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ORIGINAL RESEARCH ARTICLE

Efficacy of various botanical pesticides against leaf eating caterpillar (*Artona chorista* Jordan) on large cardamom (*Amomum subulatum* Roxb.) field of Sankhuwasabha District, Nepal

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ABSTRACT

Four treatments (Dadaguard Plus (0.05%), mugwort (Titepati) Oil (0.05%), azadiractin (Neem) Oil (0.25%), and tobacco extract (1%) of different botanicals and an absolute control) were evaluated in a field experiment against a lepidopteran pest, the leaf eating caterpillar infesting large cardamom, in a randomized complete block design (RCBD) with an area of 4.2× 3.88 m^2 in each experimental unit having 5 treatments with 4 replications at Khandbari, Sankhuwasabha, Nepal. Leaf-eating caterpillars cause a white papery thin epidermis-like structure at the primary stage and defoliation of the plant, leaving the midrib of the leaves, symptoms at the severe stage. Treatment-wise application of botanicals was done by using a high-volume knapsack sprayer, and the number of larvae per plant was counted at different time intervals, viz., 3, 5, and 7 days after spraying (DAS), to access the effectiveness of the treatments. The botanical pesticides caused significant differences in their effects against the leaf-eating caterpillar. Among the different botanicals, Dadaguard Plus (0.05 %) was found highly effective in managing the leaf-eating caterpillar in large cardamom, followed by neem oil (0.25%), tobacco extract (1%), titepati oil (0.05%), and untreated control, respectively. Dadaguard could be considered an effective botanical in the successful management of the pest leaf eating caterpillar due to its efficacy.

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INTRODUCTION

Large cardamom (*Amomum subulatum* Roxb.) is a tall, perennial, evergreen, herbaceous monocot crop of the Zingiberaceae family known as Alaichi in Nepali and also known as Black Gold (Black = color of capsule, Gold = indicates its high value), "Queen of Spices," and "Grain of Paradise" (Shrestha *et al.*, 2018; Shrestha, 2018; Kattel *et al.*, 2020; Kalauni *et al.*, 2019; Khatiwada *et al.*, 2019). It is a sciophyte i.e., the plant is grown under shade, and it prefers humid subtropical, semi-evergreen forests (Vijayan *et al.*, 2020). It grows well at altitudes ranging from 1000 to 2200 masl with well-distributed rainfall spread over 200 days and a total of about 3000-3500 mm/year. It is a low-volume, high-value cash crop, and its farming is the main source of income for farmers in the Himalayan region (Pradesh *et al.*, 2018). It is an important spice used for flavoring in cookery, confectionery, baked food industry, beverages, the manufacture of medicine, and cosmetics (Joseph *et al.*, 1983). It is a partially shade-loving, tall, perennial, evergreen, herbaceous monocot plant generally pollinated by bumblebees and grows

under the Uttis (*Alnus nepalensis*) tree in the eastern Himalayas of Nepal. Cardamom begins to bear fruit in the third year after planting, but an economically viable crop cannot be obtained until the fourth year (Joseph *et al.*, 1983). There are sixteen varieties of cardamom in the world. Among them, five types of large cardamom are used in farming practices across Nepal, namely, Ramsey, Golsey, Sawney, Chibesey, and Dammersey (Kattel *et al.*, 2020). According to MOAD 2015, Ramsai, Dammersai, Jirmale, Saune, Bharlang, Golsai, Ramla, and Chebese are commonly found varieties of large cardamom in the country. Nepal produces about 9545 Metric tons under the acreage of 18,748 hectare with a yield of about 0.58 Mt/ha (Karki *et al.*, 2020/21). According to MOAD 2020/21; the cultivation of large cardamom has grown to 54 districts in Nepal, among which Taplejung is the largest producer (total area: 4299 ha; productive area: 4255 ha; total production: 2958 mt) followed by Panchthar (total area: 3425 ha; productive area: 3225 ha; total production: 1178 mt), and Sankhuwasabha (total area: 2871 ha; productive area: 2350 ha; total production: 842 mt),; these districts contribute over 80% to national production (Karki *et al.*, 2020/21; Kattel *et al.*, 2020).

Cardamom farming is a monoculture practice so there are more chances to complete several life cycles by insects, pests, fungi, bacteria, viruses, and more severity of infestation (Yadav *et al.*, 2021). Twenty-three insect pests (leaf Eating caterpillar *(Artona chorista* Jordon), stem borer (*Glyphipterix* spp.), Shootfly (*Merochloropsdimorphus Cherian*), White grub *(Holotrichia sp.*), etc.) four fungal diseases (*Colletotrichum* blight, etc.) and two viral diseases are found associated with large cardamom *(Amomum subulatum* Roxb.) (Vijayan and Shadanaika, 2020). Among them, leaf eating caterpillar *(Artona chorista* Jordon) causes economic damage to the plant and crop loss due to its voraciously eating habit on leaves and leads to a decline in plant population (Vijayan and Shadanaika, 2020; Pun, 2018).

The primary issue in agriculture that harms many crop plants is pests and insects. A variety of techniques can be applied to safeguard the plant against these natural enemies. Although the use of chemical pesticides is acknowledged as the most popular approach but the health hazards and environmental impacts need to be taken into consideration (Puripattanavong *et al.*, 2013). Botanical pesticides are biodegradable, non-phytotoxic, maintain a sustainable economic advantage, and are friendly to the environment (Puripattanavong *et al.*, 2013; Campos *et al.*, 2016). Neem (*Azadiractca indica*) is a botanical pesticide, and its oil is extracted from the seeds of the neem tree, which is least toxic to human health, has low toxicity to beneficial organisms, has an antifeeding effect, has insecticidal, germicidal, antibacterial, anti-fungal, anti-nematicidal, and medicinal properties, increased larval mortality, suppresses fecundity, ovicidal, larvicidal activity and also acts as an insect growth regulator (IGR), sterilants, antioviposition agents, and repellents (Campos *et al.*, 2016; Lokanadhan *et al.*, 2012; Benelli *et al.*, 2017; Roshan *et al.*, 2015). In addition to this, neem oil is also used in cosmetic products for the preparation of facemasks, lotions, sunscreen, soaps, toothpastes, and the residue left after the oil extraction is known as "seed cake" which performs the dual function of both biofertilizers and pesticides (Campos *et al.*, 2016; Lokanadhan *et al.*, 2012). The interesting fact about neem pesticide is that they don't kill insects, but alter their life processes and they don't leave residue on the plants (Lokanadhan *et al.*, 2012). DADA guard plus is a biological based plant growth promoter and bio pesticides. The active ingredients of the product, GAs from seaweed extracts, will regulate plant growth, and other botanical extracts like clove oil, garlic oil, and neem oil will serve as an insect-pest repellent. Its composition is 30% gibberellin, 0.10% clove oil, 1% garlic oil, 2% neem oil, 1% Karanja oil, 1% garlic extract, and 64.90% as filler, spreader, emulsifier, etc (Gautam *et al.*, 2018). The biological product has been registered for use in Nepal by the Plant Quarantine and Pesticide Management Centre, Ministry of Agriculture and Livestock Development. Mugwort (*Artemisia vulgaris*) oil exhibits biological activities such as antiseptic, antioxidant, larvicidal, nematicidal, and pesticide, and has antioxidant, antimicrobial, antibacterial, antifungal, and antiviral properties. It can be also used as an analgesic, food flavoring agent, pharmaceutical ingredient, cosmetic product preparation, and has repellent and fumigant properties (Anwar *et al.*, 2016; Wang *et al.*, 2006). Tobacco (*Nicotiana tabacum*) leaf extract, called ecological or green pesticide, is environmentally friendly and has insecticidal and pesticidal properties (Puripattanavong *et al.*, 2013). The active compound of tobacco is terpenoids, which have a bitter and antifeedant taste that inhibits insect feeding activity, and acts as a stomach poison, affects the functions of nerves, and stimulates muscle contractions in insects, leading to paralysis and death (Haryuni *et al.*, 2019).

The efficacy of different botanicals in managing Leaf Eating Caterpillar, *A. chorista* in large cardamom is supported by this study. The production of large quantity of large cardamom can be significantly increased by reducing pest infestation. Damage has acquired resistance as a result of excessive and inappropriate pesticide use. So, it is pivotal to construe how compounds can generate pesticidal toxicity. Therefore, the appropriate use of botanicals facilitates healthy crops, an increase in yield, and the nurturing of a sustainable agro ecosystem ensuing effective management of leaf blight. By considering the economic importance of the crop, the present investigation was undertaken to evaluate botanicals (Neem oil, Titepati oil, Tobacco extract, and Dadaguard) to assess their efficacy against leaf eating caterpillar, *A. chorista.*

MATERIALS AND METHODS

Site selection

A field experiment was carried out at Pangma-4, khandbari, Sankhuwasabha district, the eastern part of temperate region of Nepal, to access the efficacy of botanical pesticides in the management of the major pest of Large Cardamom, the leaf-eating caterpillar. Geographically, Field was located at latitude of 27°24'41" N, a longitude of 87°11'14" E, and at 1190 m elevation.

Field preparation

First and foremost, light trap was installed on cardamom field to detect the presence of pest in the research field. Three plants were selected from each experimental unit and three leaves were selected from each plant. Each experimental units and selected plants in the experimental unit were tagged with aluminium sheet. Three leaves from each selected plant were tagged with the ribbon of different colors indicating first, second and third leaves, respectively.

Experimental design

The experiment was established in a Randomized complete block design (RCBD) with an area of 4.2 × 3.88 msq in each experimental unit having 5 treatments with 4 replicates. Different treatments were assigned to different experimental units in each replication by the lottery method.

Treatment details

Treatments used in field experiment were:
Neem Oil: 0.25%
Titepati oil: 0.05%
Dadaguard: 0.05%
Tobacco extract: 1%
Water/ Control

Visual inspections

The experimental block was visited on a daily basis. The regular inspections on presence of any symptoms of pest on plants were carried out thoroughly. Papery thin epidermis-like structure called as skeletonization was noticed on the leaves as well as defoliation of the plant leaving the midrib of the leaves. Within a short period of time the damage became massive, and it was recorded. This was the time when the decision for the confirmation of the pest was made.

Allocation and spraying of botanicals

Treatment wise application of pesticides was given by using a high-volume Knapsack sprayer with the required concentration. The subsequent spray was given at weekly intervals.

Data collection

The observation of lepidopteran pest i.e., leaf eating caterpillar were recorded from 3 randomly selected plants per treatment per replication before spraying and three, five and seven days after each spray. First and foremost, before spraying the field data was collected. Then, First spray was given and the first count of first spray was taken after two days of spray followed by one day interval for second and third count. After gap of one day of third count of first spray, Second spray was given and first count of second spray was taken after two days of spray followed by one day interval for second and third count and again the third spray was given after the third count of second spray and same action was repeated. The identification of the symptoms and the pest was done under the guidance of entomologist. The parameters taken during the experiment were counting the no. of larvae per plant.

Statistical analysis

Data collected from the research field were firstly recorded in the data sheet. The recorded data were entered in MS-Excel. The entered data were analyzed statistically by using Gene-stat, and a mean comparison was done following Duncan Multiple Range Test (DMRT) at 5% level of probability. The data on number of lepidopteran pests were subjected to square root transformation.

RESULTS AND DISCUSSION

The first spray results showed that Dadaguard (23.98) had the greatest effect against the leaf-eating caterpillar population on large cardamom, followed by Neem oil (25.56), Tobacco extract (34.66), Titepati oil (35.18), and untreated control (45.53). After the second spray, Dadaguard showed the highest reduction (14.75), followed by Neem oil (14.79), Tobacco extract (22.45), Titepati oil (22.88), and the highest population resulting from untreated control (29.34), respectively. Also, in the third spray, Dadaguard had the highest reduction (6.136), followed by Neem oil (6.354), Tobacco extract (9.017), and Titepati oil (9.535), while the untreated control had the highest population (11.816). The data on pooled over sprays and periods, significantly the lowest (14.96 larvae/plant) larval population of Leaf Eating caterpillar was noticed in the plot treated with Dadaguard 0.05 percent. Plot treated with Neem oil 0.25 percent registered 15.57 larvae/ plant and it was on par with the plot treated with Dadaguard. Dadaguard and Neem oil were significantly more effective than other remaining treatments. The plot treated with 1 percent Tobacco extract registered 22.04 larvae/ plant and it was less effective than the plot treated with Neem oil and Dadaguard. Among the evaluated botanical pesticides, the highest (22.53 larvae/plant) larval population of Leaf eating caterpillar was recorded in Titepati oil at 0.05 percent and it was on par with 1% tobacco extract. The highest population resulted from untreated control (28.90 larvae/ plant) larval population of leaf eating caterpillar.

The present findings are in accordance with (Lokanadhan *et al.*, 2012), who reported that Neem is a natural, environmentally friendly pesticide that is non-toxic to plants and soil, and also acts as a pest repellent, pest reproduction controller, pest feeding inhibitor. According to a study by (Choudhary *et al.*, 2017), neemicides are among the most effective pesticides. The neem product affects insect growth regulation, adult fertility and also possesses anti-feedent properties (Gahukar, 2000). Mugwort extract has insecticidal properties for controlling insects (Shekari *et al.*, 2008). Titepati (Mugwort) oil was less effective than other plant pesticides because of its low toxicity to non-targeted pests. Mugwort (*Artemisia* spp.) oil contains volatile compoundthat directly stimulates insects by forming an impermeable film on the cuticle causing suffocation and also by penetrating through the cuticle which affect the cellular membrane and oxidative phosphorylation (Ivănescu *et al.*, 2021).

Table 1. Efficacy of botanicals against cardamom leaf eating caterpillar, *A. chorista* in Sankhuwasabha district, Nepal.

Treatment	Conc. (%)	No of larvae per plant days after spray												
			First spray				Second spray				Third spray				
		Before	3	5	7	Pooled	3	5	7	Pooled	3	5	7	Pooled	Pooled over spray
Dadaguard	0.05	43.66 (6.634ab)	25.71 (5.111a)	26.54 (5.174a)	19.70 (4.486a)	23.98 (4.945a)	17.79 (4.255a)	15.47 (3.976a)	10.98 (3.363a)	14.75 (3.884a)	7.72 (2.830a)	5.915 (2.495a)	4.770 (2.272a)	6.136 (2.543a)	14.96 (3.922a)
Tobacco extract	1	56 (7.481ab)	38.61 (6.183bc)	37.04 (6.017ab)	28.33 (5.322ab)	34.66 (5.893b)	27.39 (5.159ab)	23.48 (4.822ab)	16.46 (4.074ab)	22.45 (4.710ab)	11.44 (3.420ab)	8.547 (2.980 ab)	7.060 (2.727ab)	9.017 (3.056ab)	22.04 (4.704b)
Neem oil	0.25	34.13 (5.839a)	29.48 (5.455ab)	26.41 (5.182a)	20.80 (4.601a)	25.56 (5.096a)	17.82 (4.264a)	15.61 (4.006a)	10.94 (3.358a)	14.79 (3.905a)	7.81 (2.857a)	6.133 (2.551a)	5.118 (2.349a)	6.354 (2.594a)	15.57 (4.007a)
Titepati oil	0.05	42.50 (6.459ab)	38.67 (6.218bc)	37.11 (6.080ab)	29.75 (5.373ab)	35.18 (5.945b)	28.71 (5.336ab)	23.80 (4.891b)	16.12 (4.041ab)	22.88 (4.787ab)	11.65 (3.431ab)	9.170 (3.075ab)	7.780 (2.841ab)	9.535 (3.125ab)	22.53 (4.768b)
Control	-	58.94 (7.600b)	48.42 (6.990c)	49.17 (7.035b)	39.01 (6.263b)	45.53 (6.774c)	37.47 (6.146b)	29.39 (5.456b)	21.15 (4.644b)	29.34 (5.451b)	14.97 (3.931b)	11.378 (3.443b)	9.098 (3.094b)	11.816 (3.506b)	28.90 (5.414c)
SEM		6.91	3.85	4.16	3.97	2.219	3.75	2.84	2.095	2.81	1.604	1.189	0.977	1.252	1.902
CV%		29.4	21.3	23.6	28.9	13.5	29	26.3	27.7	27	29.9	28.9	28.9	29.2	18.3
F-test		NS	S	S	S	S	S	S	S	S	S	S	S	S	S

Note 1. Inside are $\sqrt{(X+0.5)}$ transformed values.
2. S= Significant and NS= Non-significant
3. Collected data were analyzed statistically by using Gene-stat and mean comparison was done following Duncan Multiple Range Test (DMRT) at 5% level of probability.

Tobacco leaf extract contains active substances such as terpenoidsthat inhibit the insect feeding activity and contains bitter and nutritive terpenoids with insect repellent properties (Wulan *et al.*, 2014). Terpenoids kill insect pests by inhibiting the arrangement of calcium ions (Ca^{2+}) in insect muscles, stimulating muscle contraction in insects, and causing paralysis and death (Haryuni *et al.*, 2019).

Conclusion and suggestions

This study was conducted to find out the efficacy of botanicals against leaf eating caterpillar, *A. chorista*. Proper and timely application of botanical protects the crop from yield loss. The treatments used in our experiment are easily available in the market. Result of these studies show that Leaf eating caterpillar can be effectively controlled by the application of different botanicals. From an experiment, it is concluded that Dadaguard Plus 0.05% was the most effective ones among the tested botanicals and can significantly reduced the larval population of Leaf eating caterpillar. The effectiveness of other botanical pesticides used in the field experiment did not show better results although some of them showed a lower number of larval populations than non-treated control. Regular and indiscriminate use of chemicals in the field causes a slew of issues, including pest resistance, and resurgence of minor pests to major pest, health hazards, and environmental problems, among others. So, it is necessary to find the alternative to chemical pesticides. So, to minimize these problems, eco-friendly management i.e. use of botanicals should be practiced. Awareness program should be conducted for the farmers to know about the Cardamom pests. Disease and insect-pest susceptible varieties should be discouraged for cultivation. Government and concerned authorities should be provided with subsidies for resistant source. Farmers should be provided with good farming skills, knowledge and training program regarding symptoms and management strategies of specific pest. The results of this study will aid in the management of *A. chorista*, the leaf-eating caterpillar of large cardamom. Also, researchers and students will be benefitted from this research. For the transdisciplinary study and development of large cardamom, it is necessary to create a distinct Spice Research Institute. The public and private sectors should involve farmers in research, technology development, and quality control. Research organizations like NARC should create high-yielding cultivars that are appropriate for Nepal's various biophysical domains. The development of methods for dealing with illness and pests is also necessary. It is important to undertake additional tests on infected plants using different botanicals, such as essential oils, to ascertain their effectiveness in real-world settings. For farmers, there should be a program of education.

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