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Bioefficacy of Botanical extracts against Blackgram Borer Pests and Safety to their Natural Enemies

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ABSTRACT: The present study was aimed to study the bioefficacy of botanical extracts against the pod borers, spotted pod borer, *M. vitrata* and pea blue butterfly, *L. boeticus* in blackgram. The field experiments I and II were carried out at Kunnathur, Tirupur district of Tamil Nadu, India and at the Eastern farm of PAJANCOA and RI, Karaikal, India, respectively, during the period from September 2020 to May 2021. Considering the significance of eco-friendly pest management, the objective of this study was to test some natural and commercial botanical insecticides against the pests of blackgram. The experimental results revealed that chlorantraniliprole 18.5 SC at 100 ml/ ha reduced the infestation of spotted pod borer (7.53 and 8.35 %) and pea blue butterfly (8.03 and 8.07 %) with the reduction over control of 59.31 and 55.38 % and 56.77 and 57.98 %, respectively. Among the botanicals, garlic and chilli extract 5% reduced the infestation of spotted pod borer (8.34 and 9.67 %) and pea blue butterfly (8.67 and 9.24 %) with the reduction over control of 54.96 and 48.36% and 53.35 and 51.89 %, respectively. The population of predatory coccinellids and spiders were high in untreated check, and on par with garlic and chilli extract 5%, followed by five leaf extract 10% and bitter apple and devil pepper leaf extract 10% in both the experiments. From these findings, it was concluded that among the botanical insecticides garlic and chilli extract 5 % was the most effective, safety to natural enemies and economic over the other treatments, may be incorporated in the pest management strategies followed against the borer pests of blackgram.

Keywords: Blackgram, blackgram borer pests, botanical insecticides, bioefficacy of botanical extracts, pests of blackgram, spotted pod borer in blackgram, pea blue butterfly management.

INTRODUCTION

One of the most significant pulse crops in India is blackgram (*Vigna mungo* L. Hepper), a short-lived plant from the Leguminaceae family (Kundagar *et al*., 2021). At various stages of blackgram's growth and under various agroclimatic conditions, more than 200 insect pests from 48 families of the orders Lepidoptera, Coleoptera, Thysanoptera, Diptera, Hemiptera, Hymenoptera, Isoptera, and Orthoptera, as well as 7 species of mites from the order Acarina, have been reported to cause severe damage (Naik *et al*., 2019). In India, the spotted pod borer, *Maruca vitrata* (Geyer), is thought to be responsible for yield losses of about $30 million per year (Saxena *et al*., 2002). *M. vitrata* is responsible for the 20 to 60 % of grain yield loss in cowpea (Singh and Allen, 1980). A significant amount of damage is done to buds, flowers, and pods by the pea blue butterfly, *Lampides boeticus* (Linnaeus), and its presence reduces cowpea yield by 60–90% (Durairaj, 2006).

In order to manage insect pests, blackgram growers use a variety of insecticides. Pesticide indiscriminate use resulted in a number of detrimental side effects, including the rise of resistant insect species, environmental degradation, risk hazard to farmers, and the extinction of beneficial organisms such as predators, parasitoids, and pollinators (Berani *et al*., 2018). Botanical insecticides are the naturally occurring, often slow acting crop protectants and secondary metabolites (phytochemicals) which are extracted from the plant sources that can control and kill the pests thus aid in agricultural pest management (Dimetry, 2014; Laxmishree and Nandita 2017). Adathoda (*Adathoda vasica* Nees) leaf extract shown a significant antifeedent effect against tobacco cutworm (Anuradha *et al*., 2010). Garlic and chili extract combined with 0.1 % soap solution had the greatest impact on reducing diamond back moth populations (DBM) (Tuan *et al*., 2014). According to Iamba and Malapa (2020), chilli constitutes insecticidal phytochemicals that have strong deterrent and repellent effects on DBM. Narayanasamy *et al*. (2009) reported that the highest mortality of the brinjal fruit and shoot borer, pumpkin caterpillar and tapioca whitefly were achieved from *Calotropis* leaf extract + onion + garlic + chilli powder. Garlic and chilli extract 5 % was the best treatment among botanicals against rice yellow stem borer (Nishanthini and Kandibane 2021). Gulzar *et al*. (2017) discovered that bitter apple extract had insecticidal properties by suppressing the growth of *H. armigera* larvae. Seed treatment with Neem seed extract at 5% and bitter apple extract at 5% were shown to be the most effective treatments for controlling borers of bhendi (Javed *et al*., 2019). Selvam (2018) discovered that neem extracts were effective in the reduction of flower and pod damage in spotted pod borer, *M. vitrata* andin gram blue butterfly, *Euchrysops cnejus* (Fabricius) in blackgram. According to Packiam *et al*. (2013) ponneem had the highest insecticidal activity and extensively damaged the midgut of *H. armigera*. Due to their negligible adverse effects on non-target organisms, the use of botanicals for insect pest management assisted in the conservation of natural enemies of pests (Baidoo and Mochiah 2016). Interest in pest management with botanicals and biopesticides has been sparked by growing environmental safety concerns and a global desire for food free of pesticide residues (Raghavendra *et al*., 2016).

Considering the significance of eco-friendly pest management in the blackgram environment, the current study was conducted to assess the effect of botanical extracts against the pod borers, spotted pod borer, *M. vitrata*, and pea blue butterfly, *L. boeticus*.

MATERIALS AND METHODS

A. Study site

Two field experiments were performed: field experiment I in Kunnathur, Tirupur, Tamil Nadu during *Kharif* 2020 and field experiment II in the Eastern farm of Pandit Jawaharlal Nehru College of Agriculture and Research Institute (PAJANCOA and RI), Karaikal, U. T. of Puducherry during *Rabi* 2020-2021. The experiment was set up in a randomised block design (RBD), with nine treatments reproduced three times. The seeds of the ruling blackgram variety VBN (BG) 8 were sown in the plots of 5 x 4 m with a spacing of 30 × 10 cm. Table 1 showed the treatments of the experiment, formulation/concentration and rate of application.

B. Pest assessment

Ten randomly selected plants were observed for symptoms at weekly intervals starting from seven days after sowing. Treatments were imposed once the pest incidence reached the economic threshold level (10%).

Assessment of bore holes in buds, flowers and pods, infested parts with webbed shoots and pods caused by the larvae of the spotted pod borer and green pods with bore hole symptoms caused by the larvae of blue butterfly were made on ten randomly selected plants per plot. The observations were taken one day prior to treatment and at 1, 3, 5, 7, 9, 12 and 14 Day After Treatment (DAT) (Selvam, 2018).

The percentage pod damage was worked out by using the formula.

$$\text{Per cent pod damage} = \frac{\text{Total number of damaged pods}}{\text{Total number of examined pods}} \times 100 \quad \text{(Selvam } et\ al.\text{, 2020)}$$

C. Preparation of botanical extracts

The leaves of the following plants were used to make the five leaf extract: neem (*Azadirachta indica* A. Juss), giant milkweed (*Calotrophis gigantea* (L.) Dryand.), noni (*Morinda citrifolia* Linnaeus), tulsi (*Ocimum sanctum* Linnaeus), and adhathoda (*A. vasica).* Cleansed and cut plant leaves weighing about 2 kg apiece were used. The chopped plant leaf pieces were each macerated into a paste and added to a wide-mouthed bucket with a height and width of 30.5 cm and 28.5 cm, which contained 12 to 15 litres of cattle urine (add more if necessary). The plant materials were then completely submerged in the cattle urine, and 3-5 kg of cow dung (mixed with cattle urine) and 100 to 250 g of turmeric powder (if available) were added. The mixture was then allowed to ferment for 7-15 days. Double-layered kada cloth was used to filter the fermented solution before spraying.

For the preparation of garlic and chilli extract, about 200 g of each was mixed with 1 litre of water and blended with an electric blender to obtain juice. Then the mixture was sieved to obtain a uniform extract without turbidity (Tuan *et al*., 2014).

For the preparationof bitter apple and devil pepper leaf extract, about 500g of each bitter apple, *Citrullus colocynthis* ((L.) Schrad.) and devil pepper, *Rauwolfia tetraphylla* (Linnaeus) leaves were blended with 500 ml of water in a mixer grinder to create a fine paste, which was then filtered. The filtered solution was diluted and sprayed in accordance with the concentration.

D. Data analysis

In order to do a statistical analysis, the data recorded for pod damage (%) was transformed to angular transformation (Arc sine) while the data on natural enemies was transformed to square root transformation using the formula $\sqrt{X + 0.5}$. The data collected in the field were analysed using the simple randomised block design by "F" test for significance as outlined by Panse and Sukhatme (1958). Using Duncan's Multiple Range Test (DMRT), the experiment's critical difference values were calculated (Gomez and Gomez 1984).

RESULT AND DISCUSSION

A. Management of the spotted pod borer, M. vitrata

The field experiment I results, which are presented in Table 2, showed that the spotted pod borer, *M. vitrata* caused the least amount of pod damage when chlorantraniliprole 18.5 SC was applied at 100 ml/ ha (7.53%), followed by garlic and chilli extract at 5% (8.34%). Similar results were found in the field experiment II, with chlorantraniliprole 18.5 SC at 100 ml/ ha causing the least damage (8.35%) and garlic and chilli extract at 5% causing the second-least damage (9.67%) (Table 2, Fig. 1).

These findings are consistent with Mahalle and Taggar (2018), who stated that chlorantraniliprole 18.5 SC at 30 g a.i./ha considerably reduced the amount of *M. vitrata*'s pod damage in pigeonpea. In comparison to the varied doses of coragen 20 SC at 10, 15, 20, and 25 g a.i./ ha, Mahalakshmi *et al*. (2013) observed that coragen 20 SC at 30 g a.i./ha was beneficial in lowering the larval incidence and pod damage of *M. vitrata* on blackgram. Khinchi and Kumawat (2021) expressed that chlorantraniliprole 18.5 SC at 150 ml/ ha was most effective for controlling pod borer (*Helicoverpa armigera* (Hubner)) and pod fly (*Melanagromyza obtusa* (Malloch)) damage in pigeonpea. Aryal *et al*. (2021) concluded that chlorantraniliprole 18.5 SC at 0.2 ml/ l and spinosad 45 SC at 0.2 ml/ l were rather safe and could be a feasible alternative for managing the spotted pod borer (*M. vitrata*) in cowpea. According to Ahmed *et al*. (2009), plant extracts, in particular those from tobacco, sweetsop, and garlic, show great promise as biopesticides for the management of the cowpea-infesting brown pod-sucking bugs *Clavigralla tomentosicollis* (Stal) and *M. vitrata*. Lakshmanan (2001) showed that garlic bulb extract, either alone or in combination with kerosene, neem oil, chilli, and other extracts, efficiently controlled sucking pests such aphids, whiteflies, thrips, tetranychid mites, and various lepidopteran pests, including *Earias vittella* (Fabricius), *Chilo partellus* (Swinhoe), *Corcyra cephalonica* (Stainton), *H. armigera* and *Spodoptera litura* (Fabricius) on various crops.

B. Management of the pea blue butterfly, L. boeticus

The results showed that chlorantraniliprole 18.5 SC at 100 ml/ ha (8.03 %) recorded the least pod damage of pea blue butterfly, *L. boeticus*, followed by garlic and chilli extract at 5 % (8.67 %). Similar findings were confirmed in field experiment II, least pod damage was observed in chlorantraniliprole 18.5 SC at 100 ml/ ha (8.07 %), followed by garlic and chilli extract at 5 % (9.24 %) (Table 2, Fig. 2).

Patel *et al*. (2015) revealed that most efficient pesticide against pigeonpea pod borer (*H. armigera*) and blue butterfly (*Euchrysops cnejus* (Fabricius)) was chlorantraniliprole 18.5 SC at 30 g a.i./ ha. Mohanraj *et al*. (2012) stated that chlorantraniliprole 20 SC at 20 - 30 g a.i./ ha recorded the lower mean larval population of (0.44–0.47 larva/ plant) and least pod damage against *Lampides* sp. in blackgram. According to Harshita *et al*. (2021), two sprays of chlorantraniliprole 18.5 SC at 0.2 ml/ l between ten days interval recorded the least larval population and the least pod damage in blue butterfly, *L. boeticus* in vegetable pigeon pea. Iamba and Malapa (2020) reported that chillies have insecticidal phytochemicals that effectively inhibit and repel the diamond back moth, *Plutella xylostella* (Linnaeus). Narayanasamy *et al*. (2009) concluded that highest mortality of the brinjal fruit and shoot borer, pumpkin caterpillar and tapioca whitefly was recorded in the mixture of *Calotropis* leaf extract + onion + garlic + chilli powder. Ladji *et al.* (2011) stated that garlic chilli aqueous (2%) + garlic chilli kerosene (0.5%) exhibited maximum reduction in larval population of 46.85 per cent against chickpea pod borer, *H. armigera*. The above results are in consonance with the present findings.

C. Safety to natural enemies

The population density of predatory coccinellids was high in the untreated check (3.31/ plant), which was on par with the extracts of garlic and chilli at 5%/ ha, five leaf extract at 10%/ ha, and bitter apple and devil pepper leaf extract at 10%/ ha (3.28, 3.25, and 3.24/ plant) in the field trial I. The highest population density of spiders was found in untreated check (3.67/plant), which was on par with the extracts of garlic and chilli at 5%/ha, five leaf extract at 10%/ha, and bitter apple and devil pepper leaf extract at 10%/ha (3.65, 3.63, and 3.61/plant) (Table 3). In the field experiment II, similar results were also seen.

These findings support the claims made by Tang *et al*. (2002) that neem oils and extracts are target-specific, safe for beneficial organisms, and compatible with biological control agents. Selvam (2018) found that adhatoda leaf extract up to 10% was the safest and that the coccinellid population (2.14 beetles/plant) and the spider population (0.97 spiders/plant) were at their highest levels in blackgram. Kunbhar *et al.* (2018) expressed that *C. collocynthis* extracts were less harmful against the coccinellid predators *i.e.*, *Coccinella septempunctata* (Linnaeus), *Brumus suturalis* (Fabricius) and *Menochilus sexmaculatus* (Fabricius).

Table 1: Treatments of the experiment.

Treatment No.	Treatments	Conc. %/ g/ ml per Hectare
T_1	Five leaf extract	10
T_2	Garlic and chilli extract	5
T_3	Bitter apple and devil pepperleaf extract	10
T_4	Ponneem 45 per cent	3000
T_5	Azadirachtin 0.03 EC	2000
T_6	Azadirachtin 0.15 EC	1500
T_7	Chlorantraniliprole 18.5 SC	100
T_8	Thiamethoxam 25 WG	100
T_9	Untreated check	-

Table 2: Efficacy of botanical extracts against spotted pod borer, *M. Vitrata* and pea blue butterfly, *L. boeticus* in blackgram during Field experiment I and II (*Kharif* 2020 and *Rabi* 2020 - 2021)

Treatments	Conc. %/ ml/ g per ha	Mean per cent pod damage # Field experiment I (*Kharif* 2020)								Mean per cent pod damage # Field experiment II(*Rabi* 2020 - 2021)							
		M. vitrata				*L. boeticus*				*M. vitrata*				*L. boeticus*			
		2nd Foliar spray#	3rd Foliar spray#	Overall mean	Percent reduction over control	2nd Foliar spray#	3rd Foliar spray#	Overall mean	Percent reduction over control	2nd Foliar spray#	3rd Foliar spray#	Overall mean	Percent reduction over control	2nd Foliar spray#	3rd Foliar spray#	Overall mean	Percent reduction over control
Five leaf extract	10	10.58^{d}	9.12^{d}	9.85	46.77	10.18^{d}	10.04^{d}	10.11	45.57	11.26^{d}	11.18^{d}	11.22	40.05	11.00^{d}	11.18^{d}	11.09	42.25
Garlic and chilli extract	5	9.45^{b}	7.22^{b}	8.34	54.96	8.83^{b}	8.50^{b}	8.67	53.35	9.84^{b}	9.49^{b}	9.67	48.36	9.43^{b}	9.05^{b}	9.24	51.89
Bitter apple and devil pepper leaf extract	10	10.03^{c}	8.43^{c}	9.23	50.12	9.42^{c}	9.59^{c}	9.51	48.83	10.59^{c}	10.50^{c}	10.55	43.65	10.38^{c}	10.27^{c}	10.33	46.24
Ponneem 45 per cent	3000	12.92^{h}	12.29^{h}	12.61	31.88	12.60^{h}	13.46^{h}	13.03	29.85	13.84^{h}	15.18^{h}	14.51	22.47	13.87^{h}	14.27^{h}	14.07	26.74
Azadirachtin 0.03 EC	2000	11.18^{e}	9.69^{e}	10.44	43.61	10.74^{e}	10.71^{e}	10.73	42.26	11.89^{e}	12.47^{e}	12.18	34.92	11.62^{e}	11.98^{e}	11.80	38.56
Azadirachtin 0.15 EC	1500	12.31^{g}	11.55^{g}	11.93	35.53	11.98^{g}	12.70^{g}	12.34	33.57	13.20^{g}	14.33^{g}	13.77	26.45	13.21^{g}	13.38^{g}	13.30	30.77
Chlorantraniliprole 18.5 SC	100	8.47^{a}	6.59^{a}	7.53	59.31	8.23^{a}	7.83^{a}	8.03	56.77	8.55^{a}	8.15^{a}	8.35	55.38	8.47^{a}	7.67^{a}	8.07	57.98
Thiamethoxam 25 WG	100	11.74^{f}	10.35^{f}	11.05	40.31	11.32^{f}	11.58^{f}	11.45	38.36	12.57^{f}	13.39^{f}	12.98	30.64	12.28^{f}	12.67^{f}	12.48	35.04
Untreated check	-	16.36^{i}	20.65^{i}	18.51	-	16.91^{i}	20.24^{i}	18.58	-	16.85^{i}	20.58^{i}	18.72	-	17.71^{i}	20.70^{i}	19.21	-

In a column mean followed by a common letter are not significantly different by DMRT (P=0.05); # - observed on pretreatment, 1, 3, 5, 7, 9, 12 and 14 DAT

Table 3: Effect of botanical extracts on predatory coccinellids and spiders in blackgram during Field experiment I and II (*Kharif* 2020 and *Rabi* 2020 - 2021).

Treatments	Conc. %/ml/g per ha	Field experiment I (*Kharif* 2020)								Field experiment II (*Rabi* 2020 - 2021)							
		Mean number of coccinellids/ plant				Mean number of spiders/ Plant				Mean number of coccinellids/ plant				Mean number of spiders/ Plant			
		1st Foliar spray#	2nd Foliar spray#	3rd Foliar spray#	Overall Mean	1st Foliar spray#	2nd Foliar spray#	3rd Foliar spray#	Overall mean	1st Foliar spray#	2nd Foliar spray#	3rd Foliar spray#	Overall mean	1st Foliar spray#	2nd Foliar spray#	3rd Foliar spray#	Overall mean
Five leaf extract	10	2.19^{a}	3.30^{a}	4.26^{a}	3.25	2.50^{a}	3.79^{a}	4.60^{a}	3.63	2.04^{a}	3.15^{a}	4.09^{a}	3.09	2.13^{a}	3.07^{a}	4.15^{a}	3.12
Garlic and chilli extract	5	2.21^{a}	3.33^{a}	4.29^{a}	3.28	2.52^{a}	3.81^{a}	4.63^{a}	3.65	2.08^{a}	3.16^{a}	4.12^{a}	3.12	2.16^{a}	3.10^{a}	4.18^{a}	3.15
Bitter apple and devil pepper leaf extract	10	2.17^{a}	3.29^{a}	4.25^{a}	3.24	2.49^{a}	3.77^{a}	4.59^{a}	3.61	2.02^{a}	3.12^{a}	4.08^{a}	3.07	2.12^{a}	3.06^{a}	4.14^{a}	3.11
Ponneem 45 per cent	3000	1.92^{b}	2.66^{b}	3.29^{b}	2.62	2.20^{b}	2.75^{b}	3.34^{b}	2.76	1.62^{b}	2.44^{b}	3.05^{b}	2.37	1.86^{b}	2.68^{b}	3.55^{b}	2.69
Azadirachtin 0.03 EC	2000	1.96^{b}	2.69^{b}	3.32^{b}	2.66	2.22^{b}	2.77^{b}	3.35^{b}	2.78	1.65^{b}	2.46^{b}	3.07^{b}	2.39	1.88^{b}	2.69^{b}	3.58^{b}	2.72
Azadirachtin 0.15 EC	1500	2.00^{b}	2.70^{b}	3.35^{b}	2.68	2.24^{b}	2.79^{b}	3.40^{b}	2.81	1.69^{b}	2.50^{b}	3.10^{b}	2.43	1.91^{b}	2.73^{b}	3.60^{b}	2.75
Chlorantraniliprole 18.5 SC	100	1.06^{c}	1.12^{c}	1.07^{c}	1.08	1.04^{c}	1.30^{c}	1.21^{c}	1.18	1.07^{c}	1.23^{c}	1.34^{c}	1.21	1.20^{c}	1.27^{c}	1.34^{c}	1.27
Thiamethoxam 25 WG	100	0.79^{d}	0.89^{d}	0.84^{d}	0.84	0.85^{d}	0.97^{d}	0.96^{d}	0.93	0.70^{d}	0.79^{d}	0.91^{d}	0.80	0.83^{d}	0.85^{d}	0.91^{d}	0.86
Untreated check	-	2.25^{a}	3.36^{a}	4.33^{a}	3.31	2.55^{a}	3.82^{a}	4.65^{a}	3.67	2.12^{a}	3.20^{a}	4.14^{a}	3.15	2.18^{a}	3.12^{a}	4.21^{a}	3.17

In a column mean followed by a common letter are not significantly different by DMRT (P=0.05); # - observed on pretreatment, 1, 3, 5, 7, 9, 12 and 14 DAT

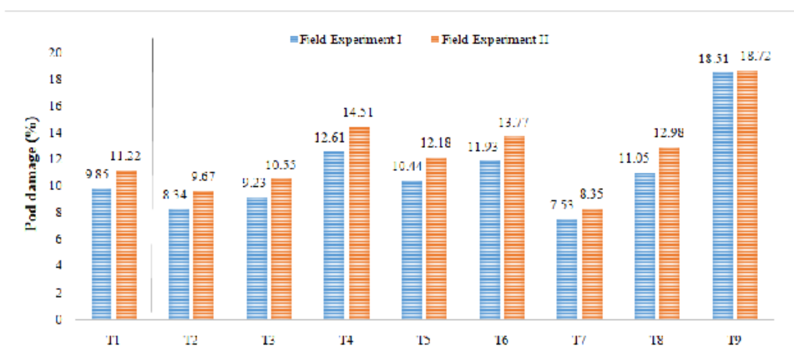

Fig. 1. Efficacy of botanical extracts against spotted pod borer, *M. vitrata* in blackgram during Field experiment I and II.

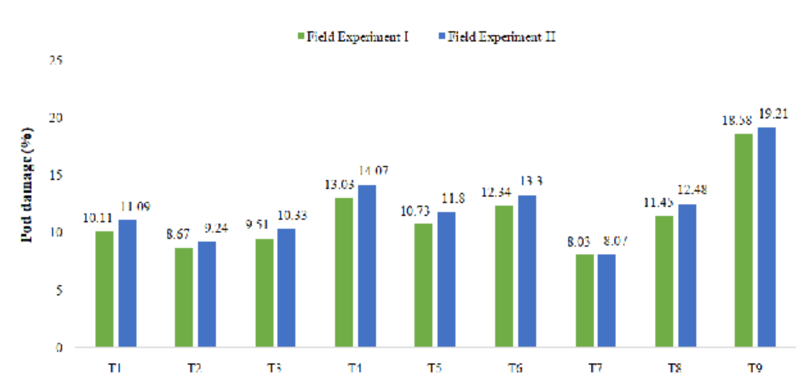

Fig. 2. Efficacy of botanical extracts against pea blue butterfly, *L. boeticus* in blackgram during Field experiment I and II.

CONCLUSION

It was concluded that chlorantraniliprole 18.5 SC at 100 ml/ ha was found effective to borer pests of blackgram and among botanical treatments, garlic and chilli extract at 5 per cent was found to be effective in reducing the damage of spotted pod borer and pea blue butterfly. Botanical extracts did not have any negative impact on the population of predatory coccinellids and spiders after spraying.

FUTURE SCOPE

The overuse of synthetic pesticides endangered human health, the environment, and the development of resistant insect and pathogen strains. Therefore, due to their renewable nature and contribution to human and environmental safety, the effectiveness and significance of botanical pesticides in managing agricultural pests must be evaluated. Large-scale cultivation of source plants could be carried out in marginal lands that are unsuitable for arable agriculture to reduce competition with food crops, taking into account the enormous amounts of material required to create botanical pesticides. To enhance the use of plants that have bioactive chemicals relevant to crop protection, more research is needed. In order to improve the source plants, it may be necessary to discover the genes controlling the production and accumulation of active substances. This information will then be used to guide breeding techniques that will produce high yields of the desirable pesticidal compounds. In future more research is required on different climatic field conditions to stabilize the botanical insecticides and their formulations.

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Conflict of Interest. None.

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