

Infestation Instability and Parasitism of Saw-Toothed Grain Beetle, *Oryzaephilus Surinamensis* (L.) on Prominent Dry and Semi-Dry Date Fruits

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Abstract

The research study was conducted on staple fruit of Pakistan “dates” on five prominent date palm varieties of District: Khairpur, Sindh. The infested fruits were brought under laboratory conditions for pests and their biological control appearance. The maximum pest population was observed on variety; Karbalian on dry dates; 26.35 and on semi-dry; 24.45 with the minimum on dry dates; 08.45 and on semi-dry; 06-36; followed by Fasli, 21.25 and 23.10 to 05.10 and 08.45; Gajar, 22.45 and 20.33 to 07.20 and 04.70; Daki wari, semi-dry; 24.55 and dry; 16.80 to 09.80 and 06.10 in December and June with the Aseel, on dry dates; 19.45 semi-dry; 17.20 to 04.90-04-60 in January and July months. Thus; the variation of parasitism % was recorded with the maximum mean population on variety; Karbalian on dry dates; 24.35 and semi-dry dates; 26.70-22.40-15.60; Gajar, semi-dry; 24.35 and dry; 22.4 to 06.30-09.15; Daki wari, semi-dry; 27.20 dry; 18.90 to 13.80-06.70; Aseel, semi-dry; 25.80 and dry dates; 22.25 to 16.16-15.20 in January and July similarly, on variety; Fasli, dry dates; 22.45 semi-dry; 24.20 to 17.34-13.70 in December and July months, respectively. The present results indicated that pest infestation occurred in both types of fruits in all five varieties which were found with severe infestation hence; the overall mean population of parasitoids which is known as biological control agents that ultimately reduced the pest population under laboratory conditions that should be encouraged in dates producing factories and stored godowns to reduce the pest instability.

Keywords: Aseel; Fasli; Gajar; Infestation; Karbalian; Parasitism

INTRODUCTION

The *Phoenix dactylifera* L. is known as a monocotyledonous woody, dioecious with evergreen and perennial plant that belongs with the family of Palmae (Arecaceae). It is an economic and highly valuable cash crop, grows well in hot and arid world regions (Omotesho et al., 2015), considered as the initial crop to the man who believed their origin from Mesopotamia, Middle East, and West Indian regions (Chao & Krueger 2007). The molecular methods and spectroscopic methods to gender in immature date palms were detailed evaluated (Khan et al., 2021). In an archaeological place at Larkana Sindh province, “*Mohen-jo-daro*” here the presence of date seeds during excavation indicates that the cultivation of date cultivars in Sindh as earlier as 5,000 old (Bakhsh et al., 2006). Alexander the Great brought date palm first to India when his army soldiers feed hereafter that during traveling of

Balochistan, Kech valley along the coast of Makran in the 4th century BC, but Sindh's dates were spread when Muhammad Bin Qasim 712 AD came here with soldiers they discarded seeds of dates at their camps during wars from which date palm flourished and grew in Valley of Indus (Dhillon et al., 2005). In Pakistan dates crop is essential after citrus and mangoes. Dates contain essential nutrients, carbohydrates, glucose, fructose, and minerals, hold dietary fibers, fatty acids, proteins, and vitamins (Chandrasekaran & Bahkali 2013). Dates serve as emergency food and have medicinal value including, antibacterial, immunomodulatory, antifungal, antitumor, antioxidant properties animals use seeds of dates because seeds are enriched with dietary fibers, fats, proteins and are more popular due to their wide importance due to nutritional, social, medicinal, religious, industrial, and cultural values (Chao & Krueger 2007).

The date palm in Sindh, particularly in Khairpur faces severe effects of diseases and insect pests, these infestations cause decline syndrome and the majority of dates fall during semi-dry conditions (Markhand et al., 2010). The sudden lethal disease mostly hits thirty-five to forty years old plantations and Dadhi, Aseel, Karbalian, and Fasli varieties are frequently damaged and due to this damage fifteen percent in every month fruit drop (Shar et al., 2012). The *Carpophilus hemipterus* and *Oryzaephilus surinamensis* species of beetles are cosmopolitan and largely harm agriculture merchandise post-harvest before as well and overall disease and pests cause a 30% loss in date production (El-Juhany and Loutfy 2010). The saw-toothed grain beetle is the wide pest of both qualities of date fruits but also infest flours, dried fruits and meats, cereals, pasta, nuts, and candies rendering the food item unpalatable and unsalable (Zabar & Borowy 2012). Further damage of this pest includes a reduction in phospholipids, polar and non-polar lipids, lysine and isoleucine, glycolipids, amino acid, methionine, and an increase of moisture content and high relative humidity increase the feeding ability of the pest (Mallah et al., 2016), due to this journey 18 to 50% of date production potentially mislaid and infested dates reduce their sugar level (Sahito et al., 2017). In the same region (Jatoi et al., 2020) documented another pest, *B. amydraula*, and their infestation on unripened fruit of dates. Generally, the larval stages of the insect pests are voracious feeders (Mangrio et al., 2019).

By the use of certain insecticides, we are reducing the quality of our date fruits and due to this, we are unable to export date fruit to advanced countries, America and Europe. The *O. surinamensis* is an injurious pest that widely infests dry and semi-dry dates (Al-Deeb, 2012). It is considered the native of Southeast Asia and has been regarded as a major pest of *P. dactylifera* varieties (Hashem et al., 2012). Several Arecaceae species have been documented by the researchers namely; *Areca catechu*, *Calamus merrillii*, *Arecastrum romanzoffianum*, *Borassus flabellifer*, *Caryota cumingii*, *Corypha utan*, *Arenga pinnata*, *C. nucifera*, *Metroxylon sagu*, *Chamaerops humilis*, *Livistona decipiens*, *Elaeis guineensis*, *L. chinensis*, *Oncosperma horridum*, *Roystonea regia*, *O. tigillarum*, *P. dactylifera*, *Washingtonia robusta*, *P. canariensis* and *Trachycarpus fortune* (Dembilio et al., 2012) are harmed by *O. surinamensis* which has an extensive geographical distribution with a broad host range from Asia, Africa, the USA, and Europe (Fiaboe et al., 2012). Singh et al., (2021) reported that the 45 types belong to Bethyilidae (*Cephalonomia tritici*, *Chlorepbris biharina*, *C. mackenziei*, *C.*

pusana, *C. Sanctipauli*). Eliopoulos, (2019) described that the larval parasitoid *Cephalonomia tarsalis* on *O. Surinamensis*, the host conveyed the longer developmental period and adult female longevity. Based on evaluating and improving the performance of *C. tarsalis* as a biocontrol agent against *O. surinamensis* in storage facilities was better. Keeping in view prevention from pests of store products is of paramount importance. Hence; these studies for the presence of pests on various date varieties are informative and crucial for developing management strategies to keep balance in the quantity, quality, and economical value of the staple fruits “the dates” in this region.

MATERIALS AND METHODS

Pest appearance

Here in the province of Sindh, Pakistan, there are some problems with the sufficient growth of the date palm industries regarding production, processing, and protection measures. The monsoon seasons and irregular rainfalls at the ripening stage of dates fruit is serious risk and challenge for growers. Unavailability of tissue culture and modern equipment, unconventional methods, fewer mechanical lines of factories, unhygienic, and fewer cold storage facilities for the processing sector are the main problems in the Queen district of dates producing sector. The same problems are facing local growers of this region for a few decades but early diagnosis and treatment are necessary for the betterment of this crop. So, it was necessary to carry research study on this vigorous pest and its control measure.

Sample collections

For this purpose, the samples of dry and semi-dry dates from five varieties were collected from different godowns located at Khajoor mandi Khairpur during, 2020-21. Collections were brought under laboratory conditions population of *O. surinamensis* was observed on the fortnightly basis and also attention was taken to parasite prevalence. At the early emergence of the pest population which was counted through magnifying glasses. Fig 1. shows the sample collection point.



Fig. 1 Annaj & Kajoor Mandi -Farmers' market, Jail Rd, Khairpur, Sindh: Latitude: 27°32'33.48"N; Longitude: 68°45'33.99"E

Fruits arrangements for pest prevalence

In the initial step, the infested date fruits of all five prominent varieties a total of (n= 100) fruits were kept individually in 05kg plastic jars, and both types of fruits were weighted through a weight gram machine then placed in plastic jars. Each jar was arranged individually in a rowing manner after name marking of varieties. The jars containing dry and semi-dry dates were covered with muslin cloth and observed in the first and fifteenth days. During the whole, work samples were brought interval basis from Khajoor mandi of Khairpur.

Rearing of saw-toothed grain beetle under laboratory conditions

During the whole study in every interval collection, the population of pest insect *O. surinamensis* was observed from dry and semi-dry date fruits with certain fluctuations at Date palm Research Institute (DPRI), 2020-21. The population of parasites was observed from both types of date fruits in all date palm varieties. Careful attention was given to the population of the pest insect in consequent months of the research period and focus was taken parasitism percentage on the reduction population of the *O. surinamensis* in different months of the research period. The population of *O. surinamensis* was kept under observation at post-treatment and pre-treatment and later on released biological controlling agents. Under laboratory examination, the infestation instability and parasitism percentage of saw-toothed grain beetle on semi-dry and dry fruits of the Daki wari, Fasli variety, Gajar variety, Karbalian variety, Aseel variety, and overall parasitoid infestation against the population of saw-toothed grain beetle were recorded in both years of the study. Fig 2. the point where laboratory examination was performed.



Fig. 2 Entomology Laboratory, DPRI, SALU-Khairpur, Latitude: 27°29'35.26"N; Longitude: 68°45'44.32"E

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

The application of eco-friendly techniques like; the application of pheromones, biological control measures, insect-proof packing, storage under hygienic places, improved date storing methods, and radiation techniques offer an alternative method to control *O. surinamensis*. Long-term management strategies and better information are needed to sustain and save economically important date palm crops effectively. Unfortunately, very modest research work has been conducted to observe the lethal effects of *O. surinamensis* on different five varieties of dry and semi-dry dates fruits of this region at District: Khairpur. Thus; the research study has been conducted and the fruiting results are described as under:

Sawtoothed grain beetle; Oryzaephilus surinamensis Linnaeus, 1758 (Coleoptera: Silvanidae) with a super family; Cucujoidea attack on Karbalian variety

During the all months of laboratory-based research study, the infested fruits of Karbalian variety in both semi-dry and dry dates were found with the maximum pest, *O. surinamensis* infestation. The infestation instability was taken from the counted (n=100) Karbalian dry and semi-dry date fruits seperatively which were remained with the maximum mean population in January, 26.35 to 24.45; followed by February, 24.80-21.55; December, 22.44-19.30; November, 21.57-18.90; March, 19.35-17.40; April, 16.88-15.10; October, 17.23-14.90; September, 16.60-14.58; August, 16.25-13.80; May, 14.60-09.80; June, 09.70-08.45, and July, 08.45-06.36. The analysis of variance was found with significant, non-significant and highly significantly differences in different months, as in the month of May it was found significantly different, DF= 1; F= 256; P= 0.01, whereas; in the month of June, DF= 1; F= 43.3; P= 0.02, July, DF= 1; F= 68.8; P= 0.01, August, DF= 1; F= 59.5; P= 0.04, September, DF= 1; F= 194; P= 0.86, October, DF= 1; F= 83.1; P= 0.03, November, DF= 1; F= 63.5; P= 0.04, December, DF= 1; F= 140; P= 0.03, like in the month of January, DF= 1; F= 6.29; P= 0.06, February, DF= 1; F= 20.1; P= 0.39, March, DF= 1; F= 297; P= 0.52, April, DF= 1; F= 178; P= 0.27, were found at P-value of highly significantly different, respectively. The overall maximum mean infestation was recorded on the Dry date fruits variety of Karbalian when compared with semi-dry dates. The mean±SE of six replications of the same letters were taken through the help of Tukeys test after one-way ANOVA at (P<0.05) which was mostly found with a significant difference as shown in Fig. 3.

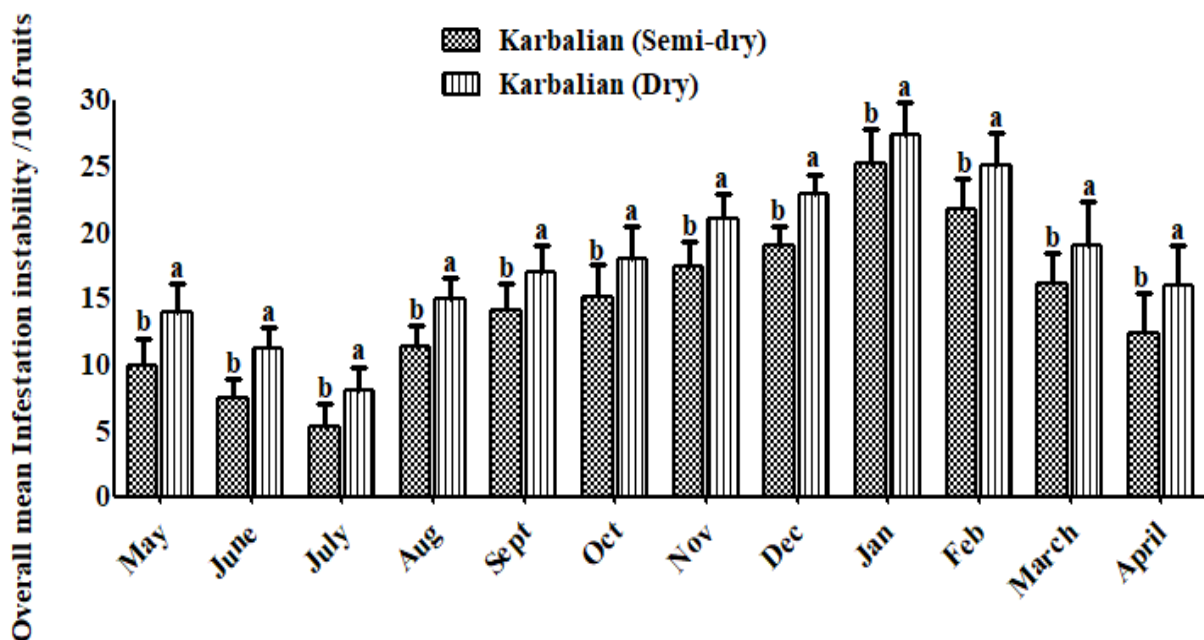


Fig. 3. The overall mean population of pest infestation of STG beetle on dry and semi-dry date fruits of Karbalian variety during, 2020-21.

Oryzaephilus surinamensis attack on Fasli variety

In this region, this variety is cultivated abundantly but frequently attacked by *O. surinamensis*. The fruits semi-dry and dry dates were observed within the twelve consequent months through different intervals but infestation mean population was found gradually with a differences. The results also having highlighted the severe damage of pest attack. Further, the overall infestation instability of *O. surinamensis* total of (n=100) fruits of Fasli dry and semi dry dates had with the overall maximum population in the month of January, 21.25 to 23.10; followed by February, 18.30-20.45; November, 19.80-17.25; December, 18.55-16.70; March, 14.56-18.45; April, 14.10-15.20; October, 14.45-17.23; September, 13.10-15.40; August, 11.70-14.20; May, 14.80-09.80; June, 11.80-11.30, and July, 05.10-08.45. The ANOVA of semi-dry and dry dates of Fasli variety infestation instability was found with significant and non- significant differences in consequent months of the year such as; May, DF= 1; F= 276; P= 0.01, June, DF= 1; F= 43.3; P= 0.02, July, DF= 1; F= 224; P= 0.00, August, DF= 1; F= 457; P= 0.04, September, DF= 1; F= 133; P= 0.05, October, DF= 1; F= 51.9; P= 0.02, November, DF= 1; F= 29.3; P= 0.99, December, DF= 1; F= 29.0; P= 0.45, January, DF= 1; F= 1.02; P= 0.36, February, DF= 1; F= 5.43; P=0.08, March, DF= 1; F= 562; P= 0.00, and April, DF= 1; F= 314; P= 0.01, respectively. The overall maximum mean infestation instability was counted on dry dates when compared with semi-dry date fruit of variety Fasli. The values with the same letters found with no significant differences at (P< 0.05) through one-way ANOVA in six replications within the different months of the year as shown in Fig. 4.

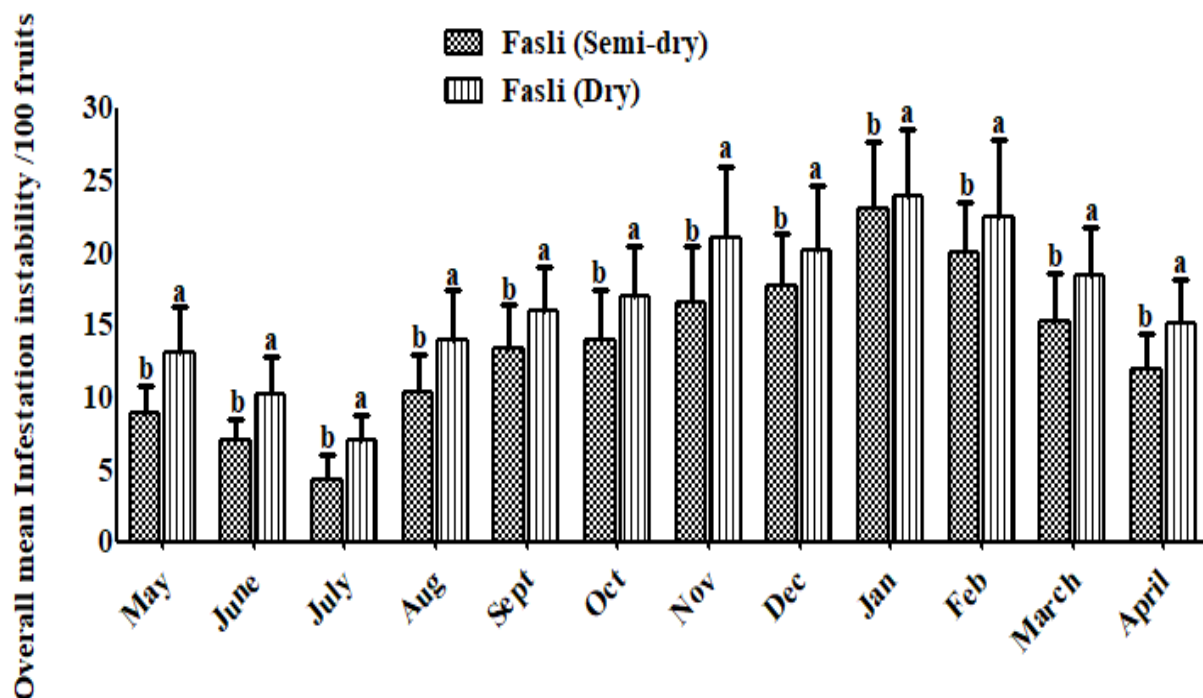


Fig. 4. The overall mean population of fruit infestation instability of STG beetle on dry and semi-dry date fruits on Fasli variety.

Saw-toothed grain beetle population on Gajar variety

This is also a prominent variety of this region one unique importance of this variety is that it gave the earlier season fruit as compared to other varieties due to this growers are taking earlier benefit. But during present work under laboratory conditions, it was found that this variety is also a sufficient host for this pest. The instability of the infestation of *O. surinamensis* on the same counted amount of variety; Gajar dry and semi-dry date fruits was found with high prevalence in the month of January, 22.45 to 20.33 followed by February, 21.70-19.80; March, 19.90-15.45; December, 19.35-16.60; November, 19.15-15.30; April, 15.45-13.70; October, 13.55-16.25; September, 15.70-16.88; August, 11.90-14.45; May, 14.20-09.10; June, 10.35-07.60, and July, 07.20-04.70 on both type of date fruits, respectively. The ANOVA of the infestation instability was found with a significant differences in the consequent months of the years, in the month of May, DF= 1; F= 1205; P= 0.00; June, DF= 1; F= 129; P= 0.03; July, DF= 1; F= 320; P= 0.03; August, DF= 1; F= 213; P= 0.01; September, DF= 1; F= 213; P= 0.04; October, DF= 1; F= 35.4; P= 0.04; November, DF= 1; F= 107; P= 0.00; December, DF= 1; F= 30.0; P= 0.02; January, DF= 1; F= 571; P= 0.07, February, DF= 1; F= 5.95; P= 0.07; March, DF= 1; F= 225; P= 0.02; April, DF= 1; F= 572; P= 0.00, respectively. The overall maximum infestation of *O. surinamensis* recovered from dry dates when compared with semi-dry date fruits of Gajar variety. The values of the same letters found with significant differences in six replications at (P< 0.05) through Tukeys test after doing one- way ANOVA, further description is shown in Fig. 5.

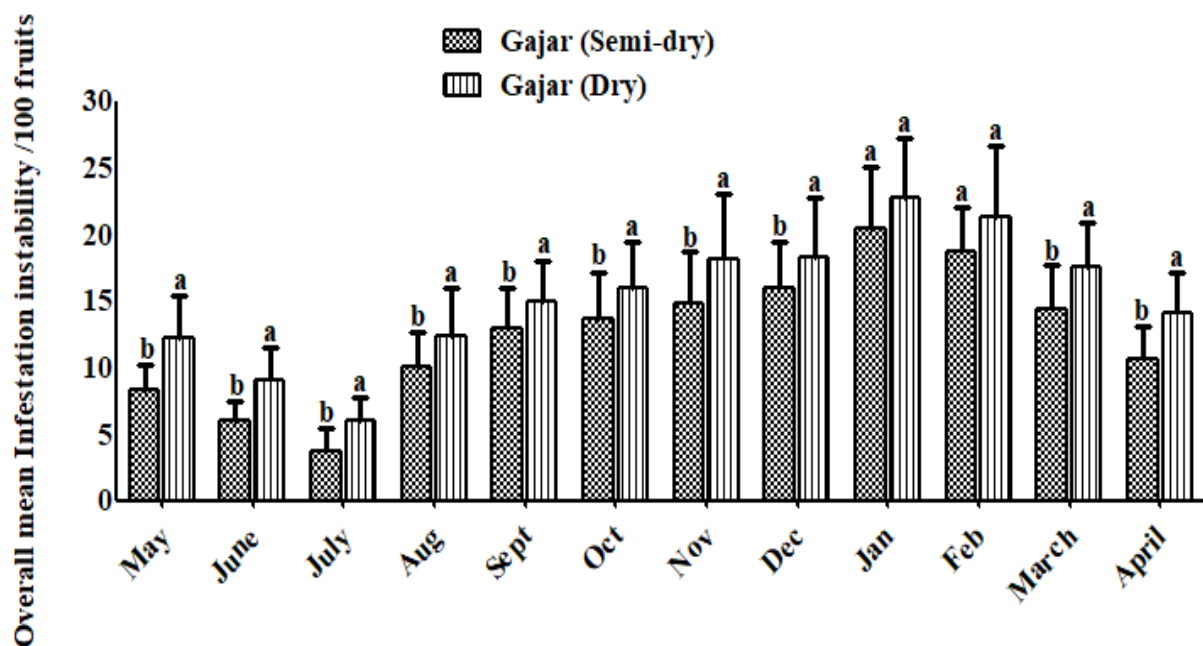


Fig. 5. The overall mean population of fruit infestation instability of STG beetle on dry and semi-dry date fruits on Gajar variety.

Saw-toothed grain beetle survival on Daki wari variety

Daki wari variety is economically valuable especially; the fruit of the dry date which is locally called “Nur” has a high nutritional value. People widely purchase dry fruit of this variety at a high-priced level as per the quality level and used for better health elements. The semi-dry and dry date fruits of this variety are large-sized as compared to others but it was observed that this pest relay negative effects of this kind of the Daki wari variety in semi-dry and dry dates fruits as well. After infestation the fruit minimized its size and reduced the nutritional value, it is compared to more or less pest infestation during the research study. The overall maximum mean infestation instability of *O. surinamensis* in (n=100) fruits of Daki wari semi-dry dates was found in December, 24.55 to 16.80, in the last month of the year, followed by April, 22.77-15.28; January, 20.45-22.56; February, 18.55-20.25; March, 14.80-16.25; November, 11.55-17.25; October, 11.35-16.77; September, 12.46-14.33; July, 14.90-5.20; August, 12.25-11.30; May, 09-45-11.35, and June, 09.80-06.10, respectively. Further, the analysis of variance shows the significantly and highly significantly differences as mentioned in the consequent months like; May, DF= 1; F= 356; P= 0.01; June, DF= 1; F= 250; P= 0.03; July, DF= 1; F= 663; P= 0.02, August, DF= 1; F= 494; P= 0.00; September, DF= 1; F= 1251; P= 0.04; October, DF= 1; F= 125; P= 0.04; November, DF= 1; F= 46.0, P= 0.02; December, DF= 1; F= 260; P= 0.01; January, DF= 1; F= 258; P= 0.18; February, DF= 1; F= 13.6; P= 0.02; March, DF= 1; F= 157; P= 0.05; April, DF= 1; F= 1346; P= 0.00, respectively. The overall maximum infestation instability was recorded on the semi-dry when compared with dry date fruits of the Daki wari variety. The values of six replication of the same letters were found with the most significant differences when done through the help of the Tukey test in one-way ANOVA at (P< 0.05), as shown in Fig. 6.

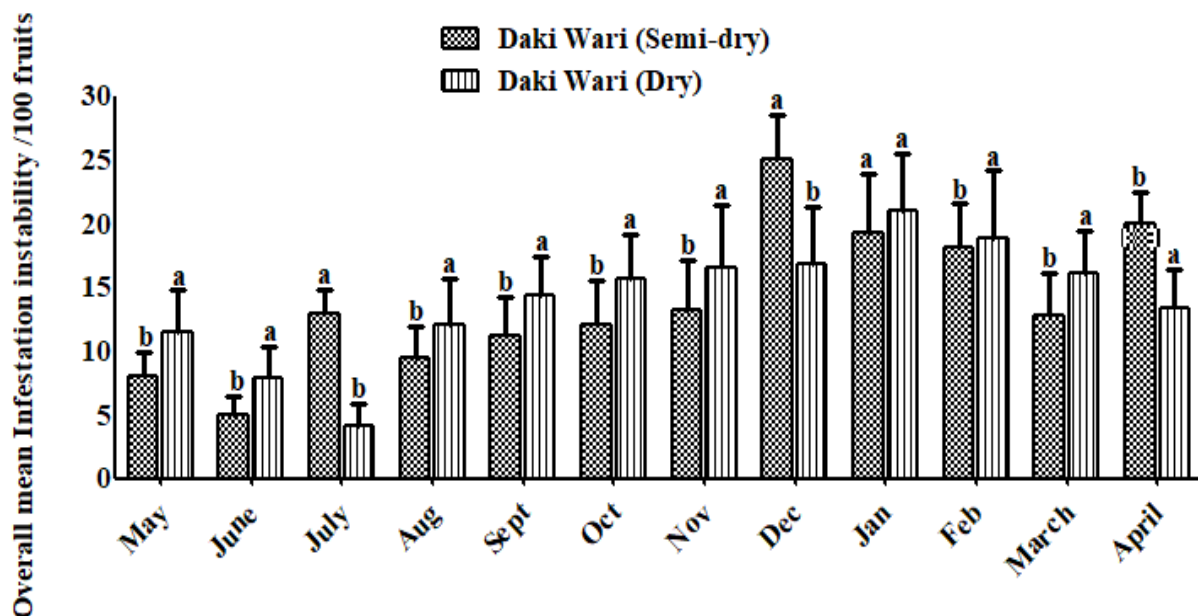


Fig. 6. The overall mean population of fruit infestation instability of STG beetle on dry and semi-dry date fruits on Daki Wari variety.

Saw-toothed grain beetle hazardous on Aseel variety

The Aseel variety is regarded as the queen variety of this region and high economically profitable. The semi-dry and dry fruit of this variety locally people can keep for a long time and when price increase at a high scale then they sell their dates in local markets and export to other countries. The available record of this variety is highly cultivated in this region as compared with other varieties hectore-wise. *O. surinamensis* is a cosmopolitan insect pest and this variety is also a major host for this insect. During the present work, it was observed more and less infestation of this pest when evaluating the date palm fruit with its effect on vascular health and future research directions, due to infestation of saw-toothed grain beetle the dates fall gradually at its socio-economic level and about thirty percent loss may occur. The maximum mean pest infestation of saw-toothed grain beetle was recorded at high prevalence on Aseel dry and semi-dry date fruits in the January month, 19.45 to 17.20; February, 16.55-16.20; March, 15.20-14.80; April, 14.55-13.60; December, 14.20-13.25; November, 14.10-12.90; October, 13.80-12.55; September, 13.60-11.88; August, 13.45-11.38; May, 12.77-09.10; June, 08.55-06.45, and July, 04.90-04.60, respectively. ANOVA was found with the significant and highly significant difference on Aseel semi-dry and dry in the month of May, DF= 1; F= 155; P= 0.02; June, DF= 1; F= 26.4; P= 0.05; July, DF= 1; F= 0.93; P= 0.38; August, DF= 1; F= 223, P= 0.01; September, DF= 1; F= 85.9; P= 0.08; October, DF= 1; F= 48.5; P= 0.85; November, DF= 1; F= 35.4; P= 0.04; December, DF= 1; F= 8.15; P= 0.04; January, DF= 1; F= 27.6; P= 0.04; February, DF= 1; F= 1.56; P= 0.27; March, DF= 1; F= 59.5; P= 0.64; April, DF= 1; F= 1197; P= 0.01 in their mean infestation instability among the homogenous groups. Generally, the maximum pest population recorded in the cold season with more prevalence on Aseel dry dates when compared with semi-dry date fruits. The values of six replication of the same letters were found with significant differences at (P<

0.05) through the help of one-way Tukey's test and the detailed description further given in Fig. 7.

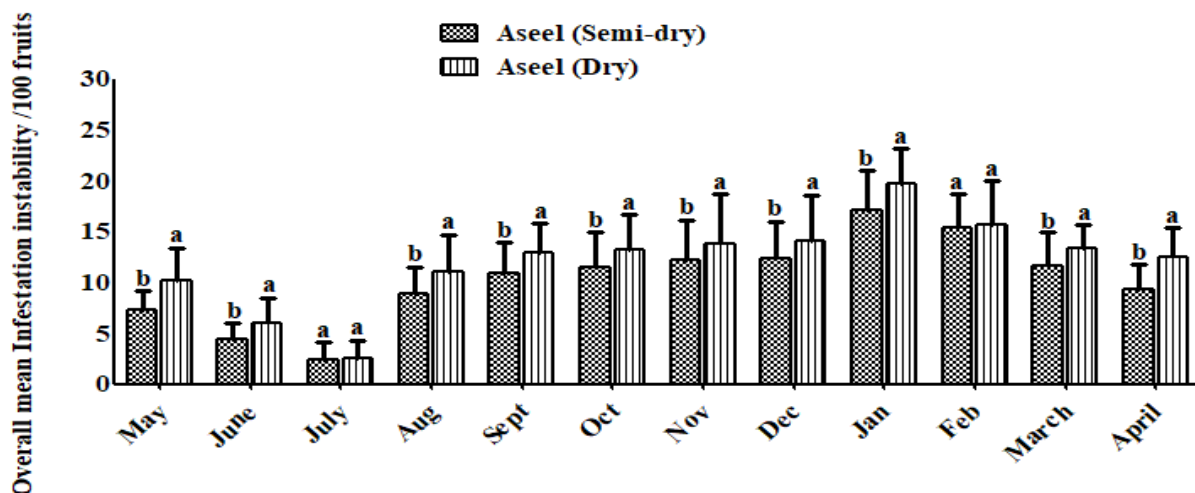


Fig. 7. The overall mean population of fruit infestation instability of STG beetle on dry and semi-dry date fruits on Aseel variety.

The emergence of the larval parasitoid, Cephalonomia tarsalis (Ashmead) (Hymenoptera: Bethylinidae) on its host O. surinamensis under laboratory conditions

The parasitism % on semi-dry and dry dates fruit of the Karbalian variety was a targeted host for the pest attack and resurgence. The population of parasitoids was found in all the months on pest from the semi dry and dry date fruits. As we know, the maximum population of saw-toothed grain beetle found in the month of January and minimum in July month. Though the overall mean percent population of parasitoid, *Cephalonomia tarsalis* from the (n=100), effected with severe larval stages of pest from each of semi-dry and dry dates fruits on Karbalian variety were observed. Hence; the parasitoid population was observed with the maximum in January, 24.35 to 26.70, followed by February, 23.10-23.60; March, 23.55-21.80; April, 23.70-21.20; August, 24.30-19.57; September, 23.55-19.40; October, 23.10-20.80; November, 21.20-22.40; December, 18.45-22.36; May, 22.10-18.25; June, 19.80-17.45, and July, 22.40-15.60 months of the both years of pooled data. Thus; the parasitism percent population was subjected to analysis that found significant and highly significant differences as; in the May, DF= 1; F= 6.18; P= 0.06; June, DF= 1; F= 1.46; P= 0.29; July, DF= 1; F= 5.72; P= 0.07; August, DF= 1; F= 7.52; P= 0.05; September, DF= 1; F= 4.89; P= 0.09; October, DF= 1; F= 7.52; P= 0.05; November, DF= 1; F= 0.67; P= 0.45; December, DF= 1; F= 20.5; P= 0.01, January, DF= 1; F= 3.83; P= 0.12; February, DF= 1; F= 2.80; P= 0.16; March, DF= 1; F= 7.52; P= 0.05; May, DF= 1; F= 0.68; P= 0.50, respectively. The overall maximum mean population of parasitoid reported on semi-dry than the dry date fruits of Karbalian variety. The each six replication values found with significant differences when data was subjected to analysis at (P< 0.05), through the Tukeys test after doing one-way ANOVA, as followed in Fig. 8.

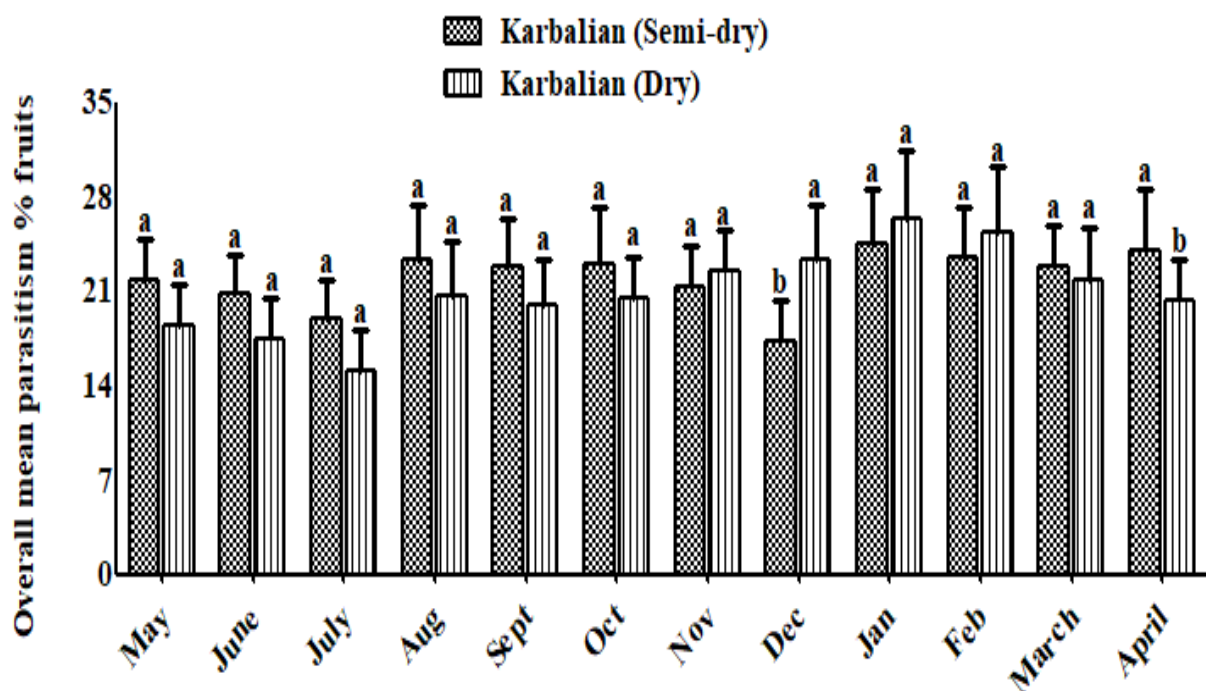


Fig. 8. The overall mean of parasitism % population of the larval parasitoid, *C. tarsalis* on its host *O. surinamensis* under laboratory conditions on variety, Karbalian

***Cephalonomia tarsalis* population against STGB on Fasli date fruits**

The maximum parasitism % on pest variety; Fasli of semi-dry and dry dates was recorded from August up to April and the minimum population was observed in June and July during the consequent years, 2020-21. The overall maximum mean parasitism % population of parasitoid, *C. tarsalis* on pest from dry and semi-dry date fruits were recorded with the maximum in December, 22.45 to 24.20, when compared to the January, 22.15-23.70; February, 20.45-22.10; November, 19.60-18.45; April, 19.80-20.45; October, 19.60-18.90; September, 19.45-18.60; August, 21.10-19.35; March, 22.45-23.60; May, 20.80-18.15; June, 19.45-17.90; July, 17.34-13.70, respectively. When the parasitism population was statistically analysed on the dry and semi dry date fruits that was found with significant and highly significant differences in the month of May, DF= 1; F= 7.77; P= 0.04; June, DF= 1; F= 7.46; P= 0.05; July, DF= 1; F= 7.86; P= 0.04; August, DF= 1; F= 9.57; P= 0.03; September, DF= 1; F= 12.2; P= 0.02; October, DF= 1; F= 153; P= 0.02; November, DF= 1; F= 0.13; P= 0.73; December, DF= 1; F= 12.2; P= 0.02; January, DF= 1; F= 0.41; P= 0.55; February, DF= 1; F= 2.40; P= 0.19; March, DF= 1; F= 1.75; P= 0.25; April, DF= 1; F= 4.51; P= 0.10, respectively. The overall maximum mean parasitism was recorded on semi-dry than dry dates fruits. The six replication values of the same letters found with significant differences when done through the Tukeys test after doing one-way ANOVA at (P< 0.05), further justification is given in Fig. 9.

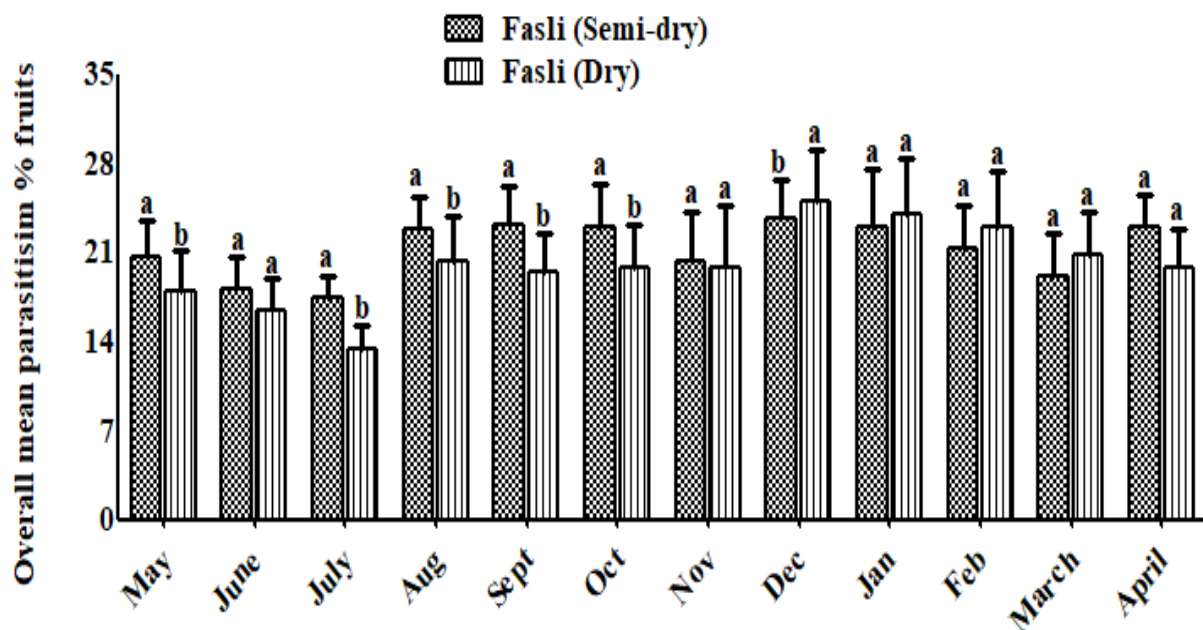


Fig. 9. The overall mean of parasitism % population of the larval parasitoid, *C. tarsalis* on its host *O. surinamensis* under laboratory conditions on variety, Fasli

The parasitism % population against STGB on variety, Gajar

The parasitism % on STG beetle from semi-dry and dry date fruits on Gajar variety was observed in the consequent months of the year and due to the infestation of this pest both type of fruits lost their weight and reduced their quality and quantity level. The dry and semi dry date fruits were found with positive influence of parasitoids in all the months of the research study. Hence; the overall mean parasitism % taken from the larval stages of pest was counted on hundred date fruits individually. That was found with high prevalence on semi-dry and dry dates of Gajar variety in the month of January, 24.35 to 22.45, followed by December, 22.90-21.35; April, 23.40-18.20; February, 20.45-21.35; August, 22.10-18.33; September, 21.30-18.10; October, 22.35-17.90; March, 21.70-22.10; November, 18.40-21.10; May, 18.10-19.15; June, 16.45-15.30, and July, 06.30-09.15, respectively. When parasitoid emergence population data was statistically analyzed that was found with significant and highly significant differences in the month of May, DF= 1; F= 0.00; P= 1.00; June, DF= 1; F= 0.27; P= 0.63; July, DF= 1; F= 0.93; P= 0.38; August, DF= 1; F= 4.78; P= 0.09; September, DF= 1; F= 2.65; P= 0.17; October, DF= 1; F= 13.7; P= 0.02; November, DF= 1; F= 12.0; P= 0.02; December, DF= 1; F= 445; P= 0.01; January, DF= 1; F= 87; P= 0.40; February, DF= 1; F= 7.78; P= 0.04; March, DF= 1; F= 0.52; P= 0.51; April, DF= 1; F= 45.3; P= 0.03, respectively. The overall maximum parasitoids population was recorded on semi-dry when compared with dry dates. In six replications, the values of the same letters were observed with significant differences at ($P < 0.05$) with Tukeys test after one-way analysis of variance, as shown in Fig. 10.

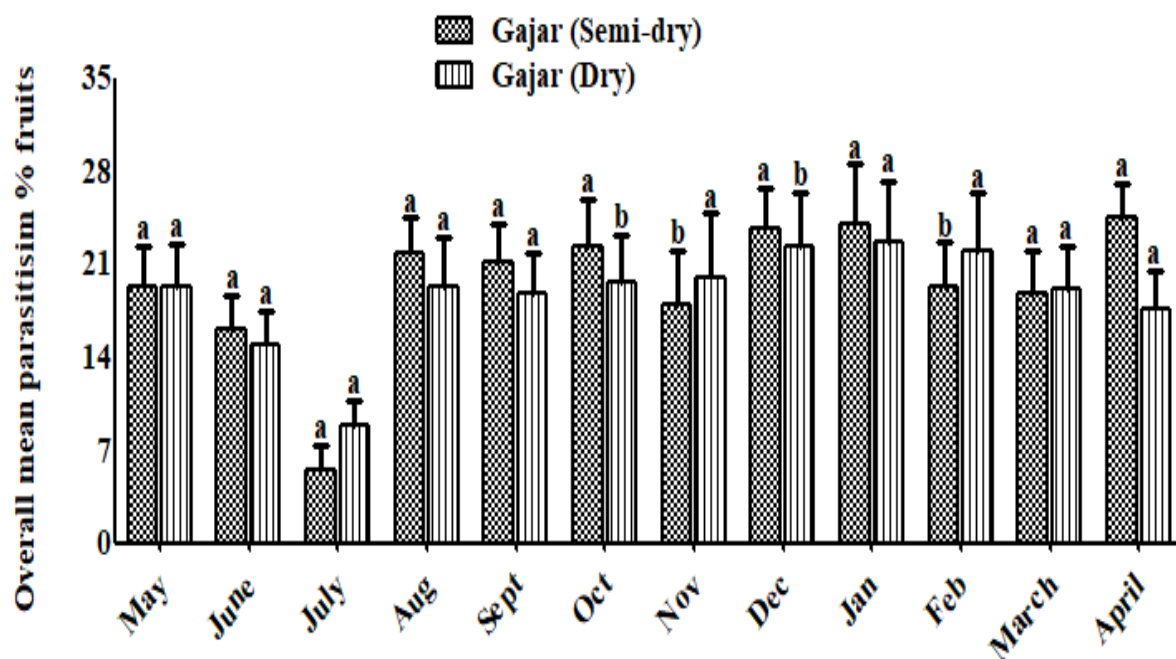


Fig. 10. The overall mean of parasitism % population of the larval parasitoid, *C. tarsalis* on its host *O. surinamensis* under laboratory conditions on variety, Gajar

C. tarsalis on the larval stage of saw-toothed grain beetle on variety, Daki wari

The overall maximum parasitoid, *Cephalonomia tarsalis* population was recorded on Daki wari variety on semi-dry and dry dates in the month of January, 27.20 to 18.90 followed by April, 24.50-15.30; November, 15.25-22.35; August, 21.90-18.56; September, 21.77-15.20; November, 16.70-23.45; June, 13.90-19.20; October, 19.30-17.45; March, 16.33-18.45; February, 16.70-21.45; May, 16.30-15.90, and July, 13.80-06.70, respectively. The analysis of variance of parasitoid population was found with significant, non and highly significant differences in the month of May, DF= 1; F= 0.27; P= 0.63; June, DF= 1; F= 4.74; P= 0.07; July, DF= 1; F= 16.4; P= 0.03; August, DF= 1; F= 4.95; P= 0.09; September, DF= 1; F= 16.5; P= 0.03; October, DF= 1; F= 1.16; P= 0.34; November, DF= 1; F= 4.04; P= 0.02; December, DF= 1; F= 30.2; P= 0.00; January, DF= 1; F= 26.0; P= 0.07; February, DF= 1; F= 3.36; P= 0.08; March, DF= 1; F= 0.39; P= 0.56; April, DF= 1; F= 6.74; P= 0.06, respectively in month wise parasitism population. The overall maximum parasitoids population was recorded on the semi-dry when compared with dry date fruits of Daki wari variety. The values of six replications found with significant differences at (P< 0.05) through the doing of one- way ANOVA with the help of Tukeys test, further detailed description is shown in Fig. 11.

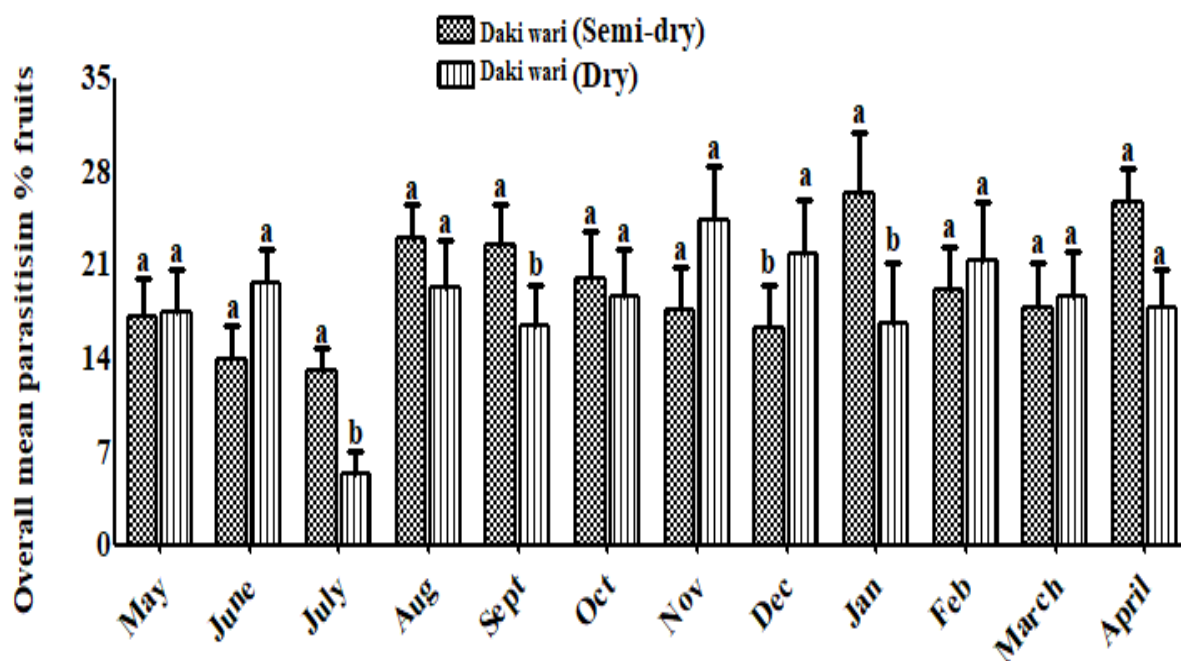


Fig.11. The overall mean of parasitism % population of the larval parasitoid, *C. tarsalis* on its host *O. surinamensis* under laboratory conditions on variety, Daki

The parasitism % against STGB larvae on variety, Aseel

The *O. surinamensis* is an injurious pest that widely infests dry and semi-dry dates, this is the cosmopolitan and secondary feeder by forming mechanical lesions and micro cracks damage to whole fruit. Their parasitism % was recorded on pest of variety, Aseel on semi dry and dry date fruits and population of parasitoids were recovered with certain fluctuations in different months of the both years. The overall mean population of parasitism found with maximum on the Aseel semi-dry and dry date fruits in the month of January, 25.80 to 22.55, followed by August, 24.45-20.80; February, 22.78-19.87; September, 19.33-22.10; October, 20.36-18.90; November, 18.45-21.88; March, 17.90-19.67; April, 17.55-19.25; December, 17.10-18.56; May, 16.80-14.88; June, 15.20-16.88, and July, 16.10-15.20, respectively. When the data was statistically analyzed that found with significant, non-significant and highly significant differences in the month of May, DF= 1; F= 0.23; 0.65; June, DF= 1; F= 0.12; P= 0.18; July, DF= 1; F= 0.46; P= 0.53; August, DF= 1; F= 53.1; P= 0.04; September, DF= 1; F= 0.03; P= 0.86; October, DF= 1; F= 1.33; P= 0.31; November, DF= 1; F= 7.02; P= 0.05; December, DF= 1; F= 4.71; P= 0.09; January, DF= 1; F= 2.17; P= 0.21; February, DF= 1; F= 23.7; P= 0.72; March, DF= 1; F= 6.97; P= 0.92; April, DF= 1; F= 0.23; P= 0.54, respectively. The overall maximum parasitoids population recorded on Aseel dry than Aseel semi-dry dates. The values of the same letters of six replications found with significant differences at ($P < 0.05$) through one-way Tukeys test ANOVA, detailed description is given in Fig 12.

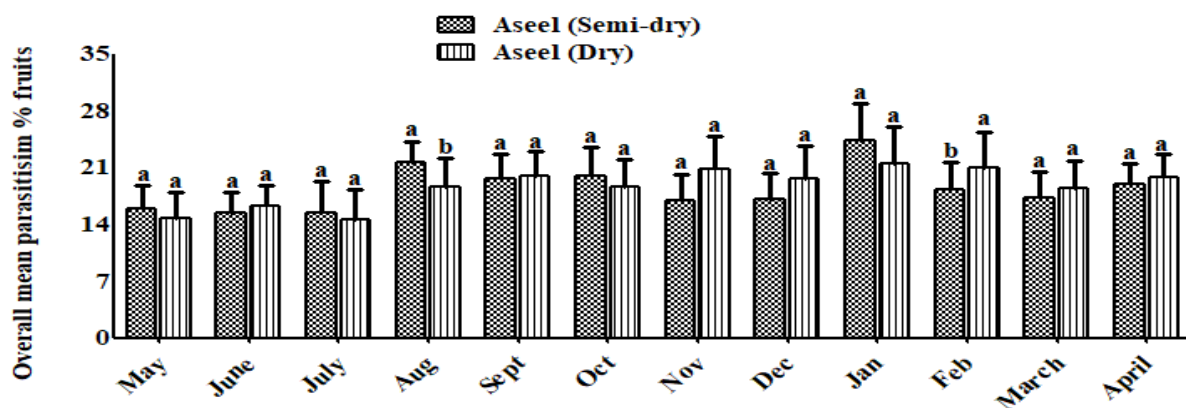


Fig. 12. The overall mean of parasitism % population of the larval parasitoid, *C. tarsalis* on its host *O. surinamensis* under laboratory conditions on variety, Aseel

The overall STGB infestation instability on five prominent date palm varieties

The overall infestation with pest on five different semi-dry and dry date fruits of individual varieties were found with the severe infestation though out the all consequent months of two years, 2020-21. The Karbalian variety showed high susceptibility to this pest, the reason might be behind because this variety contains a high amount of sugar due to the more sweet contents thus, the variety serves as the main host for the *O. surinamensis*. The overall mean pest, saw-toothed infestation on semi-dry and dry dates was observed on namely; Karbalian, 17.45 to 14.65; Fasli, 16.35-13.88; Gajar, 15.90-13.35; Daki wari, 14.66-12.90, and Aseel, 12.45-11.55. When the infestation data were subjected to analysis of variance that was observed with significant differences in semi-dry date fruits, DF= 4; F= 20.7; P= 0.02, and dry date fruits, DF= 4; F= 35.4; P= 0.00, respectively. The maximum infestation of *O. surinamensis* was found on the (n=100) individually semi-dry and dry date fruits on Karbalian followed by Fasli, Gajar, Daki wari, and Aseel varieties. The values in the six replications of the same letters found with significant differences at (P< 0.05) through the help of Turkeys test after completion of one-way analysis of variance, further described as in Fig. 13.

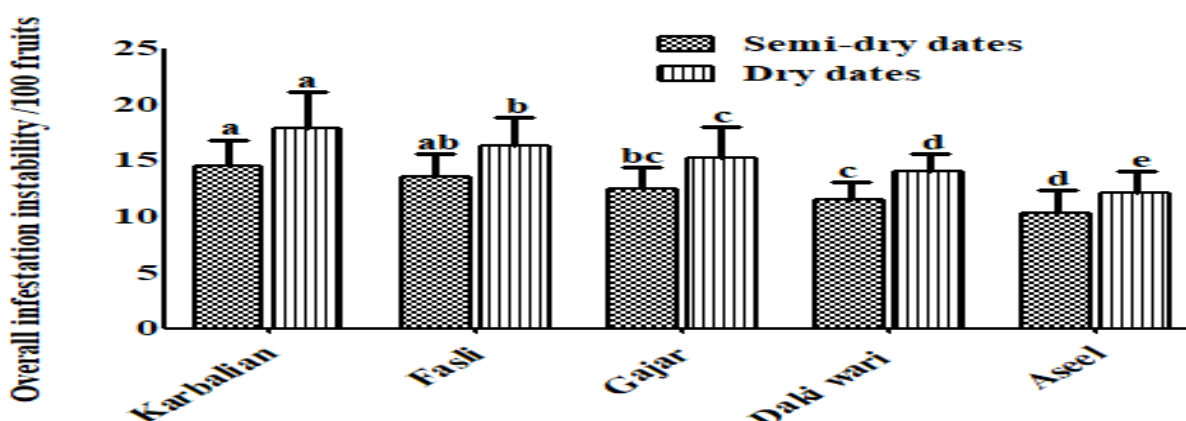


Fig. 13. The overall population infestation instability of STGB on fruits of different varieties on semi-dry and dry date fruits during, 2020-21.

The overall parasitism % against STGB on five date palm varieties

The overall parasitism % with parasitoid, *Cephalonomia tarsalis* on larvae of *O. surinamensis* on semi-dry and dry date fruits of five different *P. dactylifera* varieties were observed with positive influences under laboratory condition hatchings. Hence; the Aseel variety was found more resistant than the other four varieties. During both years of the study, the parasitism infestation on the larvae of pest observed from semi-dry and dry date fruits of different five distinct varieties i-e., Karbalian. 27.35 to 20.90; Fasli, 21.15-19.60; Gajar, 19.45-18.70; Daki wari, 18.60-17.90, and Aseel, 17.55-17.25 kept on (100) dates fruits were examined individually at Date Palm Research Institute (DPRI), SALU - Khairpur. The analysis of variance of overall parasitism % found with the significant differences in semi-dry Aseel, Daki wari, Fasli, Gajar and Karbalian varieties like; DF= 4; F= 105; P= 0.00; and dry date fruits on Karbalian, Gajar, Daki wari, Fasli, Aseel varieties as; DF= 4; F= 16.8; P= 0.00, respectively. The values are shown as monthly mean \pm SE where the maximum population of the parasitoid, *C. tarsalis* was observed on the Karbalian variety followed by Fasli, Gajar, Daki wari, and Aseel. The values of the same letters with the overall mean population were found with significant differences after doing one-way ANOVA at (P< 005), further parasitism overall means % population is given in Fig. 14.

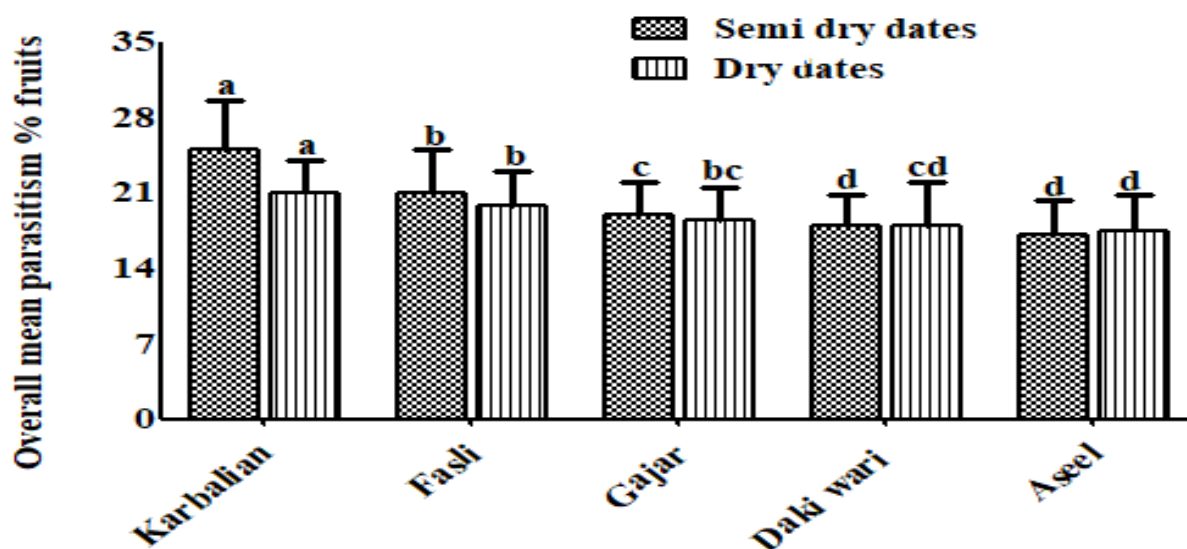


Fig. 14. The overall mean parasitism % on larvae of STGB from infested fruits of different varieties on semi-dry and dry dates during, 2020-21.

DISCUSSIONS

During the research work, it was frequently found that all five prominent different semi-dry and dry date varieties namely; Karbalian, Fasli, Gajar, Daki wari, and Aseel, frequently suspected by the destructive insect, saw-toothed grain beetle. Our results are agreed with the work of (Chao & Krueger 2007; Shar et al., 2012), who documented the attack of saw-toothed grain beetle on dry and semi-dry date fruits that faced severe problems of infestation with the pest that reduced quantity and quality including the weight of the fruits. The maximum pest population was recorded in January and the minimum in July with the work

agreement of (Jacob & Fleming, 1990), they documented the pest population on Dadhi semi-dry dates where the peak population was observed in November and on Dadhi dry dates in December. (Syarifah et al., 2018) discussed the overall maximum mean population of the pest on the Dadhi semi-dry that was found in November and on Dadhi dry in December. About one count 88% date yield is produced from the Middle East and North African countries namely; Iran, Saudi Arabia, Iraq, Egypt, Morocco, Pakistan, Algeria, India, United Arab Emirates, Oman, and Sudan but also found from other regions of the world including, Australia, South Africa, Peru, Mexico, Spain, Namibia, and USA (Johnson, 2010). This crop had ranked amongst the five top tree crops and most important as dried fruit in the world and due to their fruit dried role and many nutritional necessities of life having worldwide recognition and it is an important food source for the Arabian Peninsula (Sadiq et al., 2013). Germany, USA, India, Canada, UK, Malaysia, Denmark, Indonesia, and many other countries are widely importing fresh and dried dates from Pakistan and ranks 6th largest dates producer country in the world with annual 600.000 tons produced in 2012 with an area of cultivation 41, 240 ha in 1992 and 95,000 ha during, 2012 (FAO, 2014). More than three hundred date palm varieties are being cultivated countrywide of which 12 varieties including; Aseel, Fasli, Halwai, Karbalaen, Muzawati, Dashtiari, Begum Jhangi, Koharba, Rabai, Sabzo, Dhakki, and Jaan Swore to have economical value but Aseel of Sindh, Begum Jangi of Balochistan and Dhakki of Dera Ismail are most valuable date varieties (FAOSTAT, 2013). Date palm at the wide range can be cultivated with intercropping and farming with other crops such as; groves, oases, home gardens, etc as an intercrop in Pakistan (Bhansali, 2010).

On a fortnightly interval data basis, the population fluctuation was observed with certain changes but the peak population of the pest was found in April month on Aseel semi-dry dates and the dry date fruits the maximum in May thus; the work is in agreement with (Sahito et al., 2017), they documented a variety of pest species viz., *Arenipses sabella* Hampsm, *O. rhinoceros* Linnaeus, *R. ferrugineus* Oli, *O. surinamensis* Linnaeus, *B. amydraula* Meyrick, mites and scale insects on date fruits. The infestation means of pest and parasitism percentage found with certain differentiations with the work similarity of (Kousar et al., 2021) studied the different parameters such as; biology, morphology, and varietal distribution of *O. surinamensis* L. on dry and semi-dry date palm in which they found significant differences. This is in an agreement with the work of (Shar et al., 2012), who documented that the Karbalian variety is a targeted host for these insects. Our results have similarities with the documentary of (Maitlo et al., 2013) that highlighted the severe effects of pest attacks and a disease called decline syndrome. The result is more resemblance to the work of (Mallah et al., 2016); it is compared more or less with the work of (Sahito et al., 2017) as well.

During the present research work, we observed more and less infestation of this pest which is work resemblance with (Al-Dashti et al., 2021) who evaluated the date palm fruit with its effect on health (Markhand et al., 2010), they documented that due to infestation of Saw-toothed grain beetle dates fall gradually and about thirty percentage losses occur (El-Juhany & Loufty 2010). Further, this fruit is having more valuable due to the richness of nutritional values. Dates fruit either dry or semi-dry is regarded as the fastener and high energetic food for thousands of years, providing many benefits to the locals and communities, during

Ramadan, the whole Muslim community in the world by eating dates break their fast, their wood is used for build homes, burned for fuels and chopped, palm fronds for handicrafts, leaflets for making fruits mats and baskets (Bowditch & Madden 1997). (Junejo et al., 2021) also reported the different parameters of Red palm weevil in *P. dactylifera* orchards at Khairpur, Sindh. Farmers and date growers have little awareness about the economics of *P. dactylifera*. Small efforts have been made by researchers to determine the economic value of important crops in this region. *O. surinamensis* caused to the stored dates severe infestation and made fruits unable to human consumption and spoilage, affecting quality, quantity, and market value (Abdul-Hamid et al., 2020) with the impacts of socioeconomic impacts (Sarraf et al., 2021) are with the agreement of our research findings. It is recommended that at an egg and larval stage it is easy to control *O. surinamensis* because these stages are sensitive and vulnerable. Radiation techniques offer a substitute method for the control of saw-toothed grain beetle because it requires less time, leaves no reduction, and can be effective as fumigants.

CONCLUSION

It was frequently observed that *O. surinamensis* is a destructive pest that causes severe damage to both dry and semi-dry fruits of all five different dates' varieties. Due to the infestation of this pest both type of fruits lost their weight and reduced their quality and quantity as well. This study was chiefly based on finding out the susceptibility of five varieties of date fruits based to get the knowledge to observe which variety occurs more vulnerable and susceptible. Therefore, it is a dire need to introduce eco-friendly techniques like; biological control against saw-toothed grain beetle through these applying measures we will not only save our dry and semi-dry fruits of date palms varieties from the pest infestation but also save the quality and quantity of the date fruits as well.

AUTHORS CONTRIBUTION

T.K: designated the main research theme, data collected at Khajoor mandi, contributed to statistical data analysis, wrote the manuscript, key results, and specified the model for a research study. Z.N.M: supervised laboratory work, assisted in reviewing literature and data analysis. H.A.S: also is a co-supervisor who helped in proofreading, provided technical support, and fully monitored the research work in his Entomology laboratory at DPRI.

IMPACT STATEMENT

In this region largely grown with the most prominent and fruitful date palm varieties with the best quality and this crop is known as the main earning source of the live hood of the local people of this area but the majority of the novel date palm varieties are severely damaged due to the abruptly by the infestation of saw-toothed grain beetle. In this scenario, this research work will be the supportive and informative tool from the early combat of *O. surinamensis* through this biological control agent the parasitoid, *C. tarsalis*.

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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's publication.

AVAILABILITY OF DATA AND MATERIALS

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

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