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EFFICACY AND COST-BENEFITS OF USING COMBINED FOLIAR FERTILIZERS AND INSECTICIDES AGAINST SPINY BOLLWORM *Earias insulana* (LEPIDOPTERA: NOCTUIDAE) ON OKRA

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ABSTRACT

The combined impact of two foliar fertilizers and three insecticides was evaluated against spiny bollworms during field experiments for two consecutive growing seasons 2024 and 2025 on okra plants at the Faculty of Agriculture farm, El-Shatby, Alexandria. Crop yield and spiny bollworm infestation were estimated. The results showed that the highest efficacy was attained by Power Mix30% / NasrThrin Super® giving the lowest infestation of *Earias insulana* (0.47 and 0.53 larvae /10 plants) during both seasons, respectively, followed by Power Mix30%/ Emmy-Miner® (0.77 larvae /10 plants) in season 2024, while Power Mix30% / Protecto® gave (0.83 larvae /10 plants) in season 2025. Power Mix30% / NasrThrin Super® increased the okra yield up to (4675.23 and 4841.55 kg) during both

seasons and gave the best cost-benefit ratio (1:12.30) during season 2025. During season 2024, Power Mix30% / Emmy-Miner® gave the best cost-benefit ratio (1:15.08). These findings suggest that the combined application of certain foliar fertilizers and insecticides, particularly Power Mix30% with Nasr Thrin Super ®, is a promising strategy for effective management of spiny bollworm infestation, leading to improved okra productivity and economic returns under field conditions.

Keywords: Okra, foliar fertilizers, insecticides, *Earias insulana*, Yield

INTRODUCTION

Okra, *Abelmoschus esculentus* (L.), is a popular and widely cultivated vegetable crop in Egypt, recognized for its economic significance in tropical and subtropical regions globally (**Saifullah and Rabbani, 2009**). Despite its importance, okra production is consistently challenged by various insect pests throughout its growth stages (**Ismail, 2018**). Among these, sucking insects are prominent, causing considerable damage at different developmental phases of the crop (**Ismail, 2018**).

A major threat to okra cultivation is the spiny bollworm, *Earias insulana* (Boisduval) (Noctuidae: Lepidoptera). This pest directly impacts yield and quality; females deposit eggs on flowers, tender shoots, and immature fruits, which are subsequently consumed by emerging larvae. The larvae bore into developing fruits, leading to deformities, discoloration, and rendering them unmarketable (**Ankur *et al.*, 2022**). Furthermore, feeding sites facilitate secondary bacterial and fungal infections, further degrading fruit quality (**Carmona-Hernandez, 2019**). Historically, synthetic pesticides have been the primary method for managing spiny bollworm infestations (**Rudramuni *et al.*, 2012**).

While various insecticides, including acetamiprid, indoxacarb (**Jadhav *et al.*, 2009**), organophosphorus compounds, and pyrethroids

(**Chandra *et al*., 2010**), have shown efficacy against *E. insulana*, their widespread and repeated application has led to the development of insecticide resistance in target pests (**Al-Beltagy *et al*., 2001; Qasim and Hussian, 2015**). This growing challenge necessitates the integration of diverse management approaches such as the deployment of transgenic crops, plant extracts, and biological means (**Fadare, 2004; Ali *et al*., 2015; Toundou *et al*., 2020**).

Beyond direct pest control, optimizing plant health through effective nutritional management can significantly enhance a crop's ability to withstand pest pressure and minimize damage. Foliar nutrient sprays represent a valuable strategy for promoting vigorous okra growth, enabling plants to outcompete weeds and better overcome problems arising from diseases and insect damage. These sprays are also crucial for correcting deficiencies of essential nutrients, whether macro or micro-elements (**Mesbah *et al*., 2000; Torres-Olivar *et al*., 2014**). By improving overall plant resilience, foliar fertilizers can complement conventional pest control measures.

Given the complexities of spiny bollworm management and the potential benefits of integrated approaches, the main objective of this study was to assess the combined efficacy of macro and micro-foliar nutrients (Power Mix30% and FOSFATO-K) and commercial insecticides (Protecto® 9.4% WP, NasrThrin Super® 10% EC, Emmy-Miner® 5.7% WG) against spiny bollworms on okra plants under field conditions. The study also aimed to analyze the associated cost-benefit ratios of these combined treatments.

MATERIALS AND METHODS

The field experiments were conducted at the Faculty of Agriculture farm, Alexandria, during two successive seasons of 2024 and 2025. One variety of okra (Lady Fingers) was sown on 24^{th} April 2024 and

14th March 2025 in field plots (each of 3 x 2 m^2). To reduce interference caused by spray drift between treatments, a half-meter belt was placed between each plot. The data was obtained by randomly tagging ten plants from each replicate. Three replicates of each treatment and the untreated check were used in the trial program, in a randomized complete block design in both seasons. Synthetic insecticides, Cypermethrin (Nasr Thrin Super® 10% EC), Emamectin benzoate (Emmy-Miner® 5.7% WG), and Protecto® 9.4 % WP (bio-insecticide) were sprayed in sequence with two foliar fertilizers (Power Mix30% and FOSFATO-K) in the experimental area.

Tested compounds

Foliar fertilizers

Power Mix30%: (1L /600L water /feddan)

It contains 30% of nutrients, organic acids (5% citric acid), natural growth stimulants (3% amino acids, 10% fulvic acid, and 0.5% cytokinin), and minerals (5% nitrogen, 4% phosphorus, 3.5% potassium, and 1% magnesium). Produced by the Ministry of Agriculture and Land Reclamation, Egypt.

FOSFATO-K: (75 cm^3/100L water)

(Phosphorus 30%) in the form of phosphate and (potassium 20%) and (boron 1.5%) chelated on ethanolamine for easy absorption. (CairoChem for Agricultural Services).

Insecticides

Ivermectin insecticide:

Emamectin benzoate (Emmy-Miner® 5.7% WG) (60 g/200L water/ feddan) (CairoChem for Agricultural Services).

Pyrethroid insecticide

Cypermethrin (Nasr Thrin Super® 10%EC) (600cm^3/200 L water/ feddan) (El-Naser Company for Intermediate Chemicals).

Biopestisides

Bacillus thuringiensis Kurstaki (Protecto® 9.4 % WP) (300 g/ 200 L water/ feddan) (Bio-Insecticides Production Unit-Plant Protection Research Institute).

Estimation of spiny bollworm infestation

Application of treatments was done at three periods at fortnightly intervals starting after one month of sowing in both seasons. The mean fruit infestation was recorded 7 days after each spray. Before being dissected and inspected internally, fruit samples were inspected externally. Regardless of the larvae's presence, infestation data were based on the presence of damage symptoms.

Effect of okra yield

Crop yield was collected and measured from the middle rows once every three-days. The fruits were harvested and the total yield was represented in kg/fed.

Cost: benefit analysis

The yield per plant in each treatment was multiplied by the number of plants per feddan to determine the total okra crop yield per feddan. In order to calculate the cost-benefit ratio (C: B ratio), the average price per

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kilogram of produce was established at 35 L.E in season 2024 and 45 L.E in season 2025, reflecting seasonal price fluctuations. The total income per feddan was computed by multiplying the yield by the unit price. For cost estimation, each treatment involved three spray applications per season, as conducted at fortnightly intervals starting one month after sowing. The cost per spray was calculated based on the recommended dosage and market price of each product. In addition to pesticide and fertilizer costs, labor for spraying, application tools, safety equipment, and fruit collection labor were also considered to provide a more accurate estimation of total cost per feddan.

The equations are as follows

Total Protection Cost (L.E./feddan) = (Spray Material Cost + Labor Cost + Application Tools + Safety Equipment Cost) × Number of Sprays

Net Benefit (L.E./feddan) =Total Income (Yield × Price) − Total Protection Cost

$$\textbf{Cost-Benefit Ratio (C: B)} = \frac{\textbf{Total Income (Yield × Price)}}{\textbf{Total Protection Cost}}$$

To assess the economic efficiency of the treatments, the benefit from each treated plot was compared to the control (untreated) plot. All expenses were calculated on a per-feddan basis, and the final output was presented as a cost-benefit ratio.

Statistical Analysis

Data were submitted to analysis of variance (one-way ANOVA), and means were compared for significance using LSD at the 0.05 probability level, employing CoStat statistical software version 4.20 (**CoStat, 1990**).

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RESULTS

The impact of certain insecticides and foliar fertilizers on the prevalence of spiny bollworm infestation

The effects of foliar fertilizers combined with insecticides on the mean numbers of spiny bollworm larvae /10 plants of okra during two seasons, 2024 and 2025, are displayed in Table 1. It was observed that, each of the following sprays of Power Mix30%/ NasrThrin Super® were really effective and provided the minimum number of larvae estimated by 0.47 larvae /10 plants, compared to the other treatments which recorded 0.77 larvae / 10 plants for Power Mix30% ®/ Emmy-Miner® and 1.50 larvae / 10 plants for FOSFATO-K® / Emmy-Miner®. The number of larvae in the untreated blocks was 1.97 larvae / 10 plants.

In season 2025, it was also shown in Table (1) that Power Mix30% /Nasr Thrin Super® spraying administered provided extremely effective spiny bollworm control (0.53 Larvae / 10 plants) followed by Power Mix30% / Protecto® which gave (0.83 larvae / 10 plants). Spiny bollworm infestation for the various foliar treatments that were subsequently applied ranged from 0.93 larvae / 10 plants for FOSFATO-K / Nasr Thrin Super® and 1.17 larvae / 10 plants for FOSFATO-K / Emmy-Miner®. The untreated check recorded a high level of spiny bollworm infestation 2.00 larvae / 10 plants.

Table 1. Mean numbers of spiny bollworm, *E. insulana* larvae as a result of the combined impact of foliar fertilizers and insecticides during the two seasons 2024 and 2025

Treatments	Mean No. larvae /10 plants	
	2024	2025
Power Mix30% / Protecto®	0.87 ± 0.15^{bcd}	0.83 ± 0.29^{bc}
Power Mix30% / Emmy-Miner®	0.77 ± 0.32^{cd}	1.13 ± 0.42^{b}
Power Mix30% / Nasr Thrin Super®	0.47 ± 0.15^{d}	0.53 ± 0.32^{c}
FOSFATO-K / Protecto®	1.33 ± 0.59^{abc}	1.00 ± 0.26^{bc}
FOSFATO-K / Emmy-Miner®	1.50 ± 0.5^{ab}	1.17 ± 0.38^{b}
FOSFATO-K / Nasr Thrin Super®	0.83 ± 0.29^{cd}	0.93 ± 0.12^{bc}
Untreated Check	1.97 ± 0.40^{a}	2.00 ± 0.17^{a}
$LSD_{.05}$	0.66	0.49
Significant	***	***

Means in the same column with different letters differ significantly ($P \leq 0.05$)
***= highly Significant (0.001)

The impacts of the different foliar spraying treatments on the cost-benefit analysis of okra yield during seasons 2024 and 2025 are shown in Tables 2 and 3. It could be concluded that the applied sprays of the subsequent treatment of Power Mix30% / NasrThrin Super® gave the highest rate of okra yield (4675.23 kg/Fed) and (4841.55kg/Fed), respectively, in both seasons followed by Power Mix30% /Emmy-Miner® (4543.18 kg/Fed) in season 2024 and Power Mix30% / Protecto® (4705.72 kg/Fed) in season 2025, The untreated fields showed the lowest yield. Okra had the best cost-benefit ratios for Power Mix30% / Emmy-Miner® and Power Mix30% / NasrThrin Super®, with ratios of 1:15.08 and 1:11.87, respectively. Treatment expenses per fed. in Power Mix30% / Emmy-Miner® treated plots were 945 E.L., while Power Mix30% / NasrThrin Super® cost was recorded 1590 E.L., in season 2024 (Table 2). On the other hand, in season 2025 the highest cost-benefit ratio was obtained by Power Mix30% / NasrThrin Super® with ratios and cost of 1:12.30 and 2220 E.L., respectively, followed by Power Mix30% / Protecto® with ratio and cost 1:11.77 and 1800 E.L., respectively (Table 3).

Table 2. Yield of okra and cost- benefits ratio of managing spiny bollworm with foliar fertilizers and insecticides throughout season 2024.

Treatments	Yield		Total income /Fed.	Treatment cost (E.L.)	Benefit	C:B ratio
	/Plant(g)	(kg/Fed)				
Power Mix30% / Protecto®	358.32	4514.83	158019.12	1200	156819.12	1:11.05
Power Mix30% / Emmy-Miner®	360.57	4543.18	159011.37	945	158066.37	1:15.08
Power Mix30% / Nasr Thrin Super®	371.05	4675.23	163633.05	1590	162043.05	1:11.87
FOSFATO-K / Protecto®	349.24	4400.42	154014.84	1800	152214.84	1:5.14
FOSFATO-K / Emmy-Miner®	343.16	4323.82	151333.56	1545	149788.56	1:4.26
FOSFATO-K / Nasr Thrin Super®	351.07	4423.48	154821.87	2190	152631.87	1:4.60
ntreated Check	328.25	4135.95	144758.25	-	-	-

Table 3. Yield of okra and cost: benefits ratio of managing spiny bollworm with foliar fertilizers and insecticides throughout the season 2025.

Treatments	Yield /Plant(g)	Yield (kg/Fed)	Total income /Fed.	Treatment cost (E.L.)	Benefit	C: B ratio
Power Mix30% / Protecto®	373.47	4705.72	211757.49	1800	209957.49	1:11.77
Power Mix30% / Emmy-Miner®	355.31	4476.91	201460.77	1500	199960.77	1:7.27
Power Mix30% / Nasr Thrin Super®	384.25	4841.55	217869.75	2220	215649.75	1:12.30
FOSFATO-K / Protecto®	358.61	4518.47	203331.87	2400	200931.87	1:5.32
FOSFATO-K / Emmy-Miner®	351.18	4424.87	199119.06	2100	197019.06	1:4.07
FOSFATO-K / Nasr Thrin Super®	367.05	4624.83	208117.35	2820	205297.35	1:6.22
Untreated Check	336.09	4234.73	190563.03	-	-	-

DISCUSSION

The findings of the present study demonstrate the significant impact of combined foliar fertilizers and insecticides on spiny bollworm (*Earias insulana*) infestation and okra productivity, aligning with the broader body of research on pest management. Our results indicate that the application of both synthetic insecticides and bio-insecticides effectively reduced spiny bollworm populations. This is consistent with previous studies, such as **Toundou *et al.* (2020)**, who highlighted biopesticides derived from microorganisms, plants, animals, and minerals as viable alternatives due to their targeted action and reduced harm to non-target natural enemies. Similarly, the efficacy of cypermethrin as a fast-acting neurotoxin against insect infestations, as noted by (**Agramonte, 2020**; **Kaur and Singh, 2021**), supports its observed success in our field trials. While laboratory studies often utilize median lethal concentration (LC_{50}) to evaluate insecticide efficacy (**Hardke *et al*., 2011; Burgess *et al*., 2020**), our field-based observations confirm the practical effectiveness of these compounds in reducing pest populations under real-world conditions.

Despite the proven efficacy of chemical insecticides in controlling insect attacks (**Joshi *et al*., 2020; Hajjar *et al*., 2023**), the pervasive issue of insecticide resistance stemming from their frequent and indiscriminate use remains a significant concern (**Al-Beltagy *et al*., 2001; Qasim and Hussian, 2015**). This necessitates a shift towards more sustainable and integrated pest management (IPM) strategies. Our study contributes to this paradigm by exploring the synergistic potential of combining chemical and biological control agents with nutritional interventions.

The high effectiveness of the evaluated foliar fertilizers as agents that contribute to bollworm control is also noteworthy. This aligns with findings by (**Gogi *et al*., 2012**), who suggested that improved plant nutrition enhances plant health, thereby increasing their tolerance to sucking insect pests. While some studies, like (**Torres-Olivar *et al*., 2014**), indicate that imbalances in nutrient application (e.g., overuse of nitrate) can paradoxically increase plant vulnerability by reducing physical barriers like lignin, our results, consistent with (**Kiran *et al*., 2018**), underscore the importance of balanced nutrition in developing plant resistance to phytophagous insects and meeting the demand for healthier food production.

Crucially, the findings of this study highlight that the combined application of foliar fertilizers and insecticides significantly increased okra yield and improved the cost-benefit ratio. This is consistent with previous reports demonstrating enhanced economic returns from integrated approaches. For instance, (**Panse *et al*., 2012**) reported a high cost-benefit ratio with cypermethrin combined with neem oil, while **Kumar *et al*. (2013)** found that combinations of biopesticides and insecticides were statistically superior to control treatments. The observed improvements in yield and productivity can be attributed to the role of foliar nutrients in regulating metabolic and photosynthetic processes (**Haris *et al*., 2014**), which, when combined with effective pest control, allows plants to thrive. Specific examples from the literature, such as **Nalini and Kumar (2016)** and **Choudhary *et al*. (2024)**, further support that cypermethrin-based treatments often lead to high marketable yields and favorable cost-benefit ratios in okra. More recent studies by **Meena *et al*. (2023)** and **Jaz *et al*. (2024)** also reinforce the direct positive impact of optimized nutrient application on okra yield.

In the context of IPM and sustainable agriculture, our study suggests that integrating foliar nutrient management with targeted insecticide applications offers a robust strategy for *Earias insulana* control. This approach not only provides effective pest suppression and boosts crop productivity but also promotes plant resilience, potentially reducing reliance on singular, high-dose pesticide applications. Such integrated strategies are essential for minimizing environmental impact, mitigating the development of pesticide resistance, and ensuring the long-term economic viability of okra cultivation.

CONCLUSIONS

The study assessed the effectiveness of combining foliar fertilizers (Power Mix30% and FOSFATO-K) with insecticides (cypermethrin, emamectin benzoate, and *Bacillus thuringiensis*) to control spiny bollworm (*Earias insulana*) in okra. Power Mix30%/ cypermethrin (Nasr Thrin Super®) was the most effective giving the lowest larval infestation and highest yields. Power Mix30% / emamectin benzoate (Emmy-Miner®) offered the best cost-benefit ratio, while Power Mix30% / *B. thuringiensis* (Protecto®) emerged as a sustainable option. The results highlight the synergistic potential of combining foliar nutrition with insecticides in integrated pest management (IPM).

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الملخص العربي

الفعالية ونسبة التكاليف/الفوائد للتأثير المشترك لبعض الأسمدة الورقية والمبيدات الحشرية ضد دودة اللوز الشوكية على محصول البامية

هند محمود عبد الحليم أبو زيد[1]، منى عبد الكريم عبد الظاهر محمود[2]، ماهينازعبد العزيز احمد جاب الله[3] ، بسنت صبرى محمد البنا[4]

[1]قسم بحوث ديدان اللوز- معهد بحوث وقاية النباتات، [2]قسم بحوث آفات الخضر والنباتات الطبية والعطرية ونباتات الزينة- معهد بحوث وقاية النباتات، [3، 4] قسم بحوث ذبابة الفاكهة- معهد بحوث وقاية النباتات- مركز البحوث الزراعية- الإسكندرية – مصر

تم تقييم التأثير المشترك لأثنين من الأسمدة الورقية وثلاثة من المبيدات الحشرية ضد ديدان اللوز الشوكية خلال التجارب الحقلية لموسمين متتاليين (2024 و2025) على نباتات البامية في مزرعة كلية الزراعة، الشاطبي بالإسكندرية. وتم تقدير إنتاجية المحصول ومعدل الإصابة بدودة اللوز الشوكية. أظهرت النتائج أن أعلى كفاءة تم تحقيقها من خلال تطبيق باورميكس 30% / نصر ثرين سوبر® حيث أعطى أقل إصابة بـدودة اللوز الشوكية (0.47 و 0.53 يرقة / 10 نباتات) خلال كلا الموسمين على التوالي، يليه باورميكس 30% / إيمي ماينر® (0.77 يرقة / 10 نباتات) في موسم 2024، بينما أعطى باورميكس 30% / بروتكتو® (0.83 يرقة / 10 نباتات) في موسم 2025. المعاملة باورميكس 30% / نصر ثرين سوبر® أدت إلى زيادة فى إنتاجية محصول البامية (4675.23 و 4841.55 كجم) خلال كلا الموسمين وأعطى أفضل نسبة تكلفة إلى فائدة (1: 12.30) خلال موسم 2025. أعطى باورميكس 30% / إيمي ماينر® أفضل نسبة تكلفة إلى فائدة (1: 15.08) خلال موسم 2024. تشير هذه النتائج إلى أن التطبيق المشترك لبعض الأسمدة الورقية والمبيدات الحشرية، وخاصة باورميكس 30% / نصر ثرين سوبر® ، يمثل استراتيجية واعدة للمكافحة الفعالة ضد الإصابة دودة اللوز الشوكية، مما يؤدي إلى تحسين إنتاجية البامية والعوائد الاقتصادية تحت الظروف الحقلية.

الكلمات الدالة : البامية، الأسمدة الورقية، المبيدات الحشرية، دودة اللوز الشوكية ، المحصول.