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The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2023; 12(4): 951-954

www.thepharmajournal.com
Received: 25-01-2023
Accepted: 28-02-2023

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Efficacy of eco-friendly pesticides against lepidopteran pests of aonla in North Gujarat condition

GK Rudani, Sushma Deb, Gita Jadav and PS Patel

Abstract
The Efficacy of botanicals was evaluated during 2021 at the Horticultural instructional farm, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar, Gujarat against leaf rolling caterpillar (*Gracillaria acidula*) and gall forming black caterpillar (*Betousa stylophora*) of aonla. Among various eco-friendly pesticides, azadirachtin 10,000 ppm 0.002 percent was the most effective treatment as it recorded lowest infestation of lepidopteran pests *viz*., gall forming black caterpillar (4.80 galls/ 25 twigs) and leaf rolling caterpillar (5.00% leaflet damage) and also recorded with highest fruit yield (73.41 q/ha) and protection cost-benefit ratio (1:11.18).

Keywords: Aonla, eco-friendly, lepidopteran pests, azadirachtin

Introduction
An essential crop for India's horticulture is the Indian Gooseberry, also known as Aonla or *Emblica officinalis*. It is a deciduous tree of average height. In tanning and dyeing, fruit, bark, and leaves are employed. It is one of the richest natural sources of vitamin "C," which has sparked a lot of curiosity among scientists (Ascorbic acid). The fruits are an important component of both "Trifla" and "Chyavanprash." Fruits can also be used to make pickles, marmalade, jam, and sauces (Shrivastava, 1990) [8]. Despite being regarded as a hardy fruit crop, not less than 30 insect and mite species from various locations, especially from India, have been found to feed on this scared tree (Lakra, 1996) [4]. Production of aonla fruit is significantly hampered by worldwide physiological issues, disease, and insect-pests damage. Among the insect pests, the aonla shoot gall maker (*Betousa stylophora*), leaf rolling caterpillar (*Gacillaria acidula*), bark eating caterpillar (*Inderbela quardinatata*), fruit borer (*Dueodorix isocrates*), fruit moths (*Otheris fullonica*), aphid (*Cerciaphis emblica*) and mealy bug have been reported to be of major importance (Chadha, 2003) [2].
For crop protection, chemical insecticides are used as the frontline defence sources against insect pests in India. However, their indiscriminate and repeated use creates a number of consequences such as development of resistance, pest resurgence and environmental hazards including residue in soil, water and food chain. Unlike chemical pesticides, most of plants have more than one chemical compound, which possess the biological activity. These chemicals may exert a single biological effect or may have diverse biological effects. Thus, the chance of developing quick resistance to different phyto-chemicals are unlikely. Moreover, natural pesticides are less toxic to the environment, mammals and aquatic life as well as easily biodegradable in nature. In sustainable farming, biocides are often considered to be one of the most important components of Integrated Pest Management (IPM) programmes and have received much practical attention as substitutes to synthetic chemicals.

Material and Methods
To evaluate the effect of eco-friendly pesticides against lepidopteran pests, a field experiment was conducted in Completely Randomized Design (CRD) with three repetitions at Horticultural Instructional Farm, C. P. College of Agriculture, S. D. Agricultural University, Sardarkrushinagar on aonla variety NA 7 in the year 2021 with 6 m × 6 m spacing. For the purpose, six different eco-friendly pesticides were evaluated and the details of the treatment are given here under.

Treatments imposed
Seven treatments *viz.*, Neem seed kernel extract 5 percent, *Bacillus thuringiensis* 0.5 WP

(2×10^8 spores/gm), *Beauveria bassiana* 1.15 WP (1×10^9cfu/gm), Azadirachtin 10,000 ppm, *Lantana camara* leaf extract 10 percent, Custard apple leaf extract 10 percent and untreated control were imposed.

Preparation of botanical extract

For preparation of neem seed kernel extract, the required quantity of seed kernels was collected and crushed separately in an electrical grinder. The crushed kernels were mixed with required volume of water and kept overnight. The solution after filtration was utilized for further experimentation.

For preparation of leaf extract, the required quantity of leaves was collected and crushed separately in an electrical grinder. The crushed leaves were mixed with equal volume of water and kept overnight. The solution after filtration was utilized for further experimentation.

Methodology

All the eco-friendly pesticides were applied in the form of foliar spray with the help of a tractor-mounted sprayer. The first spray was applied at the appearance of pest and subsequent two sprays were given at 10 days intervals. One plant was considered as one repetition. Observations were recorded before the application of treatment and 3, 5 and 7 days after each application. Thus, the data obtained were statistically analyzed.

Observations to be recorded

Pests infestation

To record the observations on gall forming black caterpillars, twenty-five twig were randomly selected from four direction of tree. The total number of active galls were recorded from each selected twig. Leaf rolling caterpillar, *G. acidula* was recorded by counting the number of healthy and damaged leaflets from ten compound leaves in each selected tree. Obtained data were converted into percent damage.

Yield

Aonla fruit yield was recorded picking wise and converted in to hectare basis and subjected to statistical analysis.

Economics

In order to know the economics of different treatments evaluated against lepidopteran pests infesting aonla, Protection Cost Benefit Ratio (PCBR) was worked out for the purpose, total cost of insecticidal treatments per hectare was calculated for each treatment based on prevailing market price. The PCBR was calculated by dividing net gain with the cost of treatment.

Results And Discussion

Gall forming black caterpillar, *B. stylophora*

The results revealed that there was no significant difference among various treatments before first spray.

First spray

The data on pooled over periods after first spray clearly indicated that all the eco-friendly treatments were significantly different from untreated control (11.02 gall/ 25 twigs). However, azadirachtin 10,000 ppm 0.002 percent significantly the lowest number (5.30/25 twigs) of gall due to the infestation of gall forming black caterpillar and proved to be the best treatment. *B. bassiana* 1.15 WP 0.0046 percent recorded 6.89 galls per 25 twigs and stood as second most effective treatment and it was at par with *B. thuringiensis* 0.5 WP 0.0008 percent (7.22/25 twigs), neem seed kernel extract 5 percent (7.60/25 twigs), *L. camera* leaf extract 10 percent (7.92/ 25 twigs) and custard apple leaf extract 10 percent (8.02/ 25 twigs).

Second spray

The result on pooled over periods after second spray revealed that all the eco-friendly treatments were significantly different from untreated control. However, azadirachtin 10,000 ppm 0.002 percent significantly the lowest number (4.73/25 twigs) of gall due to the infestation of gall forming black caterpillar and proved to be the best treatment. *B. bassiana* 1.15 WP 0.0046 percent recorded 6.30 galls per 25 twigs and stood as second most effective treatment and it was at par with *B. thuringiensis* 0.5 WP 0.0008 percent (6.68/25 twigs), neem seed kernel extract 5 percent (6.92/25 twigs), *L. camera* leaf extract 10 percent (7.38/ 25 twigs) and custard apple leaf extract 10 percent (7.62/ 25 twigs). Moreover, all the treatments were significantly superior over untreated control which recorded significantly the highest (11.11/25 twigs) galls in aonla crop.

Third spray

After third spray, azadirachtin 10,000 ppm 0.002 percent was recorded the lowest number (4.37/25 twigs) of galls and proved to be most effective treatment against gall forming black caterpillar on aonla. However, *B. bassiana* 1.15 WP 0.0046 percent (6.42/25 twigs), *B. thuringiensis* 0.5 WP 0.0008 percent (6.46/25 twigs), neem seed kernel extract 5 percent (6.76/25 twigs), *L. camera* leaf extract 10 percent (6.95/ 25 twigs) and custard apple leaf extract 10 percent (7.32/ 25 twigs) were at par with each other and the highest number of galls was observed in the untreated control, which recorded 11.85 gall per 25 twigs.

Pooled over sprays

Looking to the data on pooled over sprays revealed that azadirachtin 10,000 ppm 0.002 percent proved to be the most effective treatment by recording the lowest (4.80/25 twigs) number of galls. However, the trees treated with custard apple leaf extract 10 percent recorded the highest number of galls (7.65/25 twigs) and found as least effective treatment and it was at par with *L. camera* leaf extract 10 percent (7.41/25 twigs), neem seed kernel extract 5 percent (7.09/25 twigs), *B. thuringiensis* 0.5 WP 0.0008 percent (6.78/25 twigs) and *B. bassiana* 1.15 WP 0.0046 percent (6.42/25 twigs). Whereas, the highest number of galls was observed in the untreated control trees, which recorded 11.32 galls per 25 twigs.

While shifting the literatures, review on evaluation of eco-friendly pesticides against aonla gall forming black caterpillar was found to be very scanty. However, present findings could not be discussed.

Leaf rolling caterpillar, *G. acidula*

The results revealed that there was no significant difference among various treatments before first spray.

First spray

The data on pooled over periods clearly indicated that all the eco-friendly treatments were significantly different from untreated control (11.27% leaflet damage). However,

azadirachtin 10,000 ppm 0.002 percent recorded comparatively lower (5.30%) leaflet damage and proved to be the most effective treatment against leaf rolling caterpillar in aonla and it was at par with *B. thuringiensis* 0.5 WP 0.0008 percent and *B. bassiana* 1.15 WP 0.0046 percent, which recorded 6.12 and 6.91 percent leaflet damage, respectively. The trees treated with Neem seed kernel extract 5 percent (7.09%) and *L. camera* leaf extract 10 percent (7.90%) were at par with each other and proved to be moderate effective treatment. Among the treatments, custard apple leaf extract 10 percent recorded higher percent leaflet damage (8.38%).

Second spray

Efficacy of various eco-friendly pesticides against leaf rolling caterpillar after second spray revealed that azadirachtin 10,000 ppm 0.002 percent to be most effective treatment by recording the lowest leaflet damage of *G. acidula* (4.98%) and it was at par with *B. thuringiensis* 0.5 WP 0.0008 percent (6.01%). The trees treated with *B. bassiana* 1.15 WP 0.0046 percent (6.97%) and neem seed kernel extract 5 percent (6.99%) were at par with each other. Treatment with custard apple leaf extract 10 percent recorded higher leaflet damage (8.14%) and it was at par with *L. camera* leaf extract 10 percent (7.70%). Moreover, all the treatments were significantly superior over untreated control which recorded significantly the highest (11.82%) leaflet damage in aonla crop.

Third spray

The data on leaflet damage percent due to leaf rolling caterpillar after third spray revealed that all the eco-friendly treatments significantly lowered the leaf roller damage and found superior in comparison to untreated control (12.26% leaflet damage). Among the treatments, azadirachtin 10,000 ppm 0.002 percent exhibited the lowest leaflet damage of *G. acidula* (4.73%) and it was at par with *B. thuringiensis* 0.5 WP 0.0008 percent (5.69%). *B. bassiana* 1.15 WP 0.0046 percent (6.68%) and neem seed kernel extract 5 percent (6.71%) were at par with each other and moderately effective against leaf roller in aonla. The highest (8.38%) leaflet damage by leaf roller was recorded in trees treated with custard apple leaf extract 10 percent and it was at par with *L. camera* leaf extract 10 percent (7.90%).

Pooled over sprays

Looking to the data on pooled over sprays, the lowest (5.00%) leaflet damage was recorded in the tress treated with azadirachtin 10,000 ppm 0.002 percent and it was at par with *B. thuringiensis* 0.5 WP 0.0008 percent (5.94%). The tress treated with *B. bassiana* 1.15 WP 0.0046 percent and neem seed kernel extract 5 percent recorded 6.85 and 6.93 percent leaflet damage, respectively and showed moderate efficacy against leaf rolling caterpillar on aonla. Custard apple leaf extract 10 percent recorded highest percent leaflet damage (8.12%) among the eco-friendly treatments and it was at par with *L. camara* leaf extract 10 percent (7.76 %). Moreover, all the treatments were significantly superior over untreated control which recorded significantly the highest (11.78%) leaflet damage in aonla crop.

Arshad *et al*. (2019) recorded that the highest mortality of Gracillariidae insect *Phyllocnistis citrella* was observed in the aqueous (61.17%) and alcoholic (58.3%) extracts of *A. indica* after 24 hours of exposure under laboratory conditions. Fitiwy *et al.* (2019) findings in both experimental sites showed that the neem seed extract had a significantly lower (30.70%) leafminer infestation levels compared to the untreated control (74.0%) in citrus. Rao *et al.* (2015) [6] revealed that Neem seed kernel extract (NSKE), Azadirachtin and *Bt* (0.005%) offered protection up to five to seventh day onwards, the fresh incidence of leaf miner was observed in all the treatments. In curative control of leaf miner by using products, *Bt* (0.005 and 0.0025%) resulted in 100 percent mortality of Gracillariidae insect *P. citrella* at 10 days. In the order of efficacy, the next best treatment Azadirachtin and NSKE which offered 79.97 and 78.39 percent larval mortality at five days after spraying in sweet orange. Perovic and Hrncic (2008) [9] evaluated the efficacy of some bioinsecticides for the control of citrus leaf miner. They were found highest efficacy (95.7%) of Azadirachtin in the control of *P. citrella* seven days after treatment.

Fruit yield

The efficacy of various eco-friendly treatments against lepidopteran pests was also reflected on fruit yield. Trees treated with different eco-friendly treatments yielded significantly higher fruit yield than untreated control (52.40 q/ha). The highest (73.41 q/ha) fruit yield of aonla was obtained from the trees treated with azadirachitin 10,000 ppm 0.002 percent and it was at par with *B. bassiana* 1.15 WP 0.0046 percent and *B. thuringiensis* 0.5 WP 0.0008 percent with fruit yield of 70.27 and 67.31 q/ha, respectively. Trees treated with Neem seed kernel extract 5 percent and *L. camara* leaf extract 10 percent were found to be mediocre with fruit yield 59.27 to 62.38 q/ha. From the evaluated treatments, the lowest (55.69 q/ha) yield was obtained from the trees treated with Custard apple leaf extract 10 percent.

Economics

Among various treatments, the highest Protection Cost Benefit ratio (PCBR) was calculated from the trees treated with azadirachtin 10000 ppm 0.002 percent (1:11.18) followed by *B. bassiana* 1.15 WP 0.0046 percent (1:10.91). Treatments *viz*., neem seed kernel extract 5 percent (1:7.09), *B. thuringiensis* 0.5 WP 0.0008 percent (1:6.43), *L. camara* 10 percent (1:4.61) and custard apple leaf extract 10 percent (1:1.69) recorded lower PCBR and found not much economical.

Table 1: Evaluation of eco-friendly pesticide in aonla during 2021

Tr. No.	Treatments	Gall forming black caterpillar (No. of galls/25 twig)				Leaf rolling caterpillar (Leaflet damage %)				Yield (q/ha)	PCBR
		1st Spray	2nd Spray	3rd Spray	Pooled*	1st Spray	2nd Spray	3rd Spray	Pooled**		
T_1	NSKE	2.85^{b} (7.60)	2.72^{b} (6.92)	2.70^{b} (6.76)	2.75^{b} (7.09)	15.44^{bc} (7.09)	15.33^{bc} (6.99)	15.01^{bc} (6.71)	15.26^{bc} (6.93)	62.38^{bc}	1:7.09
T_2	*Bacillus thuringiensis*	2.78^{b} (7.22)	2.68^{b} (6.68)	2.64^{b} (6.46)	2.70^{b} (6.78)	14.33^{ab} (6.12)	14.20^{ab} (6.01)	13.80^{ab} (5.69)	14.11^{ab} (5.94)	67.31^{ab}	1:6.43
T_3	*Beauveria bassiana*	2.72^{b} (6.89)	2.61^{b} (6.30)	2.57^{b} (6.08)	2.63^{b} (6.42)	15.24^{abc} (6.91)	15.30^{bc} (6.97)	14.98^{bc} (6.68)	15.17^{bc} (6.85)	70.27^{ab}	1:10.91
T_4	Azadirachtin 10,000 ppm	2.41^{a} (5.30)	2.29^{a} (4.73)	2.21^{a} (4.37)	2.30^{a} (4.80)	13.32^{a} (5.30)	12.89^{a} (4.98)	12.56^{a} (4.73)	12.92^{a} (5.00)	73.41^{a}	1:11.18
T_5	*L. camara* leaf extract	2.90^{b} (7.92)	2.81^{b} (7.38)	2.73^{b} (6.95)	2.81^{b} (7.41)	16.32^{bc} (7.90)	16.11^{bc} (7.70)	16.08^{c} (7.67)	16.17^{c} (7.76)	59.27^{cd}	1:4.61
T_6	Custard apple extract	2.92^{b} (8.02)	2.85^{b} (7.62)	2.80^{b} (7.32)	2.86^{b} (7.65)	16.82^{c} (8.38)	16.58^{c} (8.14)	16.27^{c} (7.85)	16.56^{c} (8.12)	55.69^{cd}	1:1.69
T_7	Untreated control	3.39^{c} (11.02)	3.41^{c} (11.11)	3.51^{c} (11.85)	3.44^{c} (11.32)	19.62^{d} (11.27)	20.10^{d} (11.82)	20.50^{d} (12.26)	20.07^{d} (11.78)	52.40^{d}	-
S Em ±	T	0.04	0.03	0.03	0.02	0.24	0.22	0.22	0.22	2.54	-
	S	0.05	0.05	0.05	0.04	0.36	0.33	0.33	0.34	-	
	T X S	0.09	0.09	0.09	0.08	0.63	0.58	0.58	0.60	-	
CD at 5 %		0.16	0.15	0.15	0.03	1.03	0.98	0.95	0.28	7.70	
CV%		5.77	5.64	5.72	5.18	6.82	6.50	6.41	6.73	6.98	

*Figures in parentheses are retransformed values of $\sqrt{x+0.5}$ transformation. ** Figures in parentheses are retransformed values of arc sine transformation.

Treatment means with the letter(s) in common are not significant by DNMRT at 5 percent level of significance

Conclusions

It can be concluded that among various eco-friendly pesticides, azadirachtin 10000 ppm 0.002 percent was the most effective treatments as it recorded lowest number of lepidopteran pests *viz*., gall forming black caterpillar (4.80 /25 twigs) and leaf rolling caterpillar (5.00%) leaflet damage which resulted in to highest fruit yield (73.41 q/ha) and PCBR (1:11.18) in aonla during 2021.

Acknowledgement

The authors are grateful to Professor and Head, Department of Entomology, S. D. Agricultural University, Sardarkrushinagar for providing all necessary facilities to conduct experiments.

Conflict of interest

The authors declare that they have no conflict of interest.

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