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Impact of Sowing Date and Integrated Control of *Etiella zinckenlla* Treitschke (Lepidoptera) Infected Cowpea Plants

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ABSTRACT

Two experiments were conducted on cowpea plants, *Vigna unguiculata* (L) (cultivar Kafr El-sheekh), in El-Berka village, Abu-Hommus, El-Beheira Governorate, Egypt, during two consecutive summer seasons (2021 & 2022). The first experiment was investigated to study the impact of four varying sowing dates (February 13th, March 5th, March 26th, and April 16th) on cowpea pods infestation with *Etiella zincknella* Treitschke and how it affected cowpea seed yield. Results demonstrated that earlier sowing (February 13th) led to lower *E. zincknella* infestation and higher seed yield. Conversely, later sowing (April 16th) resulted in increased infestation and reduced yield. These findings suggest that early sowing is a promising strategy for managing *E. zincknella* pests in cowpea production and may reduce the need for chemical interventions. To evaluate the effectiveness of one pesticide (Lannate WP 25%) and two essential oils (Thyme and Camphor), a second experiment was conducted in the 2022 season. compared to the control treatment, the results show that all three treatments were effective in reducing the cowpea pod borer pest infestations compared to the untreated control. The most effective treatment was lannate, which significantly decreased the proportion of infected pods, seeds, and the population of larvae/ pods. Though less so than Lannate, Thymol also showed notable decreases in infested pods, seeds, and larvae numbers. While camphor oil had a minor effect on infested pods and seeds, it had a less significant impact on reducing larval numbers.

Keywords: Integrated control, cowpea pod borer, *Etiella zinckenella*, sowing date, seeds yield, essential oils, and infestation.

1. Introduction

Significant agricultural importance is attributed to the cowpea (*Vigna unguiculata*) in Egypt and other tropical and subtropical countries. It is a staple crop that is especially prized for its dried seeds. As a valuable source of complete protein, the seeds are higher in protein than other vegetable crops, with a concentration ranging from 20 to 30%. They also contain a lot of lysine, one of the important amino acids (Ddamulira *et al.,* 2015; Abudulai *et al.,* 2016; Musa & Adeboye 2017, and Mohamed *et al.,* 2019). The timing of sowing has a considerable impact on a crop's growth and overall production. The appropriate timing to sow the crop guarantees improved plant growth, prevents pest infestation and inhibits the growth of weeds. Evidence suggests that one of the many agricultural modifications, the ideal sowing time, has a significant impact on increasing output, especially in cases where the ideal sowing time varies significantly due to substantially disparate agro-climatic circumstances. Many factors influence the best time to sow, but the temperature throughout the growth season is the most significant. (Helalia *et al.,* 2011, Shaalan 2016 and Solanki *et al.,* 2023). Dangerous pests have a major impact on cowpea plants. A significant concern is posed by one of these pests, the cowpea pod borer, *E. zinckenella*. This pest causes significant financial losses due to seed damage and adverse effects on agricultural yield, both in terms of quantity and quality (Mohamed *et al.,* 2015 and Ali, 2020). Nevertheless, the harm caused by the cowpea pod borer, *E. zinckenella*, cannot be reduced by the use of pesticides at current levels of control. In order to evaluate several integrated management options that have demonstrated potential for controlling the cowpea pod borer, *E. zinckenella*, some

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programs were carried out. These tactics would help control pesticide resistance and lessen the reliance on pesticides in Egyptian legume farms. The simplest agricultural practice that significantly affects the degree of infestation is crop sowing timing. Proper crop sowing ensures better plant growth (Ali, 2020; El-Sayed & Hend 2021; Anany & Yahya 2021; Aliyu *et al.,* 2023 and Solanki *et al.,* 2023). Using agricultural control methods may be helpful in suppressing cowpea pests. Use some safe control methods using plant extracts that help limit the spread of pests and also benefit plants the fragrant perennial subshrub known as common thyme (*Thymus vulgaris* L.) is a member of the Lamiaceae family and is endemic to the western Mediterranean. According to reports, thyme volatile oil is in the top ten essential oils (Letchamo and Gosselin 1995). Thyme's insecticidal, anesthetic, antiseptic, antioxidant, and food-preservative qualities and its constituents are attributable to the oil's physiologically active ingredients (Hudaib *et al.,* 2002 and Wang *et al.,* 2014). Its primary ingredient, thymol, is frequently employed in dentistry or to make menthol because it is efficient against a variety of plant pathogenic fungi and pests (Ange´lica *et al.,* 2020). The wood of camphor laurel (*Cinnamomum camphora*) and other similar laurel family trees is the source of the white, crystalline compound known as camphor (*C. camphora*), which has a strong odor and unpleasant taste. Camphor is the primary constituent found in *C. camphor* leaves. Other constituents include cineol, linalool, eugenol, limonene, safrole, p-cymene, nerolidol, α_pinene, β-pinene, β -myrecene, α-humulene, borneol, and camphene (Ho *et al.,* 2009). According to Ali and Ibrahim (2018) GC-Mass analysis, camphor oil contains a variety of insecticidal and antifeedant chemicals.

In a previous study, Sobhi *et al.,* (2020) found that camphor oil exhibited significant toxicity to *Spodotera littoralis* larvae, with a lethal concentration (LC50) of 20.000 ppm. Furthermore, biochemical analysis revealed that camphor oil adversely affected the larvae's physiological functions. The oil caused a substantial reduction in the levels of essential biomolecules, including total proteins, carbohydrates, and lipids, as well as a significant decrease in the activities of key enzymes involved in metabolism and growth, such as invertase, trehalase, chitinase, and transaminases.

The main objective of the current study is to assess the impact of various sowing dates and the application of some controlling agents on the cowpea incidence of the cowpea pod borer, *Etiella zinckenella* pests, and how this influences the productivity yield of cowpea seeds.

2. Materials and Methods

In two consecutive summer plantation seasons in 2021 and 2022, two experiments were carried out at El-Berka village, Abu-Hommus, El-Beheira Governorate, Egypt, on cowpea plants, *Vigna unguiculata* (L) (cultivar Kafr El-sheekh). The first experiment aimed to determine how the infestation rate of cowpea pod borers was affected by the timing of cowpea plant sowing. Four dates were selected for the seeding, with a 20-day interval between each: Feb. 13th, Mar. 5th, Mar. 26th, and Apr. 16th. The 2,000 m^2 experimental area was divided into twelve plots, each measuring 155 m^2. For every sowing date, three experimental plots were employed, and they were set up in a full-block arrangement that was randomized. Samples of cowpea pods were taken fifty days after seeding. Each week, ten randomly chosen pods from each plot were packed in paper bags and transported to the lab to count the larvae of the cowpea pod borer, *E. zinckenella*, by visual inspection. The standard agricultural procedures were adhered to without the use of pesticides. Every sowing date's net yield was evaluated and weighted. The proportion of damaged pods, average weight per 500 seeds, and damage per 500 seeds were also included in the study.

To assess the efficacy of essential oils (Thyme oil and Camphor oil) and insecticide (Lannate WP 25%), a second experiment was designed for the 2022 season (Table l). Four replicates were included in the split-plot design of the experiment. 16 plots, each measuring 85 m^2, were created from an area that approximately 1500 m^2. Every week samples during the reproductive development stage, 10 pods per plot were randomly collected in paper bags, and the pod borer, *E. zinckenella* larvae, were counted in the lab. Through the reproductive period, three applications of each chemical were made. The first spray was applied on June 12, 2022, and the subsequent sprays were applied every 14 days. The inspection was done before and after the first and every 7 and 14 days of spray treatments. The percentage reduction of each pesticide was determined using the Henderson-Tilton method (1955).

Table 1: Insecticide and essential oils as control agents used in the study.

Trade name	Common name	Rate / 5 liter water
Untreated (control)	----	----
Lannate WP 25%	Methomyl	25 g
Thyme oil	*Thymus vulgaris*	10 ml
Camphor oil	*Cinnamomum camphora*	10 ml

The tested compounds were applied as foliar treatments using a 5 L backpack sprayer; the testing chemical application rate is indicated in Table (1). Ten randomly selected plants were labeled in each plot at harvest, and the pods were harvested twice, a decade apart. The grains were divided into intact and damaged categories after the harvest pods were allowed to dry in the air, and their weights per ten plants were calculated.

2.1. Statistical analysis

Statistical analysis was conducted using analysis of variance (ANOVA) to evaluate the effects of infesting pests and yield variables. The SAS software (1999) was used to perform the ANOVA and calculate appropriate error terms for F-tests of interactions. Duncan's multiple range test at a significance level of 0.05 was employed for pairwise comparisons of means.

3. Results and Discussion

Data from Tables 2 and 3 demonstrated the impact of four distinct sowing date on the larval *Etiella zinckenella* cowpea pod borer infestation of cowpea pods over the course of two seasons, 2021 and 2022, as well as some yield calculation.

3.1. Impact of different sowing dates on the population density of infection *Etiella zinckenella* larvae.

The data demonstrated a considerable difference in the population density of the cowpea pod borer, *Etiella zinckenella* larvae, infesting cowpea pods during the two consecutive seasons (2021 and 2022). The population density of the cowpea pod borer, *E. zinckenella* larvae increased, in the 1st season, by deferring the sowing date. The cowpea plants were sown on the first sowing date (Fab, 13th) significantly infested by the lowest mean number of the cowpea pod borer, *E. zinckenella* (1.89 larvae/10 pods).

Conversely, the plants from the last sowing date, Apr.16th had the largest mean number of *E. zinckenella* (14.7 larvae/10 pods). The outcomes from the second season followed the same general pattern as the first. During the 2022 season, the seasonal mean numbers of *E. zinckenella* were 1.94, 5.0, 11.24, and 16.0 larvae/10 pods on the Fab.13th, Mar.5th, Mar.26th, and Apr. 16th sowing date, respectively. The current study supported the findings of Helalia *et al.,* (2011), who suggested that early sowing would help lower the infestation of the cowpea pod borer, *E. zinckenella*, and thereby raise cowpea output. According to Shaalan (2016), postponing the sowing date resulted in a considerable increase in the degree of infestation by the cowpea pod borer, *E. zinckenella*. This is consistent with the findings of Muhammad *et al.,* (2017a) and Muhammad *et al.,* (2022b), who reported that changes in the sowing date might account for variances in pod-borer populations.

3.2. Relationship between infestation and yield parameters

The study revealed that the sowing date significantly influenced the infestation rate of *Etiella zinckenella* and the yield of cowpea seeds. Early sowing on February 13th resulted in fewer insect attacks and higher seed weight compared to later sowing on April 16th. The plants sown on April 16th experienced greater damage from the pest, leading to lower seed weight and a higher number of damaged pods and seeds. These findings suggest that early sowing can be an effective strategy to minimize *Etiella zinckenella* infestation and improve cowpea seed yield (Table 3).

The cowpea plants that were grown on the first sowing date produced the greatest seasonal mean weight of seeds, which was 33.5 and 30.8 kg/100 m^2, respectively. The two succeeding seasons produced the highest average weights per 500 seeds, which were 147 and 150 gm, respectively. Nonetheless, throughout both seasons, the lowest numbers of damaged pods/100 pods and

Table 2: Average number of *E. zinckenella* larvae, the cowpea pod borer, on cowpea pods at various sowing dates in the El-Beheira Governorate during the summer sowing seasons of 2021 and 2022.

Sampling data	Average no. of *E. zinckenella* larvae / 10 pods							
	2021 season				2022 season			
	1st Sowing Fab.13th	2nd Sowing Mar.5th	3rd Sowing Mar.26th	4th Sowing Apri.16th	1st Sowing Fab.13th	2nd Sowing Mar.5th	3rd Sowing Mar.26th	4th Sowing Apri.16th
April , 10	0	--	--	--	1	--	--	--
17	1.2	--	--	--	1	--	--	--
24	1.4	--	--	--	1.2	--	--	--
31	2.2	0	--	--	1.6	1	--	--
May , 7	2.6	4	--	--	2.8	2.8	--	--
14	3	4.2	--	--	3	3.6	--	--
21	2.8	5.3	7.2	--	3	4.8	7.8	--
28	--	6.4	8.3	--	--	5.2	8.2	--
June, 5	--	7.3	8.8	--	--	8.2	9.4	--
12	--	8	10	--	--	9.4	11	--
19	--	--	10.4	11.2	--	--	11.8	12.8
26	--	--	10.8	13	--	--	14.3	15.8
July, 2	--	--	12.4	13.2	--	--	16.2	15.3
9	--	--	--	14.6	--	--	--	15.8
16	--	--	--	14.8	--	--	--	16.6
23	--	--	--	16.2	--	--	--	17.2
30	--	--	--	16.2	--	--	--	18.5
Means	**1.89±0.63d**	**5.03±0.76c**	**9.70±1.6b**	**14.17±1.3a**	**1.94±0.78d**	**5.00±0.66c**	**11.24±1.72b**	**16.00±1.89a**
L.S.D	**2.44**				**2.79**			

Values with the same letter(s) are not significantly differ at 0.05 levels of significance, according to Duncan's test (multiple range).

damaged/500 seeds (6.4 & 7 pods/100 pods and 168 & 170 damaged/500 seeds, respectively) were recorded. Conversely, cowpea plants grown in the later sowing date yielded the lowest average weight of 500 seeds, 108.8 and 102.4 gm /500 seeds during the 2020 and 2021 seasons, respectively, and the lowest weight of cowpea seeds, 17.5 and 23.5 Kg/100m ^{2}. In both seasons, 22.1 & 23.5 damaged pods and 320 & 345 damaged seeds, respectively, were the highest numbers of damaged pods per 100 pods and damaged seeds per 500 seeds.

Table 3: Impact of sowing date on grain yield of cowpea plants in El-Beheira governorate during summer plantation sowing seasons in 2021 and 2022.

Sowing date	Yield parameters			
	2021			
	Pods yield /100m^2 (kg)	% Damaged pods	Average weight /500 seeds (kg)	Damaged/ 500 seeds
Fab. 13th	33.5 a	6.4 c	147a	168 a
Mar. 5th	25.5 b	12.8b	138.2b	204b
Mar. 26th	21.4 bc	18.2 ab	120.4c	270c
Apri. 16th	19.5c	22.1 a	108.8d	320d
L.S.D	5.77	4.44	11.6	12.8
	2022			
	Pods yield /100m^2 (kg)	% Damaged pods	Average weight /500 seeds (kg)	Damaged/ 500 seeds
Fab. 13th	30.8a	7d	150a	170d
Mar. 5th	23.4b	13.2c	130.5b	215c
Mar. 26th	19.6c	20.4b	118.2c	287b
Apri. 16th	17.5d	23.5a	102.4d	345a
L.S.D	2.12	5.1	9.9	10.3

Values having the same alphabetical letter(s) did not significantly differ at 0.05 levels of significance, according to Duncan's multiple range test.

The present results are consistent with those of Helalia *et al.,* (2011), and Shaalan (2016) indicated that sowing at the earliest date resulted in significantly higher yields. Furthermore, insect pests have been identified as the primary cause of reduced cowpea yields, with a negative correlation observed between the percentage of infected pods and the yield of dry seeds (Mansaray *et al.,* 2020). Also, Solanki *et al.* (2023) recommended sowing cowpeas (*Vigna unguiculata* L.) from the last week of Feb. to the first week of March to achieve optimal yield.

4. Impact of control agents on reducing the population density of the cowpea pod borer, *E. zinckenella* larvae on cowpea plants:

Cowpea plants were sown on April 16th and subsequently experienced a significant infestation by *Etiella zinckenella* larvae. Integrated pest management (IPM) strategies, including chemical control (Lannate) and essential oil treatments (thyme and camphor), demonstrated notable effectiveness in mitigating pest damage during the 2022 season. These results align with previous research conducted by Wang *et al.* (2014); Angélica *et al.* (2020); and Sobhi *et al.* (2020), which also highlighted the efficacy of IPM approaches in managing *E. zinckenella* infestations.

The efficiency of different treatments (Lannate, Thymol oil, Camphor oil) against *E. zinckenella* larvae infestations on cowpea pods and seeds in addition to untreated control was presented in (Table 4). The results showed that all three treatments significantly reduced the pest infestation compared to the control treatment. Lannate treatment demonstrated superior effectiveness in reducing the *E. zinckenella* infestation, with reduction percentages of 75.62% in pods and 83.53% in seeds, flowed by the Thymol oil with reduction percentages of 69.21 % in pods and 81.21% in seeds. On the other hand, the Thymol oil was the most effective in reducing the number of *E. zinckenella* larvae/pod with an 87.5 % reduction. The Camphor oil treatment had relatively lesser effects (57.5% in pods, 52.28% in seeds, and 71.56% larvae/pod) than the Thymol oil and Lannate respectively.

Similar results were obtained by Fathy *et al.* (2008), thymol was the most substantially beneficial natural essential oil. Camphor oil and other natural essential oils also considerably improved the agronomic performance of cowpea plants and the storability of their seeds. Additionally, cowpea seeds demonstrated the positive, safe, and retained insecticidal protection properties of garlic oil and camphor oil extract, respectively. Shanshan *et al.* (2016) and Sobhi *et al.* (2020) found that all essential oils of the camphor showed fumigant and contact toxicity. Other compounds exhibited various levels of bioactivities. The results indicate that the essential oils of camphor and its separated components can be considered a natural resource for the two stored-product insect management.

Table 4: Utilization of Thymol and Camphor oil for controlling *E. zincknella* compared with Lannate insecticide in cowpea cultivar (Kafr El-sheekh) on investigation during 2022 season.

Treatments	% Infested pods	% Reduction	% Infested seeds
Untreated	51.95 A	--	32.8 A
Lannate	21.00 B	75.62A	5.4 C
Thymol	18.13 C	69.21B	6.16 C
Camphor oil	19.66 B	57.5 C	15.65 B
L.S.D	**1.6**	**5.4**	**18.9**
Treatments	**% Reduction**	**No. of Larvae /pod**	**% Reduction**
Untreated	--	3.2 A	--
Lannate	83.53 A	0.37 C	82.43 B
Thymol	81.21 AB	0.4 C	87.5 A
Camphor oil	52.28 B	0.91B	71.56 C
L.S.D	**3.13**	**0.4**	**3.8**

Values having the same alphabetical letter(s) did not significantly differ at 0.05 levels of significance, according to Duncan's multiple range test.

4. Conclusion

The earliest sowing date (Fab, 13th) may have produced a higher yield than the other three sowing dates that were tested. This may have been due to *E. zinckenella* being present in lower numbers and the favorable climatic conditions that favored the growth of cowpea plants on this sowing date. The statistics indicate that using chemical ways to control *E. zincknella* is less safe and less appropriate than using integrated control verified approaches. Also using Thyme essential oil in integrated pest management programs is very promising and is considered an effective strategy to reduce the use of chemical insecticides.

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