2018. Chemical composition of date palm (*Phoenix dactylifera* L.) seed oil from six Saudi Arabian cultivars. *Journal of Food Science* 83: 624-630.
45. Pimentel, M.A.G., Faroni, L.R.D., Silva, F.H.D., Maurílio, D., Batista, M.D. & Guedes, R.N.C. 2010. Spread of phosphine resistance among Brazilian populations of three species of stored product insects. *Neotrop Entomol*39: 101-107.
46. Sahito, H.A., Mallah, N.A., Kousar, T., Kubar, W.A., Shah, Z.H., Jatoi, F.A. & Mangrio, W.M. 2017. Life table parameters of Saw-toothed grain beetle, *Oryzaephilus surinamensis* (L., 1758) on different varieties of stored date palm fruits infested under laboratoryconditions. *Journal of Entomology &Zoology Studies* 5: 95-99.
47. Saqib, S., Zaman, W. Ayaz, A. Habib, S. Bahadur, S. Hussain, S. Muhammad, S. & Ullah, F. 2020. Postharvest disease inhibition in fruit by synthesis and characterization of chitosan iron oxide nanoparticles. *Biocatalysis and Agricultural Biotechnology* 28: 101729.
48. Sarraf, M., Jemni, M., Kahramanoglu, I., Artes, F., Shahkoomahally, S., Namsi, A., Ihtisham,M., Brestic, M., Mohammadi, M. & Rastogi, A. 2021. Commercial techniques for preservingdate palm (*Phoenix dactylifera*) fruit quality and safety: A review. *Saudi Journal of Biological Sciences* 28:4408-4420.
49. Tavakolian, M.S., Silaghi, F.A. Fabbri, A. Molari, G. Giunchi, A. & Guarnieri, A. 2013. Differentiation of post harvest date fruit varieties non-destructively using FTNIR spectroscopy. *International Journal of Food Science and Technology* 48: 1282-1288.

50. Tsaganou, F.K., Vassilakos, T.N. & Athanassiou, C.G. 2021. Insecticidal effect of thiamethoxam against seven stored-product beetle species. *Journal of Stored Products Research* 93: 101843.
51. Wallbank, B. E. & Collins, P. J. 2003. Recent changes in resistance to grain protectants in eastern Australia. In: Wright, E.J.W., Highley, M.C: E., ed. *Proceedings of the Australian Postharvest Technical Conference, 25-27 June 2003 Canberra. CSIRO Stored Grain Research Laboratory, Canberra* 66-70.
52. Walsh, K.B., Blasco, J. Zude-Sasse, M. & Sun, X. 2020. Visible-NIR 'point'spectroscopy in postharvest fruit and vegetable assessment: The science behind three decades of commercial use. *Postharvest Biology and Technology* 168: 111246.
53. Yasir, M., Mansoor ul Hasan., Sagheer, M., Fiaz, M. & Serrao, J.E. 2020. Residual efficacy of Pyriproxyfen on grain commodities against stored product insect pests. *Gesunde Pflanzen* 72:265–272.