ABUNDANCE AND POPULATION DYNAMICS OF THE MAJOR INSECT PESTS OF DATE PALM UNDER THE DATE PALM- FORAGE INTERCROPPING SYSTEM

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ABSTRACT

The objective of this study was to investigate the influence of blue panic (*Panicum antidotale* Retz.) and alfalfa (*Medicago sativa* L.) growth around palm trees on insect pests. Four experimental treatments were employed to develop fodder around date palms in the field: alfalfa, blue panic, combination of alfalfa and blue panic, and a palm monoculture without any fodder. Each treatment consisted of six replications, resulting in a total of 24 date palms examined. Insect pests were collected monthly utilizing light and pitfall traps from January to December 2020. A one-way ANOVA was used to evaluate the effect of fodder treatments on the number of pests collected. Additionally, an ANOVA with repeated measures was used to analyze the impact of time on the quantity of insects collected across various fodder treatments. Each of these analyses was performed through SAS version 9.2. The study's findings demonstrated that most palm pests, such as *Oryctes elegans*, *Phonapate frontalis*, *Sphenophorus parumpunctatus*, *Xyleborus perforans*, and *Tenebroides mauritanicus*, significantly decreased with the introduction of fodder cultivations around the examined date palms. Additionally, the data demonstrated a highly significant difference over time and the fodder treatments on several insect pests, including *P. frontalis*, *X. perforans*, and *O. elegans*.

Keywords: Pest Management, Fodder Cultivation, Cultural Control and Plant Diversity, sustainability, climate action.

الوفرة والتذبذب الديناميكي لأهم الآفات الحشرية الرئيسة لنخيل التمر في ظل نظام التحميل بين محاصيل النخيل والأعلاف

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المستخلص

كان هدف هذه الدراسة هو فحص تأثير نمو حشيشة البلوبانك (Panicum antidotale Retz.) والبرسيم الحجازي (Medicago sativa L.) حول أشجار النخيل على أهم الآفات الحشرية. أُستخدامت أربع معاملات تجريبية لزراعة الأعلاف حول أشجار النخيل في الحقل وهي: محصول البرسيم الحجازي، حشيشة البلوبانك ، ومزيج كلا العلفين ، وزراعة النخيل بشكل منفرد بدون أي علف. تألفت كل معاملة من ست مكررات، و 24 نخلة تمر. تم جمع الآفات الحشرية شهريًا باستخدام المصائد الضوئية والمصائد الارضية بداءً من شهر شباط إلى شهر كانون 2020. أُستخدام تحليل التباين أحادي الاتجاه لتقييم تأثير معاملات الأعلاف على عدد الآفات التي جُمعت. بالإضافة إلى ذلك، أُستخدم تحليل التباين باستخدام القياسات المتكررة لتحليل تأثير الوقت على كمية الحشرات التي جُمعت عبر معاملات زراعة الأعلاف المختلفة. إجريت كل من هذه التحليلات الاحصائية من خلال برنامج SAS 9.2. وأظهرت نتائج الدراسة أن معظم آفات النخيل مثل جعل النخيل Oryctes elegans و حفار سعف النخيل Phonapate frontalis وسوسة النخيل السوداء Sphenophorus parampunctatus وعثة التين Xyleborus perforans وخنفساء الكادل Tenebroides mauritanicus انخفضت بشكل ملحوظ ومعنوي مع إدخال زراعة الأعلاف حول أشجار النخيل المدروسة. ايضاً، أظهرت البيانات وجود فروق معنوية كبيرة بمرور الوقت ومعاملات الاعلاف على العديد من الآفات الحشرية، بما في ذلك P. frontalis و X. perforans و O. Elegans.في الختام، يشير هذا البحث إلى إمكانية استخدام نظام التداخل بين زراعة أشجار النخيل والاعلاف كحل مستدام لإدارة آفات النخيل الشائعة.

الكلمات المفتاحية: ادارة الآفات، زراعة الأعلاف، المكافحة الزراعية والتنوع النباتي، الاستدامة، العمل المناخي.

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INTRODUCTION

One of the world's oldest known fruit crops, the date palm tree (*Phoenix dactylifera*) is native to subtropical areas and it has improved food security in dry parts of the world, particularly in the Middle East and North Africa (3, 15). Saudi Arabia is ranked third globally in date production, with a cultivation base exceeding 25 million palm trees (4). However, numerous insect pests and diseases target date palm trees, with the severity of the damage varies depending on the cultivar, region and climatic condition (5). Pests are known to affect various parts of a palm tree; some prefer to target the main trunk, while others focus on the fronds or fruits (2). Some insecticides are broad spectrum, potentially harming human health and the environment; they have generally affected agricultural goods and human life (17). The direct use of pesticides can pollute food, soil, and groundwater (12). Concerns about the detrimental effects of pesticides on human health, non-targeted species, and natural enemies have increased in the public in recent years, and many pests have developed resistance to some of the most widely used insecticides (29, 37). An increasing number of researchers are exploring alternative pest management strategies due to growing awareness of the adverse effects of pesticides (6, 16). Adding diversity to agricultural areas through the use of "polycultures," which includes multiple diverse crop varieties within a field, serves as an alternative method to pesticides (9). Farmers benefit significantly from plant diversity, including higher revenue, enhanced production and improved soil fertility. To reduce insect pest populations, researchers have recently focused on the modification and diversity of plants in agriculture (12). Crop diversification can reduce insect pests directly by preventing pest outbreaks or indirectly by attracting natural enemies that subsequently eliminate the targeted pest (29). Before the development of modern synthetic pesticides, crop diversification was a common method of pest management across various agricultural systems (10). Numerous studies have demonstrated the advantages of plant diversity over monoculture crops in terms of lowering pest rates (39, 30, 36). Intercropping grains with legumes significantly reduces the damage caused by cereal insect pests (8). In addition, natural enemies are more abundant and active due to the diversification's provision of additional resources such as food and shelter (33). Consequently, plant diversity can be described as a safe and sustainable method applicable in the pest management (30). This study aimed to investigate the impact of cultivating two fodders around date palms on their main pests.

MATERIALS AND METHODS

Study Area and Field Experimental Design : The study was conducted at King Abdul-Aziz University's Agriculture Research Station, located in the Hada Al-Sham region, around 120 kilometers from Jeddah governorate in western Saudi Arabia. In this experiment, date palm trees (*P. dactylifera*) Var. Barhi, were surrounded by quaternary forages of blue panic grass (*P. antidotale*) and alfalfa (*M. sativa*). A pesticide-free-date palm orchard (Checked through pesticide residue analysis) with an area of 2300 m^2 and consisting of 12 years old plants, was randomly selected for the date palm experiment, with each tree functioning as an experimental unit. The four treatments that were applied to the chosen date palm trees were as follows:

1- A total of 40 grams of alfalfa seeds were sown in and around the basin of date palm trees (Figure 1A).

2- A total of 40 grams of blue panic seeds were sown in and around the basin of date palm trees (Figure 1B).

3- Mixed-feed treatment: 20 grams of alfalfa and blue panic were quaternary-cultivated around a date palm trees basin (Figure 1C).

4- As a control, a date palm monoculture devoid of fodder (Figure 1D).

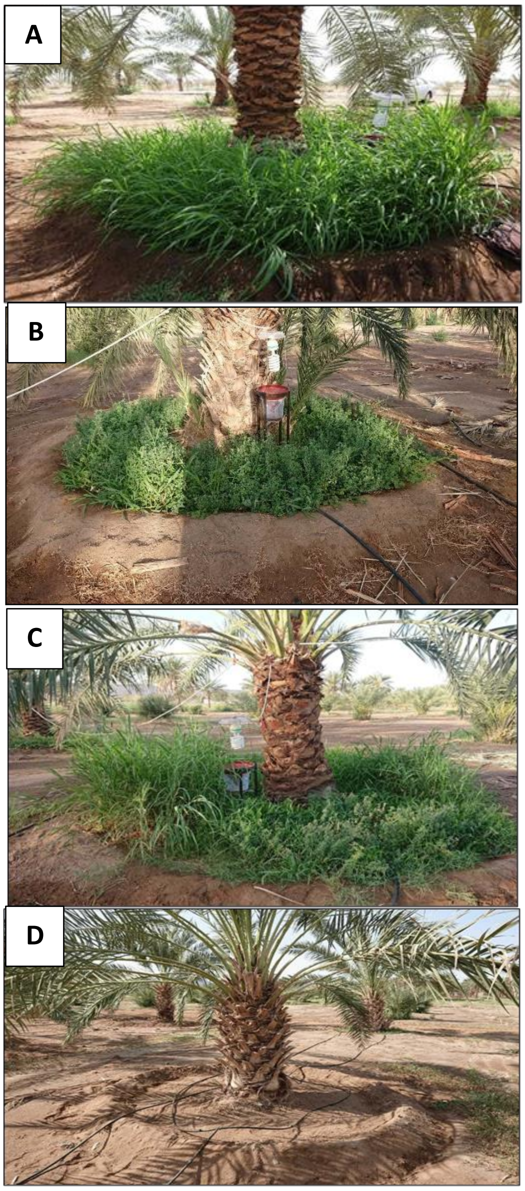

Figure 1. The date palm *P. dactylifera* was interplanted with the following species: A) blue panic *P. antidotale* alone; B) alfalfa *M. sativa* alone; C) mixed fodders (blue panic and alfalfa); D) date palm monoculture without any fodder as a control

Twenty-four date palm trees, or six duplicates of each treatment, were examined in this study using a Randomized Complete Block Design (RCBD). The hand-held equipment was used to control weeds between and within the experimental units.

Sampling protocols: From January 1, 2020, to December 30, 2020, specimens were collected biweekly using two distinct approaches to examine the impact of fodder production surrounding the selected date palm trees on the primary date palm pests:

Light traps :Light traps were purchased from Gardner Products, a reputable manufacturer specializing in the production of trapping devices to monitor nocturnal insect activity. These traps were placed on the ground at the base of date palms. Insect populations were captured using one light trap per palm. A gallon can of each light trap contained 60% propylene glycol to avoid the decomposition of insects. Specimens from the light traps were taken out every two weeks and brought back to the laboratory for further processing and organization. All specimens were preserved in 70% ethanol after the collection to prevent decomposition and facilitate future identification.

Pitfall traps :Pitfall traps were obtained from Gardner Products, a reputable manufacturer specializing in the production of trapping devices to monitor nocturnal insect activity. These traps were placed on the ground at the base of date palms. For each date palm treatment, a single pitfall trap (8.5 diameter x 13 cm depth) was employed. Each pitfall trap contained 60% propylene glycol and was left open for a duration of two weeks. Pitfall traps were collected and returned to the laboratory for further storage and categorization after a two-week period. All specimens were preserved in 70% ethanol to facilitate future identification.

Specimen's identification : The collected samples were counted and classified to the species level through taxonomic keys (Marshall (25).

Statistical analysis : The data was analyzed using the one-way analysis of variance (ANOVA) function in a computer program called SAS version 9.2 (SAS, 2009). An ANOVA was used to determine the impact of date palm-fodders intercropping system on the average total pest population. Data processing was conducted to achieve normality and improve the homogeneity of variances before executing the analysis of variance. Upon detection of significant treatment effects, *posthoc* Tukey tests were used to determine differences in the treatment means. The following components were evaluated using a separate repeated measure ANOVA to ascertain the temporal distributions of insect pests of date palms: time (repeated factor, 24 points), the fodder treatments (4 levels), and interactions between these factors. Block was included in the model as a covariate random component as well. To simplify the explanation, means and standard errors are presented in actual terms.

RESULTS AND DISCUSSION

The impact of the fodders' cultivation around date palm trees on the main date palm pests' abundances: A total of 18,358 insect pests from the Coleoptera and Orthoptera orders were collected for this study's experiment. Six species of Coleoptera were captured: *Oryctes elegans* (Coleoptera: Scarabaeidae), palm stem borer beetle; *Rhynchophorus ferrugineus* (Coleoptera: Curculionidae), red palm weevil; *Tenebroides mauritanicus* (Coleoptera: Trogossitidae); *Phonapate frontalis* (Coleoptera: Bostrichidae) (584 individuals); Denver billbug *Sphenophorus parumpunctatus* (Coleoptera: Curculionidae) (809 individuals); and *Xyleborus perforans* (Coleoptera: Curculionidae) (16466 individuals). In contrast, only 141 specimens of a single Orthoptera species (*Schistocerca gregaria* (Orthoptera: Acrididae), known as the desert locust, were successfully collected (Table 1). The results indicated a significant difference between the fodder treatments on the abundances of frond borer *P. frontalis*, *X. perforans*, stem borer beetle *O. elegans*, *S. parumpunctatus*, and cadelle beetle, *T. mauritanicus* (Table 1). In comparison to the control treatment, the application with mixed fodders around the date palm trees had a positive effect on decreasing the abundances of *O. elegans* (Figure 2), *P. frontalis* (Figure 3), and *S. parumpunctatus* (Figure 4). However, this effect did not exist when the fodders were either absent or separately cultivated around the date palm trees. In comparison to the control treatment, the fodders treatment (alfalfa, blue-panic, and mixed) effectively reduced the abundance of *T. mauritanicus* to the same degree (Figure 5). On the other hand, the alfalfa treatment was unable to reduce the abundance of this insect pest, whereas the blue-panic and mixed treatments considerably decreased it when compared to the control (Figure 6). The overall abundances of *S. gregaria* and *R. ferrugineus* did not significantly change across the fodder treatments, according to the data (Table 1).

Table 1. The effects of cultivating fodder surrounding date palms on insect pest abundance examined through ANOVA testing, Yielding F-values and P-value.

Pest name	Common name	Abundance	Degree of Freedom	Sum of Squares	Mean Square	F.value	P.value
O. elegans	Palm stem borer beetle	149	3	5.4436	1.8145	4.87	0.0147
P. frontalis	Palm frond borer	584	3	3.5964	0.7932	2.39	0.0382
S. parumpunctatus	Denver billbug	809	3	3.9851	1.3283	13.39	0.0002
R. ferrugineus	Red palm weevil	122	3	0.9171	0.3057	1.00	0.4216
S. gregaria	Deset locust	141	3	1.5210	0.5070	0.99	0.4242
X. perforans	Pinhole borer	16466	3	2.2687	0.7562	8.00	0.0020
T. mauritanicus	Cadelle beetle	87	3	10.951	3.6504	11.49	0.0004

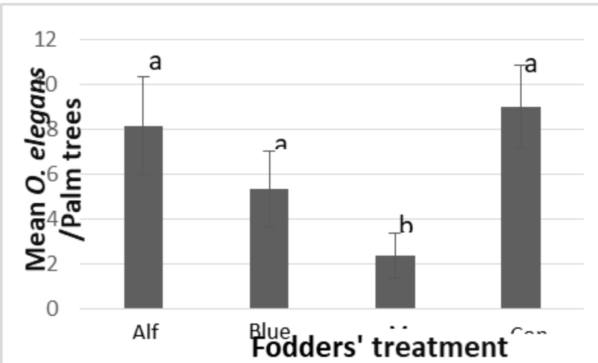

Figure 2. The effect of fodders' cultivation treatments around date palm trees on the abundance of *O. elegans*. The bar presented the means and standard errors (±SE) of means. Mean with the same letter in each bar are not a significant difference (P> 0.05).

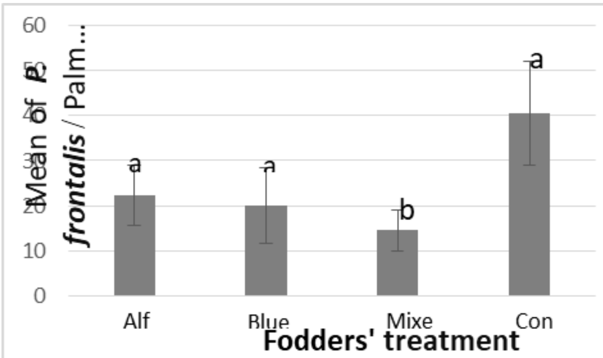

Figure 3. The effect of fodder treatments around date palm trees on *P. frontalis* abundance. The bar presented the means and standard errors (±SE) of means. Mean with the same letter in each bar are not a significant difference (P > 0.05).

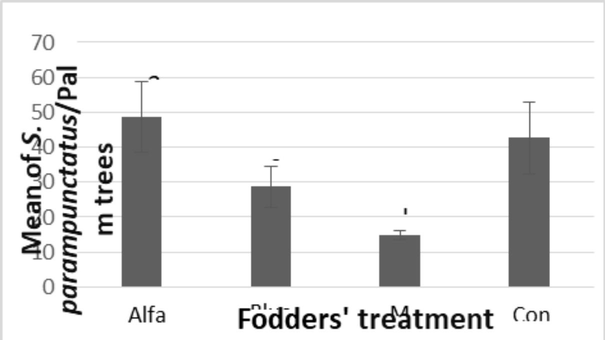

Figure 4. The effect of fodders' cultivation treatments around date palm trees on the abundance of *S. parumpunctatus*. The bar presented the means and standard errors (±SE) of means. Mean with the same letter in each bar are not a significant difference (P> 0.05).

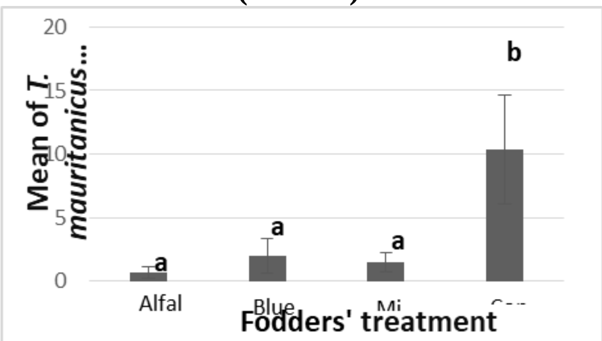

Figure 5. The effect of fodders' treatments around date palm trees on *T. mauritanicus*. The bar presented the means and standard errors (±SE) of means. Mean with the same letter in each bar are not a significant difference (P > 0.05)

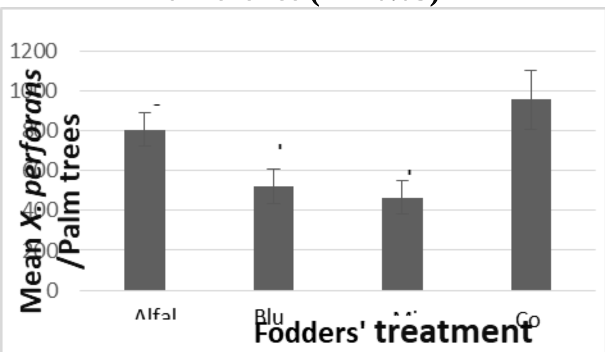

Figure 6. The effect of fodders' treatments around date palm on *X. perforans* abundance. The bar presented the means and standard errors (±SE) of means. Mean with the same letter in each bar are not a significant difference (P> 0.05).

The impact of the fodders' cultivation around date palm on temporal distribution of *O. elegans*: The population of *O. elegans* was significantly affected by both time and the fodder treatments ($F_{33.220}$=1.79, P<0.0075). The abundance of *O. elegans* initially surfaced in the alfalfa and control treatments in January 2020. The populations of *O. elegans* elevated in April 2020 among the control, alfalfa, blue panic, and mixed fodders treatments, respectively (Figure 7). Despite a general decline in *O. elegans* abundance in May 2020 across all treatments, it attained a significant peak in the alfalfa treatment (Figure 7). During this peak, the *O. elegans* population was reduced by mixed fodder treatment, with a decrease in abundance observed in May and June 2020 for the blue panic, control, and mixing fodder treatments, respectively (Figure 7). Nevertheless, from July 2020 until the year's end, this pest disappeared due to the presence of mixed fodders within palm basins (Figure 4 and 6). From July to August 2020, density of *O. elegans* in other treatments was found to be low. Subsequently, in September 2020, there was an increasing density of *O. elegans* in the alfalfa, control, and blue panic treatments, respectively (Figure 7).

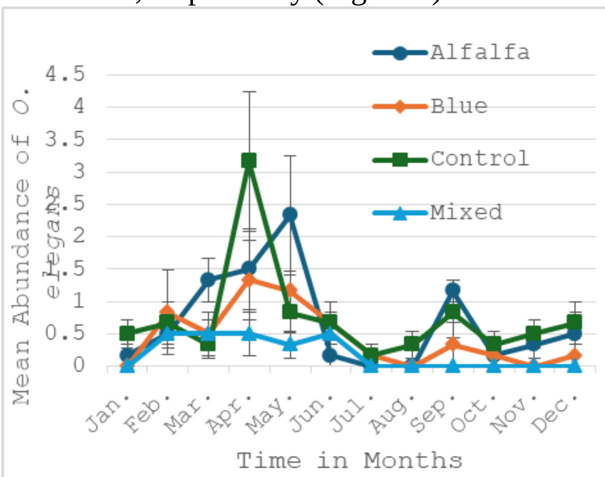

Figure 7. Temporal distribution of *O. elegans* within the four fodder treatments (Alfa: alfalfa, Blue: blue panic, Mix: Mixed fodders, and control), (the mean of *O. elegans* / month ± SE).

The impact of the fodders' cultivation around date palm on temporal distribution of *P. frontalis* : The abundance of the palm frond borer *P. frontalis* is significantly affected by both time and the fodder treatments, according to the data ($F_{33.220}$=1.75, P<0.0099). In January 2020, *P. Frontalis*, palm frond borer, made its initial appearance in the alfalfa, blue panic, mixed, and control treatments, respectively (Figure 8). In control and alfalfa treatments, the density of *P.*

frontalis peaked in April 2020. At its peak, the insect pest had a low density inside the mixed fodders and blue panic treatments. In May 2020, the density of *P. frontalis* decreased in both the alfalfa and control treatments (Figure 8). The pest continued to appear in limited numbers across all treatments until the year-end, except for the mixed fodder treatment, which resulted in the complete absence of *P. frontalis* from August 2020 until year-end (Figure 8).

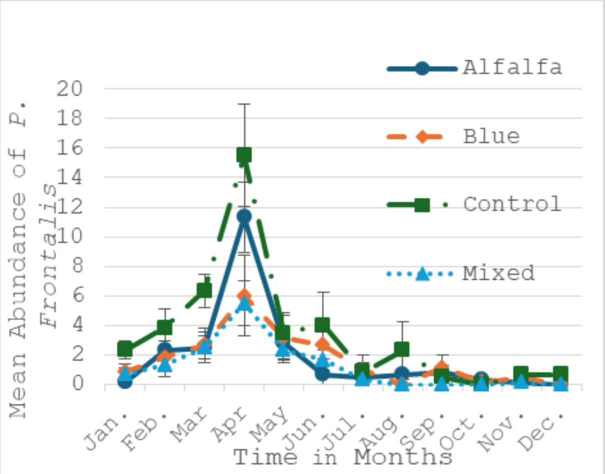

Figure 8. Temporal distribution of *P. frontalis* within four fodder treatments (Alfa: alfalfa, Blue: blue panic, Mix: Mixed fodders, and control) (the mean of P. frontalis / month ± SE).

The impact of the fodders' cultivation around date palm on temporal distribution of *X. perforans* : The findings demonstrated a highly significant difference ($F_{33.220}$=1.86. P<0.0049) in the abundance of *X. perforans* across the fodder treatments and time. In January 2020, *X. perforans* initially emerged in all applied treatments. Across all treatments, the abundance of *X. perforans* had two peaks in March and April 2020, with the control treatment having the highest abundance (Figure 9). The prevalence of *X. perforans* in May and June 2020 is notably lower than in the preceding two months, particularly in the mixed and blue panic fodder treatments (Figure 9). Subsequently, July 2020 saw a decrease in *X. perforans* abundance, primarily within the mixed fodders treatment (Figure 9). Following that, the density of *X. perforans* in alfalfa reached two maxima in September and November 2020. The control methods of blue panic and fodder mixing consistently reduced this pest during these peaks (Figure 9).

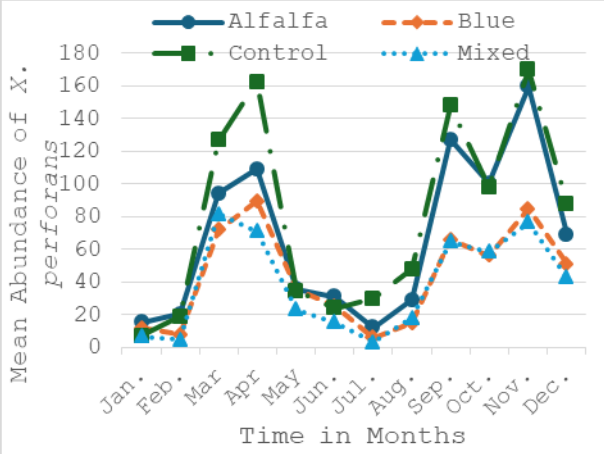

Figure 9. Temporal distribution of *X. perforans* within four fodder treatments (Alfa: alfalfa, Blue: blue panic, Mix: Mixed fodders, and control) (the mean of *X. perforans* / month ± SE).

The impact of the fodders' cultivation around date palm on temporal distribution of *S. parampunctatus* : The results indicated a significant difference in *S. parumpunctatus* among the crop treatments on the sample dates ($F_{33.220}$=1.58, P<0.0297). *S. parumpunctatus* first appeared in all tested treatments in January 2020 (Figure 10). The presence of *S. parumpunctatus* in the alfalfa treatment marginally increased in July 2020. While the mixed and blue panic fodder treatments were able to reduce the prevalence of *S. parumpunctatus* between August and September 2020; however, the density of this species peaked in August 2020 within the alfalfa treatments (Figure 10). In October 2020, the abundance of *S. parumpunctatus* attained a new peak in the control treatment, while its abundances increased in the mixed fodder and blue panic treatments. Subsequently, the alfalfa treatment had a significant increase of *S. parumpunctatus* in November 2020, whereas the mixed treatment successfully reduced the abundance of *S. parumpunctatus* during that month (Figure 10). In December, a reduction in the population density of *S. parumpunctatus* was recorded within the Alfalfa treatment compared to the previous month (Figure 10).

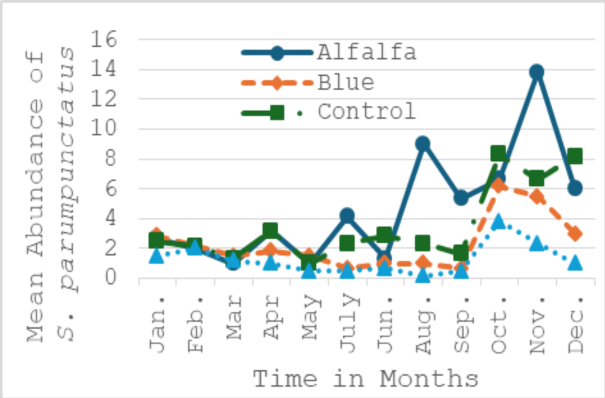

Figure 10. Temporal distribution of *S. parumpunctatus* within four fodder treatments (Alfa: alfalfa, Blue: blue panic, Mix: Mixed fodders, and control) (the mean of *S. parumpunctatus* / month ± SE).

The impact of the fodders' cultivation around date palm on temporal distribution of *T. mauritanicus* : The findings showed a significant difference ($F_{33.220}$=1.50, P<0.0481) in the abundance of *T. mauritanicus* between the fodder treatments and time. In the blue panic and control treatments, *T. mauritanicus* made its initial appearance in January 2020 (Figure 11). In control treatment, there was a small increase in the *T. mauritanicus* density between February and July 2020. The alfalfa fodder treatment continued to lower the *T. mauritanicus* population despite this minor rise (Figure 11). The abundance of *T. mauritanicus* in the control treatment began to rise in September 2020 and peaked in October 2020 (Figure 11). The alfalfa, blue panic, and mixed fodder treatments were successful in reducing the *T. mauritanicus* population during this peak. The *T. mauritanicus* density then decreased in November 2020 across all treatments that were evaluated until the end of the year (Figure 11).

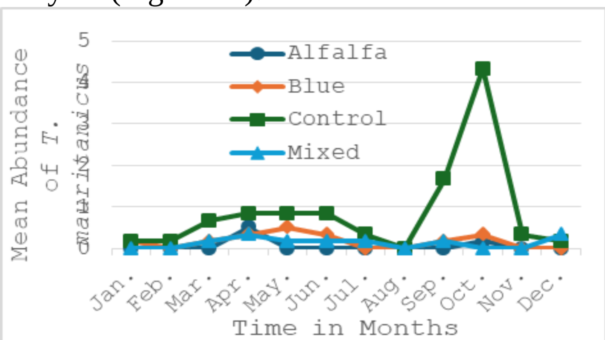

Figure 11. Temporal distribution of *T. mauritanicus* within four fodder treatments (Alfa: alfalfa, Blue: blue panic, Mix: Mixed fodders, and control (the mean of *T. mauritanicus* / month ± SE).

Data on the mean abundance of the desert locust, *S. gregaria* ($F_{33.220}$=1.05, P<0.4034), and red palm weevil, *R. ferrugineus* ($F_{33.220}$=0.82, P<0.7500), did not, however, show any statistically significant variations between the crop treatments over time. The intercropping system is one of the most traditional strategies employed to minimize the insect pest populations and enhance crop productivity (1). Thus, the goal of the current study was to determine the impact of fodder production surrounding date palm trees on insect pests' distribution in the Hada Al-Sham region, Saudi Arabia. However, the results provided fundamental information regarding the abundance of insect pests affecting data palms and their natural enemies. The results of our study supports the resource concentration hypothesis, which states that chemical and visual cues from host and non-host plants influence colonization rate of herbivores in intercropping systems and their subsequent behavior, thereby reducing insect pest population in a diverse plant environment (14, 10, 20, 7). Numerous studies indicated that plant diversity reduces pests in many crops and outcomes of the current investigation align with these findings (30, 36, 19, 40). Intercropping mustard with either onion or garlic, in contrast to a mustard monoculture, resulted in a significant reduction of the mustard aphid *Lipaphis erysimi* (Homoptera: Aphididae) (28). In comparison to tomato monoculture, cultivating spicy peppers with tomatoes reduced the infestation percentages of *Phthorimaea absoluta*, the tomato leaf miner (18). The findings of his investigation demonstrated the effectiveness of spicy pepper in reducing *P. absoluta* infestation percentages through its emitted aroma (18). When compared to willow Salix spp. monocultures, it has been found that intercropping between different genotypes of the plant decreased beetle damage and oviposition of (*Phratora vulgatissima* L.) (35). It has been observed that intercropping cowpea significantly reduced the infestation of stem-borers (*Chilo partellus*) in the maize crop (32). Furthermore, under control treatment, the abundance of *X. perforans* increased after the date fruit set in April 2020 and grew once again during the harvest season in September and November.

However, the presence of fodder with date palm in our study had led to reduce the abundance of *X. perforans* during its activity in the date fruit set. It has been demonstrated that crop diversification effectively reduced the infestation of date spider mites *Oligonychus afrasiaticus* (McGregor 1939) (Acari: Tetranychidae) (21). Spurthi et al., (34) observed that intercropping red gram (*Cajanus cajan*) and groundnut (*Arachis hypogaea*) with sorghum (*Sorghum bicolor*) had a positive impact on income and decreased the occurrence of armyworms (*Spodoptera frugiperda*). There was no discernible change in the mean abundance of *S. gregaria* and *R. ferrugineus* across the treatments examined for fodder, indicating that the "Resource Concentration Hypothesis" was not supported. This may be explained by their low abundances, and the light traps utilized in this investigation may not be the effective method for sampling these pests because light traps are effective primarily against nocturnal insects (24); however, the activity of *S. gregaria* and *R. ferrugineus* is predominantly observed during daylight hours (11, 31). According to (9) intercropping four crops such as barley, oats, wheat, and canola reduced the damage caused by grasshoppers *Melanoplus sanguinipes* (Orthoptera: Acrididae). Furthermore, (26) observed that a system of three rows of cabbage intercropped with one row of tomato decreased the number of painted grasshoppers (*Zonocerus variegatus*) compared to cabbage monoculture. Most of the study's data may be used to support the hypothesis even if the resource concentration hypothesis does not apply to two insect pests: *R. ferrugineus* and S *gregaria* (11, 31, 38). These results are consistent with the observation that certain pests of palm trees did not react to the hypothesis that chemical and visual cues from host and non-host plants influence colonization rate of herbivores in intercropping systems and their subsequent behavior, thereby reducing insect pest population in a diverse plant environment (13). A recent review by (23) of the published literature (fifty original research articles) found that most agricultural diversification studies significantly decreased insect populations.

CONCLUSION

In conclusion, the crop diversity is more effective to reduce most pests of date palms such as *O. elegans*, *P. frontalis*, *S, parampunctatu*, *X. perforans*, and *T. mauritanicus* in the Hada Al-sham region. However, this cropping system did not work as a cultural technique against some insect pests. The current study examined the viability and effectiveness of plant diversity under field conditions by using date palm fodders to optimize outcomes that enable farmers to manage pests using less and selective pesticides, thereby saving use of pesticides and ensuring safe and healthy food. According to this study, growing fodder around date palms is a more effective way to control most date palm insect pests. The application of mixed fodders showed to be more effective in decreasing insect pest populations and offering enhanced protection against pests before they pose a threat to date palms. Consequently, the Hada Al-Sham region should consistently cultivate date palm fodder. Additionally, more investigation into the predator-prey dynamics in this system is needed to validate using this cropping method as a pest control method.

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