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# Ecofriendly and sustainable management of *Spilosoma obliqua* Walker on sesame (*Sesamum indicum* L.) crop by new botanicals

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## Abstract
Sesame (*Sesamum indicum* L., cv. Rama) is a widely used oldest oil seed crop throughout the world and they are highly affected by different herbivorous insect pests including *Spilosoma obliqua* Walker. We investigated the efficacy of two botanicals [mahogany (*Swietenia mahagoni*) and Indian beach or karanja (*Millettia (Pongamia) pinnata*) leaf extract] in 5% neem oil individually and in combined mixture for determination of $LC_{90}$ by Log-probit analyses. Due to lowest $LC_{90}$ value of the combined botanicals in 5% neem oil (16.49%, w/v) over the synthetic pesticide (indoxacarb @ 5%) was used for sustainable and ecofriendly management of *S. obliqua* on the crop in the field conditions. The seed production were significantly increased ($F_{1,19}$=21.145, $P$<0.0001) from 4.844 to 296.546 kg/hector in botanical pesticide treated plots over the synthetic pesticide. Thus the result demonstrates the potential of new botanicals in control of the pest in future integrated pest management (IPM) programmes.

**Keywords:** *Sesamum indicum*, *Spilosoma obliqua, Swietenia mahagoni*, *Millettia pinnata*, neem oil, indoxacarb, IPM

## 1. Introduction
Sesame (*Sesamum indicum* L.; Family: Pedaliaceae) is a drought-tolerant widely used and oldest oil seed crop throughout the world and cultivated as rain fed crop in tropics and subtropics. It is widely cultivated for its edible seeds, which grow in pods having highest oil contents of any seed and harvested about more than 3.5 million metric tonnes of sesame seeds throughout the world. But various abiotic (rainfall, soil, temperature, etc.) and biotic (pests, weeds, allelochemicals, etc.) factors regulate their growth and successful production in the field condition [1, 7]. Different insect pests like hawk moth (*Acherontia styx*), Bihar hairy caterpillar (*Spilosoma oblique*, *Diacrisia casignetum*), red hairy caterpillar (*Amsacta albistriga*), pod bug (*Elasmolomus sordidus*), pentatomid bug (*Nezara viridula*), cotton aphid (*Aphis gossypii*), etc. act as powerful limiting factor in their growth and production in the field condition [1, 2, 4, 5].
Among the insect pests *Spilosoma obliqua* Walker (Lepidoptera: Arctiidae) larvae is a notorious pest and a major limiting factor in sesame production. It is a polyphagous and sporadic pest attacking nearly 126 plants species distributed in 24 families [8]. This pest has been reported to cause extensive damage to crops such as oilseeds, pulses, vegetables, fodder, fiber crops, and fruit trees [9]. The larvae are voracious feeder and its population often reaches epidemic level when they defoliate plants and move from field to field finishing the vegetation of the area of their visit [9]. It is a serious pest of sesame and other crops in West Bengal, Bihar, Uttar Pradesh, Punjab, Madhya Pradesh, Manipur and some other states in India. They cause serious damage and significant reduction in yield of preferred crops including sesame [9]. It is known fact that the Bihar hairy caterpillar showed certain levels of behavioral resistance to different class of insecticides [9, 14], hence successful control of this pest is to some extent difficult. Traditionally synthetic pesticides have been the most effective means of pest control but, continuous and indiscriminate use of insecticides over the years has resulted imbalance in our agro ecosystem [15]. The risk to human health and environmental side effects have force to look for greener alternatives like botanicals [16, 19].
Today, crop production must also ensure healthy, ecofriendly and sustainable food supply to us. The use of botanical resources for agrochemical purpose is one of the important alternatives to manage insect-pests in place of synthetic insecticides [20, 21].

The activity of crude plant extracts is often attributed to the complex mixture of active secondary compounds that alter the behavioral and physiological aspects of insects which reduces the potential chances of insect resistance to the natural complex [22]. In fact, botanical pesticides are in use in Indian agriculture for over a century to minimize losses caused by pests and diseases [14, 23-25]. Botanical pesticides are less expensive and easily available because of their natural occurrence especially in oriental countries. Some of the botanicals have already attained the status of potential pesticides of plant origin to be used in IPM of crop field insects as well as in storage ecosystems [25-28]. A number of reports on inhibitory activities of plant botanicals have been screened against *S. obliqua* [27, 29, 31]. Though, several plant botanicals have been screened for the search of promising control measures of *S. obliqua,* but reports about the effect of mahogany and karanja leaf in combination with neem oil against *S. obliqua* are scarce. So, our present work was carried out to investigate the efficacy of a new botanicals in a combination mixture against the insect pest for better production of sesame seed over the traditional synthetic pesticides for sustainable and ecofriendly management of the crop in the field conditions.

## 2. Materials and Methods

**2.1. Collection and rearing of *Spilosoma obliqua*:** The eggs of *S. obliqua* were collected from infested sesame leaves from the agricultural field near CRRC, Chinsurah, 22°53' N, 88°23' E, Hooghly, West Bengal, India during cultivation period (summer: March-June) of sesame in 2016. The eggs were incubated in the laboratory on sesame leaves (*S. indicum*) collected from the same field in plastic jars (20 cm dia. X 30 cm ht.) until emergence of caterpillars. The mass culture of *S. obliqua* was established from the larvae until pupation and adult emergence on sesame leaves under ambient conditions (temperature 26 ± 2 °C, relative humidity 70 ± 5% and 12:12 h L:D photoperiod) up to $F_2$ generation and required larval instars ($3^{rd}$ and $4^{th}$) were taken from the culture on the day of bioassay.

**2.2. Collection of plant materials:** Fresh green leaves of mahogany (*Swietenia mahagoni*; Family: Meliaceae) and karanja or Indian beech (*Millettia pinnata*; Family: Fabaceae) plants were collected from the surrounding area near CRRC, Chinsurah, Hooghly, West Bengal. The plant was identified and voucher specimens (Voucher No. ERU6-7) were kept in Department of Zoology, Ecology Research Unit, MUC Women's College, Burdwan. Each kind of plant leaves were dried well under shed for a week and ground it to powder in stainless steel blender (Phillips, India) and sieved through a piece of muslin cloth for further use.

**2.3. Botanical Extract Preparation:** The botanical extracts were prepared from the powered leaves of respective plants (mahogany and karanja) individually and in combination by equal amount (1:1) with distilled water and boiled for 30 minutes to make 100% solution stock solution. The mixture was cooled and filtered through muslin cloth and used for dose response bioassay. Different concentrations (2.5, 5, 10 and 15% solution) in 5% neem oil suspensions were used for the bioassay to determine the $LC_{90}$ of respective botanical solutions.

**2.4. Dose response bioassay:** The larvicidal bioassays were done according to the standard protocol for determination of $LC_{90}$ of the botanical individually and in combination mixture by probit analysis [15, 32]. Each experiment was done in five replicates with 20 larvae in each replicate. All the experiments were done in ambient conditions and percent mortality (M %) was recorded after 48 h of exposure. The lowest value of $LC_{90}$ of the combined mixture was used for the field experiment.

**2.5 Botanicals in field experiment:** The most effective concentration of the botanicals at $LC_{90}$ (16.49%, w/v) was used for the field experiment in two fold concentration (about 33%, w/v) because of different environmental dilution factors. The potency was observed over a traditional synthetic pesticide (indoxacarb @ 5%) along with control (without pesticide) side by side. The experiment was done by using 200 $ft^2$ plots near CRRC, Chinsurah, West Bengal, India, with 10 replications for each treatments. The average density of the sesame plants were 10±2 plants/$ft^2$ in the plots. The data from plants were collected by RBD from the field for find the ultimate potency of the new botanicals in production and sustainability.

**2.6. Infestation and yield calculation:** After flowering to harvest plant height (inch.), total pods and affected pods per plant as well as occurrence of hairy caterpillars of *S. obliqua* were recorded by random block design (RBD) for each treatment with control also. On the basis of the number of affected pods and hairy caterpillar infestation the efficacy of the botanicals over the traditional synthetic pesticide were determined in terms of infestation reduction (IR %), seed damage reduction (SDR %) and yield increase per plot (YIP) as well as per Hectare (YIH) [23].

For calculation of these parameters the number of total *S. obliqua* larvae (L) observed in the two treated plots infestation reduction (IR %) were calculated. On the basis of the number of total pods (TP) and infested pods (IP) the percent fruit infestation was calculated using the following formula: % Pod infestation by number = (Number of infested fruits/Total number of fruits)X 100 [23]. From this by comparing % Pod infestation in the two treatments SDR % were calculated. The yield increase per plot (YIP) as well as per Hectare (YIH) were also calculated on the basis of prevailing market prices of sesame, botanicals or synthetic pesticides and spraying cost [23].

**2.7. Statistical analyses:** The experiment was conducted in completely randomized block design (RBD) and the data of the different parameters of sesame plants were subjected to one-way Analysis of Variance (ANOVA), regression analysis, paired sample tests and correlation analysis. Means were compared by Tukey's (HSD) test to analyze the significant difference between the treatments. All the statistical analysis was performed on SPSS (version 16.0) computer software program.

## 3. Results

**3.1. $LC_{90}$ value from dose response bioassay:** Determination of $LC_{90}$ values of the botanical extract was carried out through Log-probit analyses. The $LC_{90}$ value of individual plant leaf extract in neem oil was significantly ($F_{2,12}$=362.437, $P$<0.001) higher (mahogany $LC_{90}$=23.76% and karanja $LC_{90}$= 27.68%) than their combined mixture ($LC_{90}$=16.49%). The lowest $LC_{90}$ value of combined botanicals (mahogany and karanja leaf) in neem oil (16.49%, w/v) was used for the control of *S. obliqua* hairy caterpillars in the field conditions.

**3.2. Efficacy of the Botanicals in field condition:** Different parameters of the sesame plants (plant height, total pods, affected pods and hairy caterpillar infestation) were collected from the respective fields for find the efficacy of both synthetic and botanical pesticides. All the selected parameters were differentially significant (Tukey's HSD) in the both treated plots compare to control plots (Figure 1-4). ANOVA result represent statistically significant response of the botanicals over the synthetic pesticide treated plants only in affected pods ($F_{1,18}$=845.670, $P$<0.0001) and hairy caterpillar infestation ($F_{1,18}$=444.861, $P$<0.0001). Whereas plant height ($F_{1,18}$=0.116, $P$=0.737) and pod numbers ($F_{1,18}$=0.212, $P$=0.651) were not significantly differed in the treated plots (Table 1). Among the possible pairs of the selected parameters in both treatments plant-pods affected (r=-0.990, $p$<0.0001), plant-pest (r=-0.980, $p$<0.0001), height-pod affected (r=-0.003, $p$=0.991), pod-pod affected (r=-0.030, p=0.901) and pod-pest(r=-0.016, p=0.946) were negatively correlated with different level of significance (Table 2). Whereas other pairs like plant-plant height (r=0.080, p=0.737), plant-pod (r=0.108, p=0.651), plant height-pod (r=0.486, p=0.030), plant height-pest (r=0.038, p=0.874) and pod affected-pest (r=0.991, $p$<0.0001) were positively correlated with different level of significance (Table 2). Paired sample t-test of the selected parameters represent significant difference ($t$=3.275 to 141.271, $df$=19, $P$<0.005) between two treatments (Table 2). Paired sample t-test considering affected pods and hairy caterpillars of both treatments were significantly differed ($t$=25.009, $df$=19, $P$<0.0001 and $t$=18.649, $df$=19, $P$<0.0001, respectively) (Table 3). On the other hand, affected pods and hairy caterpillars were also significantly differed separately in the paired sample t-test in synthetic ($t$=21.491, $df$=19, $P$<0.0001) as well as botanical ($t$=5.679, $df$=19, $P$<0.0001) pesticide treated plots (Table 3).

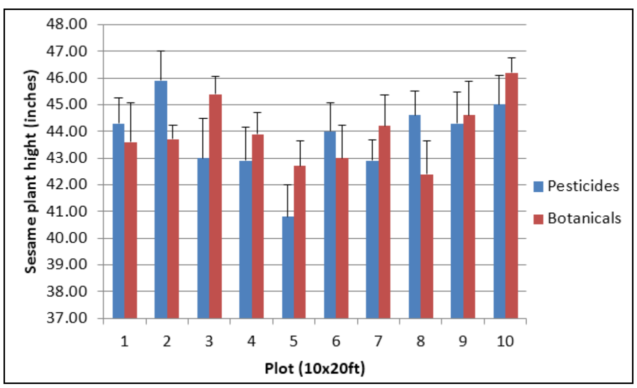


**Fig 1:** Sesame (*S. indicum* L.) plant height in synthetic and botanical pesticides treated plots in the field condition. Different letters over the bars indicate that the means (Mean ± SE of 10 observations) are significantly different ($P$<0.05), while comparing one type of plants with the other within the column by Tukey's HSD test.

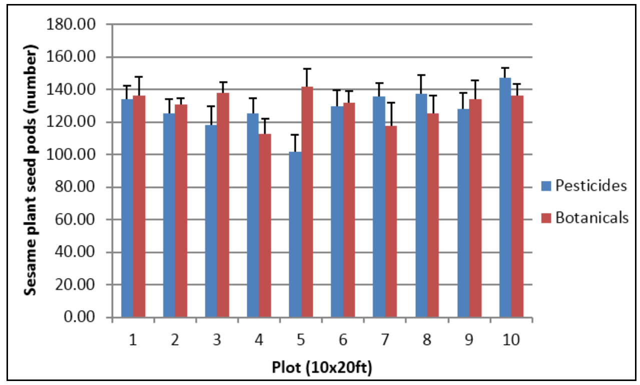


**Fig 2:** Seed pods of sesame (*S. indicum* L.) plant in synthetic and botanical pesticides treated plots in the field condition. Different letters over the bars indicate that the means (Mean ± SE of 10 observations) are significantly different ($P$<0.05), while comparing one type of plants with the other within the column by Tukey's HSD test.

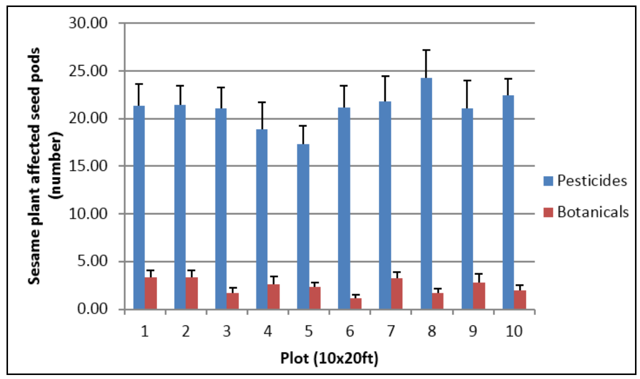


**Fig 3:** Affected seed pods of sesame (*S. indicum* L.) plant by hairy caterpillar (*S. obliqua*) in synthetic and botanical pesticides treated plots in the field condition. Different letters over the bars indicate that the means (Mean ± SE of 10 observations) are significantly different ($P$<0.05), while comparing one type of plants with the other within the column by Tukey's HSD test.

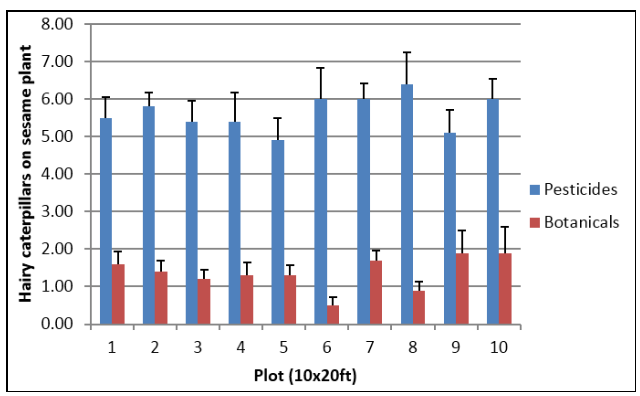


**Fig 4:** Occurrence of hairy caterpillars (*S. obliqua*) on sesame (*S. indicum* L.) plant in synthetic and botanical pesticides treated plots in the field condition. Different letters over the bars indicate that the means (Mean ± SE of 10 observations) are significantly different ($P$<0.05), while comparing one type of plants with the other within the column by Tukey's HSD test.

**Table 1:** ANOVA result of different parameters of sesame (*S. indicum* L.) plant in synthetic and botanical pesticides treated plots in the field condition.

| Parameters | Sum of Squares | Mean Square | $F_{1,19}$ | Sig. |
|---|---|---|---|---|
| Plant height | 0.200 | 0.200 | 0.116 | 0.737 |
| Pod number | 25.088 | 25.088 | 0.212 | 0.651 |
| Pod affected | 1744.712 | 1744.712 | 845.670 | 0.0001 |
| Hairy caterpillars | 91.592 | 91.592 | 444.861 | 0.0001 |
| Regression | 4.938 | 1.235 | 302.461 | 0.0001 |

**Table 2:** Paired sample tests (correlations and t-test) of different parameters of sesame (*S. indicum* L.) plant in synthetic and botanical pesticides treated plots in the field condition.

| Paired Samples | Correlation (r) | Sig. | t ($df$=19) | Sig. (2-tailed) |
|---|---|---|---|---|
| Plant & Height | 0.080 | 0.737 | -141.271 | 0.000 |
| Plant & Pod | 0.108 | 0.651 | -53.916 | 0.000 |
| Plant & Pod affected | -0.990 | 0.000 | -4.493 | 0.000 |
| Plant & Pest | -0.980 | 0.000 | -3.275 | 0.004 |
| Height & Pod | 0.486 | 0.030 | -37.894 | 0.000 |
| Height & Pod affected | -0.003 | 0.991 | 14.704 | 0.000 |
| Height & Pest | 0.038 | 0.874 | 71.129 | 0.000 |
| Pod & Pod affected | -0.030 | 0.901 | 36.012 | 0.000 |
| Pod & Pest | -0.016 | 0.946 | 51.554 | 0.000 |
| Pod affected & Pest | 0.991 | 0.000 | 4.927 | 0.000 |

**Table 3:** Paired sample tests (t-test) of different parameters of sesame (*S. indicum* L.) plant in synthetic and botanical pesticides treated plots in the field condition.

| Paired Samples | Mean | SD | SE | t($df$=99) | Sig. (2-tailed) |
|---|---|---|---|---|---|
| Affected pod in synthetic and botanical pesticides treated plots | 18.538 | 7.413 | 0.741 | 25.009 | 0.0001 |
| Hairy caterpillars in synthetic and botanical pesticides treated plots | 4.158 | 2.230 | 0.223 | 18.649 | 0.0001 |
| Affected pods and hairy caterpillars in synthetic pesticide treated plots | 15.273 | 7.107 | 0.711 | 21.491 | 0.0001 |
| Affected pods and hairy caterpillars in botanical pesticide treated plots | 0.893 | 1.572 | 0.157 | 5.679 | 0.0001 |

**3.3. Infestation and seed production:** The efficacy of botanicals over the synthetic pesticides on sesame in term of hairy caterpillar infestation reduction and seed production increase were calculated in table 4. The hairy caterpillars infestation were significantly ($F_{1,18}$=444.861, $P$<0.0001) reduced (62.745 to 91.667%) in all the 10 plots treated with botanicals relative to the synthetic pesticides (Table 4). Seed damage reduction was also highly significantly differed ($F_{1,18}$=1637.068, $P$<0.0001) in botanical pesticide treated plots over the synthetic pesticides (Table 4). Ultimately the overall production of sesame seed in the respective plots were also significantly increased ($F_{1,18}$=21.145, $P$<0.0001) in botanical pesticide treated plots than the synthetic pesticide treated plots (Table 4). The seed production increased from 4.844 to 296.546 kg/hector in botanical pesticide treated plots over the synthetic pesticides (Table 4).

**Table 4:** Efficacy of botanicals over the synthetic pesticides on sesame (*S. indicum* L.) plants in hairy caterpillar infestation and seed production in the field.

| Plot | Hairy caterpillar infestation reduction (%) | Seed pod damage reduction (%) | Seed yield increase/plot | Yield increase/ha |
|---|---|---|---|---|
| 1 | 70.909 | 13.498 | 0.205 | 110.330 |
| 2 | 75.862 | 14.552 | 0.234 | 125.938 |
| 3 | 77.778 | 16.619 | 0.392 | 210.973 |
| 4 | 75.926 | 12.747 | 0.032 | 17.222 |
| 5 | 73.469 | 15.358 | 0.551 | 296.546 |
| 6 | 91.667 | 15.551 | 0.228 | 122.709 |
| 7 | 71.667 | 13.372 | 0.009 | 4.844 |
| 8 | 85.938 | 16.340 | 0.104 | 55.972 |
| 9 | 62.745 | 14.419 | 0.244 | 131.320 |
| 10 | 68.333 | 13.739 | 0.093 | 50.052 |
| Total | 754.294 | 146.194 | 2.092 | 1125.905 |
| $F_{1,19}$ | 444.861 | 1637.068 | 21.145 | 21.145 |
| $P$ | 0.0001 | 0.0001 | 0.0001 | 0.0001 |

## 4. Discussion

Approximately one third of the global food production is destroyed annually by insect pests. Today in this modern era of industrial as well as intensive agricultural practices by using chemical pesticides are a major cause of wide spread ecological imbalances. There is a growing global need for promoting environmentally sustainable agriculture practices by Integrated Pest Management (IPM) strategy. Now the holistic approach of crop protection is shifting to more ecologically sustainable Agro-Eco System Analysis (AESA) based IPM strategies. Majority of the currently using synthetic pesticides have biomagnifications potential with catastrophic effects on food chain [22, 33]. Research on pesticides of botanical origin are progressing in top gear globally as these are eco-friendly, non-pollutive, renewable, inexhaustible, indigenously available, easily approachable, readily biodegradable and relatively cost effective [16, 18, 19, 22, 34].

There are several reports about the natural pesticidal properties of different plants like, *Annona squamosa*, *Azadirachta indica*, *Croton tiglium*, *Argemone mexicana*, *Swietenia mahagoni, Argemone mexicana*, *Allium sativum*, *Melia azedarach* etc. against several insect pests like, *Spilarctia obliqua*, *Plutella xylostella*, *Spodoptera litura, Helicoverpa armigera*, *Earias vitella*, etc. including *S. obliqua* [14, 23-25, 27, 34-37]. Mahogany seed (*S. mahogany*) extract contains limonoid and saponin which acts as insecticide against *Spodoptera litura*, causing antifeedant activity, larval mortality and stop emergence [37, 38]. Karanja or Pongamia oil (*M. pinnata*) possesses toxic components such as karajin, karanjae and pongaglabrone, effective against insect pests of field and plantation crops [15, 39, 41]. Karanja oil also showed superiority over azadirachtin on 2nd instar larvae of *S. oblique* [31]. Neem oil at various concentrations was used for the management of *Nilaparvata lugens*, *Bemisia tabaci*, *Helicoverpa armigera*, *Maruca testulalis*, *Melanagromyza obtusa*, *Clavigralla gibbosa*, *Spodoptera litura*, *Callosobruchus chinensis*, *C. maculates* etc. [42, 43]. Among the different synthetic pesticides endosulfan can effectively control the larva of *S. oblique* [12]. Whereas, further study by Nair *et al.* [44] found that indoxacarb was highly toxic than endosulfan against the larva of *S. oblique* in laboratory condition.

In our study crude leaf extracts of the selected plants (mahogany and karanja) have highly adverse effects in neem oil suspension on the survival of *S. obliqua* larvae which might be due to the presence of different active secondary metabolites of the respective plants [15, 37, 38, 42, 43, 45]. The larvae had apparent adverse effect on their feeding and survival for longer duration due to the presence of feeding deterrent and toxic component in the mixture. Moreover, complex mixtures of different active constituents present in the new botanical insecticide may also be advantageous in terms of pest resistance as well as behavioral desensitization for sustainable management of different economic crops from their respective pests including sesame in the field. The results suggest the new botanical formulation (mahogany and karanja leaf extract in neem oil) is more potent than traditional synthetic pesticide against the neonates of *S. obliqua* in the field condition for better production of sesame. The formulation may also useful for control of other hairy caterpillars grow on different economic crops in our agroecosystem for ecofriendly and sustainable management of crops as well as pests.

## 5. Conclusion

The present study suggests that the new botanical formulation (mahogany and karanja leaf extract in neem oil) has tremendous potential for the management of *S. obliqua* in the field. The botanicals utilized for the study are easily available in nature. Further, it causes no deleterious effect on natural enemy complex coexists with pests in the sesame ecosystem which takes care of biological pest suppression. Ultimately, these pesticides may have greatest impact in future integrated pest management (IPM) programmes due to their safety to non-target organisms and benign to the environment. The result also demonstrates the potential of the new botanicals for further development into a multipotent botanical insecticide against different pest complex in IPM programmes considering its effectiveness and sustainability.

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