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Efficacy of Chemical and Bio-Rational Insecticides Against Cotton Leaf Worm (*Spodoptera littoralis*) in Soybean

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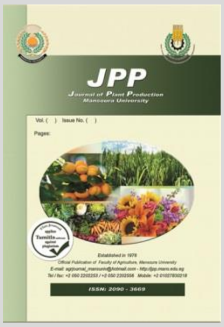

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ABSTRACT

The cotton leafworm, *Spodoptera littoralis***,** poses a significant threat to soybean production in Egypt, prompting a search for the insect control using sustainable alternatives to conventional chemical insecticides. This study aimed to evaluate the efficacy of a chemical insecticide (indoxacarb), a bio-pesticide (*Bacillus thuringiensis* - Agerin), and a botanical extract (lemongrass) on three soybean varieties (Giza 111, Giza 35, and Crawford) for managing *S. littoralis* and to assess their interactive effects on pest mortality, agronomic performance, and seed quality. Field experiments were conducted over two seasons (2021-2022) using a split-plot design. Results showed that while indoxacarb caused the highest larval mortality (94.38-95.48%), the bio-pesticide Agerin (84.81-86.15%) and lemongrass extract (74.89-76.25%) were also highly effective. The varieties Giza 111 and Giza 35 caused high mortality to larvae of S. *littoralis* compared to the susceptible Crawford variety (the insect susceptible check). Regarding yield, bio-rational treatments performed comparably or superior to indoxacarb. Giza 111 was the highest-yielding variety, and its combination with lemongrass or Agerin produced the highest seed yield (up to 1.99 ton/fad). Notably, Agerin and lemongrass treatments significantly enhanced seed quality, increasing protein and oil content, whereas indoxacarb application resulted in a significant reduction in protein content compared to the control. This study concludes that an integrated strategy combining the insect tolerant, high-yielding Giza 111 variety with the bio-pesticide (Agerin or lemongrass extract) is an effective and sustainable approach for managing *S. littoralis*, maximizing both yield and seed quality while avoiding the negative impacts of chemical insecticides.

Keywords: Soybean varieties; insecticides, biocides, cotton leafworm, seed quality

INTRODUCTION

Soybean (*Glycine max* (L.) Merr.) is a globally significant crop, valued for its food and industrial applications. It is an excellent source of high-quality protein (approx. 40%), which is comparable in nutritional value to animal protein, and provides about 20% cholesterol-free oil. In Egypt, the acreage and economic importance of soybean has increased rapidly during recent years, where area has increased progressively from 32000 feddans in 2020 to 133500 feddan in 2024. During the same period the average seed yield increased from 1.298 to 1.350 ton/fed. Soybean plants are attacked by the cotton leafworm, *Spodoptera littoralis* (Boisd), feeding vigorously on leaves causing significant yield losses. To combat these pests, farmers often rely heavily on chemical insecticides due to their rapid knockdown effect (Selim and El-Sebae, 1995) and El-Agroudy *et al*., 2011).

In Egypt, soybean production faces numerous challenges, including infestation by a wide range of insect pests such as spider mites, aphids, and the particularly destructive cotton leafworm, *Spodoptera littoralis* (Bastawisy *et al*., 2008). To combat these pests, farmers often rely heavily on chemical insecticides due to their rapid knockdown effect (Selim and El-Sebae, 1995).

However, the intensive and often exclusive use of synthetic insecticides has led to severe consequences. These include the development of insecticide resistance in pest populations, harm to beneficial natural enemies, and the accumulation of toxic residues in plants, soil, and water, posing risks to human health (Lokanadhan *et al*., 2012). This situation necessitates a shift towards more sustainable and environmentally sound pest management strategies.

Among the promising alternatives are bio-rational pesticides. Biological control, which utilizes living organisms or their products, offers a targeted and biodegradable approach (Ignoffo, 1970). A prime example is the bacterium *Bacillus thuringiensis* (Bt), particularly the *kurstaki* variety. Bt is renowned for its protein crystals (δ-endotoxins) which are specifically toxic to the larvae of many lepidopteran pests, including *Spodoptera*, making it a cornerstone of integrated pest management (IPM) programs (Hougard *et al*., 1983). Botanical extracts also represent a rich source of insecticidal compounds, and many plant-derived products have shown efficacy against major agricultural pests.

In addition to alternative treatments, host plant resistance is a fundamental component of any sustainable IPM strategy. Soybean varieties exhibit significant genetic variability in their susceptibility to insect pests. In such concern, Abdel-Wahab *et al*. (2019) evaluated several Egyptian soybean varieties and reported that Giza 35 and Giza 111 showed moderate resistance to pod borer, whereas Crawford variety was found to be susceptible. Utilizing such tolerant varieties can play a crucial role in reducing the reliance on chemical pesticides and minimizing environmental residues, thus providing both ecological and economic benefits (Kuswantoro *et al*., 2017).

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While these control tactics, bio-pesticides and host plant resistance, have been validated individually, there is a need to investigate their combined and interactive effects on the insect and soybean yield. The potential synergy of integrating moderately resistant soybean varieties with safe and effective bio-rational control agents has not been fully explored. So, there is a need to investigate their combined effects on suppressing cotton leafworm and performance and quality of soybean plants under Egyptian field conditions.

Therefore, the objective of the present study were to: (1) evaluate the efficacy of a chemical insecticide (indoxacarb), a biopesticide (*Bacillus thuringiensis*), and a botanical extract (lemongrass) on mortality of the cotton leaf worm, *Spodoptera littoralis;* (2) assess the performance of three soybean varieties (Giza 111, Giza 35, and Crawford) to pest infestation; and (3) determine the interactive effects of these treatments and varieties on agronomic traits, seed yield, and seed quality, in order to identify a sustainable and effective integrated management strategy.

MATERIALS AND METHODS

1. Experimental Site and Design

The current study was conducted at the Taj A-Ezz Agricultural Research Station, Dakahlia Governorate, Egypt, during the 2021 and 2022 summer growing seasons. Soybean (*Glycine max* (L.) Merr.) seeds were sown on June 10th in the first season and June 2nd in the second season.

The experimental layout was a split-plot design with three replications. The main plots were assigned to the four insecticidal treatments, while the sub-plots were assigned to the three soybean varieties: Giza 111, Giza 35, and Crawford. The characteristics of these varieties are detailed in Table 1. Each sub-plot consisted of three rows, 3 meters in length, with an inter-row spacing of 70 cm, resulting in a plot area of 6.3 m². Standard agronomic practices for soybean cultivation were followed in both seasons.

Table 1. Genotype, origin, pedigree, maturity group, and growth habit of the studied soybean varieties.

Soybean Genotype	Origin	Pedigree	Maturity Group	Growth habit
Giza 111	Egypt	Crawford x Celest	III	Indeterminate
Giza 35	Egypt	Crawford x Celest	III	Indeterminate
Crawford	USA	Williams X Columbus	IV	Indeterminate

2. Treatments and Application

The study involved four treatments for the management of the cotton leafworm, *Spodoptera littoralis*, which were applied to the main plots. The details of each treatment are presented in Table 2.

Table 2. Description of the treatments applied for the control of *S. littoralis.*

Treatment Name	Trade Name / formulation	Active Ingredient	Type	Application Rate
Indoxacarb	Leaf carb® 30% WG	Indoxacarb	Chemical Insecticide	0.26g/L
Agerin	Agerin® 6.5% WP	*Bacillus thuringiensis* var. *kurstaki*	Bio-insecticide	1.1g/L
Lemongrass Extract	Lab-prepared organic extract	*Cymbopogon citratus* crude extract	Botanical Extract	10% w/v
Control (untrated)	Water spray only	Water	Untreated Control	-

All treatments were applied as foliar sprays using a 20-liter knapsack sprayer to ensure thorough foliage coverage. Applications were performed in the early morning when *S. littoralis* larval populations reached the economic threshold during the seedling and vegetative growth stages.

Preparation of Lemongrass Extract

A crude extract of lemongrass (*Cymbopogon citratus*) was prepared from air-dried, pulverized leaves. The powder was macerated for one week in a solvent mixture of hexane, acetone, and ethanol (1:1:1, v/v/v). The filtrate was then concentrated under reduced pressure to yield the crude extract, which was stored at -20°C until use. For field application, the extract was emulsified in distilled water with 0.1% Tween 80 to obtain the final targeted concentration.

3. Data Collection

Larval Population Assessment

The number of live *S. littoralis* larvae was counted in each plot just before treatment (pre-treatment) and 1, 3, 5, and 7 days post-treatment. The percentage reduction in the larval population was corrected for natural mortality in the control plots using Henderson and Tilton (1955) formula:

$$\text{Reduction (\%)} = [1 - (Ta \times Cb) / (Tb \times Ca)] \times 100$$

Where:

Ta = number of larvae in the treatment plot after application.
Tb = number of larvae in the treatment plot before application.
Ca = number of larvae in the control plot after application.
Cb = number of larvae in the control plot before application.

Agronomic Traits and Seed Yield

At harvest, ten plants were randomly selected from each plot to measure the following traits: plant height (cm), number of branches per plant, number of pods per plant, 100-seed weight (g), and seed yield per plant (g). The total seed yield (ton/faddan) was determined by harvesting all plants from each plot and was calculated based on the plot area, and adjusted to yield per faddan.

Seed Quality Analysis

Harvested seeds from each sub-plot were analyzed to determine the percentages of crude protein, oil, and total carbohydrates. Seeds were collected in laboratories of Seed Technology Research Department, Field Crops Research Institute, ARC. Fifty grams of seeds were air dried, then ground and stored. Chemical determinations were done using dried ground seeds at 70˚C till constant weight. Seed oil percentage determined according to (A.O.A.C., 1990) using the Soxhlet apparatus and petrolium ether as the solvent. The crude protein percentage was measured as (A.O.A.C., 2000). Carbohydrates content (%) in seeds was analyzed according to DuBois *et al*., (1956).

4. Statistical Analysis

All collected data were subjected to Analysis of Variance (ANOVA) appropriate for a split-plot design using the GenStat 21st Edition (Goedhart and Thissen, 2021). The Least Significant Difference (LSD) test was used to compare treatment means at a 5% probability level ($P \leq 0.05$) (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

1. Toxicity of insecticides, varieties and their interaction

The efficacy of the chemical, biological and lemongrass extract treatments against *Spodoptera littoralis* on three soybean varieties is presented in (Table 3). The analysis of variance (ANOVA) revealed significant differences ($P \leq 0.05$) in larval mortality percentages due to insecticidal treatments, soybean varieties, and their interaction across 2021 and 2022 growing seasons.

The highest mortality values of cotton leafworm larvae were obtained by indoxacarb insecticide (94.38 and 95.48 %), followed by agerin (84.81 and 86.15%) then the lemongrass extract (74.89 and 76.25%) in the first and second seasons, respectively.

In both seasons, the varieties Giza 111 (86.69 and 88.07) and Giza 35 (86.18 and 87.38 %) demonstrated greater mortality to the pest compared to Crawford, which induced lower mortality (81.21 and 82.43%). The significant interaction between insecticidal treatments and varieties indicates that the choice of resistant soybean variety can positively influence the success of a pest control program, especially when using bio pesticides. The efficacy of both Agerin and lemongrass extract was notably enhanced when applied to the tolerant varieties; Giza 35 and Giza 111). In conclusion, these results support the integrated pest management (IPM) strategy that combines the use of soybean varieties (Giza 111 and Giza 35) tolerant to cotton leafworn with environmentally safer control tactics (Agerin or lemongrass extract).

Table 3. Corrected mortality percentage of the second instar *S. littoralis* treated with two types of insecticides and lemongrass extract under the field condition on three soybean genotypes in the two seasons.

Insecticides sources/ variety		Season 2021	Season 2022
Insecticides (I)			
Indoxacarb 30% WG		94.38	95.48
Agerin 6.5% Wp		84.81	86.15
Lemongrass extract 10%		74.89	76.25
LSD 0.05		0.77	1.24
Varieties (V)			
Giza 35		86.18	87.38
Giza 111		86.69	88.07
Crawford		81.21	82.43
LSD 0.05		0.99	0.48
Interaction (I x V)			
Indoxacarb 30% WG	Giza 35	95.01	96.06
	Giza 111	95.86	97.10
	Crawford	92.28	93.29
Agerin 6.5% Wp	Giza 35	86.42	87.42
	Giza 111	87.92	89.32
	Crawford	80.10	81.70
Lemongrass extract 10%	Giza 35	77.11	78.67
	Giza 111	76.31	77.79
	Crawford	71.25	72.29
LSD 0.05		1.49	1.25

The high efficacy of the treatments is well-supported by existing literature. Indoxacarb's mode of action as a sodium channel blocker is known to effectively control lepidopteran pests, a finding consistent with field studies demonstrating its ability to reduce Spodoptera populations and maximize soybean yields (Shobharani and Sunilkumar, 2019; Mokbel *et al*., 2024). Similarly, the strong performance of the bio-insecticide Agerin (*Bacillus thuringiensis*) aligns with its established role as an environmentally safe stomach poison for *S. littoralis*, making it an important element of IPM programs (Elgohary, 2008; Wahab *et al*., 2007; Stout, 2014).

The observed efficacy of lemongrass extract is well-supported by previous research. The general susceptibility of *S. littoralis* to plant extracts has been confirmed (Ghoneim *et al*., 2012), and the specific activity of lemongrass is well-documented. For instance, 10% concentration of lemongrass extract was highly effective as both an antifeedant and as a direct toxin against *S. littoralis* larvae. Moreover, the insecticidal potential of lemongrass extends to other insect orders, with its oils shown to cause mortality and reduce oviposition in stored-product weevils (Rajapakse, R. H. S. and D. Ratnasekera, 2010).

2. Effect of treatments on agronomic traits and seed yield

The studied agronomic and seed yield as affected by the chemical, biological and lemongrass extract treatments against *Spodoptera littoralis* on three soybean varieties are presented in (Table 4). Analysis of variance due to treatments, varieties, and their interaction in both seasons showed significant differences in all studied agronomic and seed yield characters except for treatments in number of branches in the first season and interaction in the two seasons, treatments and interaction in seed yield/fad in the second season and all sources of variations in seed yield/plant in the second season.

Among the insecticidal treatments, indoxacarb (108.4 cm and 109.8 cm) and Agerin (108.0 cm and 107.9 cm) produced the tallest plants, significantly taller than those in control (101.2 cm and 103.2 cm). This increase in plant height is a direct result of the treatments' efficacy in controlling the cotton leaf worm. By mitigating pest-induced stress and preventing defoliation, the treatments enabled the plants to allocate resources more efficiently towards vertical growth (Mariyono, 2008). The Crawford variety (108.5 cm and 110.3 cm in 2021 and 2022, respectively) and Giza 35 (109.9 cm and 109.2 cm) were significantly taller than the Giza 111 variety, which was the shortest (100.0 cm and 101.0 cm). Under control treatment, the plants were the shortest among all treatments (except Giza 111). These findings align with the principle that protecting a plant's photosynthetic capacity during its vegetative stage is crucial for its overall development (Zhao *et al*., 2005). The treatments enabled the plants to allocate resources more efficiently towards vertical growth. It is well-established that herbivore-induced defoliation reduces a plant's photosynthetic capacity, leading to stunted growth and reduced biomass accumulation (Zhou *et al*., 2022).

While there was no significant effect of the insecticide treatment on the number of branches in the first season, a significant difference among treatments emerged in 2022. In that season, Agerin (4.00) and lemongrass extract (3.89) promoted a higher number of branches compared to the control (3.22%). This suggests that the impact of pest control becomes important for allowing the plant to express its full genetic potential for branching (Mariz *et al*., 2025). Giza 111 variety consistently produced the highest number of branches (4.17 and 4.25 in 2021 and 2022, respectively), which was significantly higher than both Giza 35 (3.67 and 3.58) and Crawford (3.25 and 3.17). The high branching trait is desirable as contributing to high yield potential (Clark and Ma, 2023).

All pest control treatments significantly increased the number of pods per plant compared to the untreated control (99.0 and 98.2). The indoxacarb (108.8 and 109.8) and Agerin (107.7 and 108.7) treatments were particularly effective, leading to the highest pod numbers. These results are in line with those of Madhukar (2025). Giza 111 variety produced a high number of pods (129.1 and 129.6 in 2021 and 2022), significantly more than Giza 35 (113.7 and 113.8) and far exceeding Crawford (72.3 and 73.8). This indicates a genetic tendency for Giza 111 to set many reproductive structures. The highest number of pods was recorded when Giza 111 variety was treated with indoxacarb (132.7 and 133.3 pods) and Agerin (130.3 and 131.0 pods). However, the greatest increase (over 35%) in pod number relative to its own control was seen in Giza 111 when treated with indoxacarb.

The bio-rational treatments, Agerin (19.0 g and 19.3 g) and lemongrass extract (17.6 g and 19.9 g), resulted in high 100-seed weights compared to the chemical insecticide, indoxacarb (17.4 g and 17.5 g) and significantly outperformed the control (15.8 g and 16.0 g). The high performance of Agerin suggests a potential bio stimulant effect where it not only protects the plant but may also enhance some physiological processes related to seed filling, a phenomenon that warrants further studies (Delfim and Dijoo, 2021). Giza 111 variety produced the heaviest seeds (19.3 g and 19.1 g in 2021 and 2022, respectively), significantly heavier than seeds of Giza 35 (17.7 g and 18 g) and Crawford variety, which had the lightest seeds (14.6 and 14.9 g). For interaction effects, the highest 100-seed weight was achieved when Giza 111 variety was treated with Agerin, reaching 24.99 g and 25.07 g in the two seasons, respectively. This demonstrates that the potential bio stimulant effect of Agerin is most expressed when applied to a variety of high seed filling (Mona *et al*., 2004).

For the seed yield, measured as both seed yield per plant (g) and seed yield per faddan (ton), all treatments resulted in a significantly higher value compared to the untreated control (which yielded 1.160 and 1.190 ton/fad). In the first season, Agerin produced the highest yield (1.650 ton/fad), while in the second season, lemongrass extract recorded the highest value (1.810 ton/fad), followed closely by Agerin (1.680 ton/fad) and indoxacarb (1.580 ton/fad). The strong performance of the bio-rational treatments, Agerin and lemongrass extract emphasizes their viability as effective alternatives for yield protection and potential enhancement (da Silva Oliveira *et al*., 2021; Duraimurugan and Vimala Devi, 2021). Giza 111 variety produced the highest yield (1.890 and 1.99ton/fad) and was significantly higher than that of Giza 35 (1.500 ton/fad in both seasons) and more than double the yield of the Crawford variety (0.910 and 0.980 ton/fad). For interaction effects, the highest seed yield was achieved by combining the superior variety with effective treatments. Treating Giza 111 with lemongrass extract (1.990 ton/fad in 2022) and with Agerin (1.94and 1.99 ton/fad) produced the highest yields. Conversely, the lowest yield was recorded for the untreated Crawford variety (0.900 and 0.93 ton/fad).

Table 4. The agronomic characters treated with two types of insecticides and lemongrass extract under the field condition on three soybean genotypes in the two seasons.

Insecticides sources/ variety		Plant height (cm)		Number of branches/plant		Number of pods/plant		100-seed weight (g)		Seed yield/ plant (g)		Seed yield/ fad (ton)	
		2021	2022	2021	2022	2021	2022	2021	2022	2021	2022	2021	2022
Insecticides (I)													
Control		101.2	103.2	3.89	3.22	99.0	98.2	15.8	16.0	28.07	28.24	1.16	1.19
Indoxacarb 30% WG		108.4	109.8	3.78	3.56	108.8	109.8	17.4	17.5	33.76	34.13	1.56	1.58
Agerin 6.5% Wp		108	107.9	3.67	4.00	107.7	108.7	19.0	19.3	36.59	32.8	1.65	1.68
Lemongrass extract 10%		106.9	106.6	3.44	3.89	104.7	106.2	17.6	19.9	35.15	35.91	1.48	1.81
LSD 0.05		1.24	0.88	0.63	0.43	3.81	1.36	0.35	0.21	0.2	6.87	0.13	0.57
Varieties (V)													
Giza 35		109.9	109.2	3.67	3.58.	113.7	113.8	17.7	18.0	34.43	34.76	1.500	1.550
Giza 111		100	101.0	4.17	4.25	129.1	129.6	19.3	19.1	34.85	32.28	1.890	1.99
Crawford		108.5	110.3	3.25	3.17	72.3	73.8	14.6	14.9	30.89	31.28	0.910	0.98.
LSD 0.05		1.50	1.13	0.40	0.35	2.20	1.35	0.32	0.21	0.26	5.28	0.07	0.42
Interaction (I X V)													
Control	Giza 35	107	106.3	3.33	3.00	113.7	111.0	15.7	15.9	30.11	30.42	1.23	1.27
	Giza 111	91.0	94.7	4.00	3.67	123.0	123.3	18.4	18.7	25.19	25.26	1.70	1.84
	Crawford	105.7	108.7	3.00	3.00	60.3	60.3	13.2	13.4	28.91	29.05	0.83	0.72
Indoxacarb 30% WG	Giza 35	110.7	111.3	3.67	3.33	112	114.0	17.3	17.8	35.45	35.99	1.51	1.58
	Giza 111	106.0	106.7	4.33	4.33	132.7	133.3	19.5	19.3	34.98	35.25	1.90	1.94
	Crawford	108.7	111.3	3.33	3.00	81.7	82.0	14.5	14.1	30.84	31.15	0.900	0.87
Agerin 6.5% Wp	Giza 35	112.3	111.3	4.00	4.00	115.3	116.3	19.6	19.8	36.91	37.11	1.73	1.67
	Giza 111	102.0	102.3	4.33	4.67	130.3	131	20.9	20.7	40.17	28.31	1.93	1.90
	Crawford	109.7	110	3.33	3.33	77.3	78.7	15.6	15.7	32.68	32.99	0.88	0.900
Lemongrass extract10%	Giza 35	109.7	108	3.67	4.00	113.7	113.7	18.4	18.7	35.25	35.5	1.51	1.54
	Giza 111	101.0	100.3	4.00	4.33	130.3	130.7	19.3	19.5	39.07	40.30	1.94	1.99
	Crawford	110	111.3	3.33	3.33	70.0	74.3	15.0	15.5	31.13	31.93	0.900	0.93
LSD 0.05		2.63	1.96	0.83	0.67	4.82	2.44	0.59	0.38	0.45	10.25	0.15	0.82

3. Effect on Seed Quality Attributes

The effects of the insecticidal treatments on seed protein, oil, and carbohydrate contents of the three soybean varieties are presented in Table 5.

For the protein content, the bio-rational treatments, Agerin (33.85% and 33.88% in 2021 and 2022) and lemongrass extract (33.16% and 3.19%), significantly enhanced seed protein content compared to the untreated control (32.56% and 32.49%). The application of the synthetic insecticide indoxacarb resulted in the lowest protein content (31.91% and 31.94%), which was significantly lower than all other treatments, including the control. This suggests that while indoxacarb is effective for pest control, it may induce a physiological stress that interferes with nitrogen metabolism or protein synthesis pathways in the plant (Raghuvanshi *et al*., 2014). The two Egyptian varieties showed superior protein accumulation, with Giza 111 having the highest protein content (33.28% and 33.32%), followed by Giza 35 (33.07% and 33.05%), both of which were significantly higher than the American variety Crawford (32.27% and 32.25%). For the interaction effect, the highest protein content was achieved by applying Agerin to Giza 111 variety (34.37% and 34.48%). Conversely, the lowest content was recorded when indoxacarb was applied to Crawford variety (31.40% and 31.34%).

For seed oil content, the bio-rational treatments again produced the highest increase in oil content (23.07% and 23.05%), followed by lemongrass extract (22.64% and 22.70%), both were higher compared to the control (20.87%

and 20.92%) and the indoxacarb treatment (21.11% and 21.12%). This supports that these treatments may actively enhance lipid synthesis pathways in the plant (Song *et al*., 2023). Giza 111 recorded the highest values (23.39% and 23.42%). Crawford had the lowest oil content (20.89% in both seasons), confirming its lower quality profile. For interaction effect, the highest oil content was found in Giza 111 treated with Agerin (24.66% and 24.65%).

Table 5. Seed quality characters of soybean genotypes as influenced by insecticides, biocide, and plant extract treatments

Insecticides sources/ variety		Seed protein content (%) 2021	Seed protein content (%) 2022	Seed oil content (%) 2021	Seed oil content (%) 2022	Seed carbohydrates content (%) 2021	Seed carbohydrates content (%) 2022
Insecticides (I)							
Control		32.56	32.49	20.87	20.92	22.3	22.31
Indoxacarb 30% WG		31.91	31.94	21.11	21.12	22.6	22.59
Agerin 6.5% Wp		33.85	33.88	23.07	23.05	23.39	23.31
Lemongrass extract 10%		33.16	33.19	22.64	22.7	22.96	22.98
LSD 0.05		0.08	0.15	0.1	0.07	0.1	0.19
Varieties (V)							
Giza 35		33.07	33.05	21.49	21.54	22.65	22.65
Giza 111		33.28	33.32	23.39	23.42	24.22	24.12
Crawford		32.27	32.25	20.89	20.89	21.56	21.62
LSD 0.05		0.08	0.10	0.06	0.06	0.08	0.14
Interaction (I x V)							
Control	Giza 35	32.66	32.56	20.67	20.73	22.65	22.63
	Giza 111	33.06	33.04	21.82	21.88	23.12	23.13
	Crawford	31.96	31.86	20.13	20.15	21.12	21.18
Indoxacarb 30% WG	Giza 35	32.17	32.25	20.36	20.4	22.26	22.26
	Giza 111	32.16	32.23	22.9	22.88	24.45	24.48
	Crawford	31.4	31.34	20.05	20.08	21.08	21.04
Agerin 6.5% Wp	Giza 35	34.02	33.92	22.78	22.76	22.94	22.93
	Giza 111	34.37	34.48	24.66	24.65	25.02	24.69
	Crawford	33.17	33.23	21.76	21.75	22.21	22.31
Lemongrass extract 10%	Giza 35	33.42	33.48	22.16	22.27	22.76	22.79
	Giza 111	33.53	33.51	24.16	24.26	24.28	24.19
	Crawford	32.54	32.57	21.61	21.57	21.83	21.97
LSD0.05		0.14	0.21	0.14	0.11	0.15	0.28

For seed carbohydrates content (%), all treatments resulted in a significant increase in carbohydrate content compared to the control (22.30% and 22.31%). Agerin (23.39% and 23.31%) and lemongrass extract (22.96% and 22.98%) led to the highest accumulation. This suggests that by mitigating pest stress, the treatments allowed for greater net photosynthesis and carbon fixation, leading to an increase in all major storage compounds (Mariyono, 2008). Giza 111 accumulated the highest carbohydrates (24.22% and 24.12%), significantly more than Crawford (21.56% and 21.62%). This emphasizes that Giza 111 is a highly efficient variety in overall biomass and nutrient partitioning (Metwally *et al*., 2021). For the interaction effect, the highest carbohydrate levels were achieved when the most efficient variety, Giza 111, was protected by Agerin (25.02% in 2021).

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فعالية المبيدات الحشرية الكيميائية والحيوية ضد دودة ورق القطن (*Spodoptera littoralis*) فى فول الصويا

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الملخص

تُشكل دودة ورق القطن (*Spodoptera littoralis*) تهديدًا كبيرًا لإنتاج فول الصويا في مصر، مما يستدعي البحث عن بدائل مستدامة للمبيدات الحشرية الكيميائية التقليدية. هدفت هذه الدراسة إلى تقييم فعالية مبيد حشري كيميائي (إندوكساكارب)، ومبيد حيوي – *Bacillus thuringiensis* (أجرين)، ومستخلص نباتي (عشبة الليمون) على ثلاثة أصناف من فول الصويا (جيزة ١١١، جيزة ٣٥، وكراوفورد) لمكافحة دودة ورق القطن، وتقييم تأثيرها المشترك على نسبة موت اليرقات، والأداء المحصولي، وجودة البذور. أجريت التجارب فى المزرعة البحثية بمحطة بحوث تاج العز (محافظة الدقهلية) خلال موسمي ٢٠٢١ , ٢٠٢٢ , باستخدام تصميم القطع المنشقة. أظهرت النتائج أنه في حين تسبب الإندوكساكارب في أعلى نسبة موت لليرقات (٩٤,٣٨-٩٥,٤٨٪)، فإن المبيد الحيوي "أجرين" (٨٤,٨١-٨٦,١٥٪) ومستخلص عشبة الليمون (٧٤,٨٩-٧٦,٢٥٪) كانا فعالين أيضًا. وتسبب الصنفان جيزة ١١١ وجيزة ٣٥ نسبة موت أعلى ليرقات دودة ورق القطن مقارنة بالصنف كراوفورد القابل للإصابة.فيما يتعلق بالمحصول، كان أداء المعاملات الحيوية مماثلاً أو متفوقًا على أداء الإندوكساكارب. وكان الصنف جيزة ١١١ هو الأعلى إنتاجية، وحققت معاملته بمستخلص عشبة الليمون أو "أجرين" أعلى محصول بذور (وصل إلى ١,٩٩ طن/فدان). والجدير بالذكر أن معاملات "أجرين" وعشبة الليمون حسّنت جودة البذور بشكل كبير، مما أدى إلى زيادة محتوى البروتين والزيت، بينما أدت معاملة الإندوكساكارب إلى انخفاض معنوي في محتوى البروتين مقارنةً بالكنترول. تخلص الدراسة إلى أن الاستراتيجية المتكاملة التي تجمع بين الصنف المتحمل عالي الإنتاجية "جيزة ١١١" مع المبيد الحيوي "أجرين" أو مستخلص عشبة الليمون هي النهج الأكثر فعالية واستدامة لمكافحة دودة ورق القطن، مما يحقق أقصى قدر من المحصول وجودة البذور، مع تجنب الآثار السلبية للمبيدات الكيميائية.