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C Muthiah
Department of Plant Protection, Horticultural College and Research Institute, Tamil Nadu Agricultural University, Periyakulam, Theni, Tamil Nadu, India

P Indiragandhi
Department of Plant Protection, Horticultural College and Research Institute, Tamil Nadu Agricultural University, Periyakulam, Theni, Tamil Nadu, India

Corresponding Author:
C Muthiah
Department of Plant Protection, Horticultural College and Research Institute, Tamil Nadu Agricultural University, Periyakulam, Theni, Tamil Nadu, India

Efficacy of bio rational insecticides against major pests of aonla under arid zone farming ecosystem

C Muthiah and P Indiragandhi

Abstract
Aonla (*Emblica officinalis*) the king of arid fruits termed as Indian gooseberry or nelli is well known for its medicinal and therapeutic value and its suitability for cultivation under arid zone condition. Despite its hardy nature, many insects pests are causing damage to this sacred crop. Field experiment was conducted to manage major insect pest *viz*., shoot gall maker, leaf roller and fruit borer with biorational insecticides. Dimethoate @ 2 ml / lit was found to be effective in reducing shoot gall maker damage. Dimethoate recorded minimum number of galls/branch (4.45 and 3.00) followed by azadirachtin1000 ppm (6.5 and 5.33) on 45 days after first and second spray respectively as against control which recorded 13.00 galls/branch and fruit yield of 24.45 t/ha with 94.04% yield increase over untreated control. Chlorpyriphos @ 2 ml/lit was found be an effective one in recording least leaf folder damage (6.47%).Botanical insecticides viz., neem oil 3% (7.24) and azadirachtin 1000 ppm (7.86) also recorded less damage on 10 days after application. The same trend was observed for reducing the incidence of fruit borer also. Hence, it could be inferred that dimethoate @ 2ml/lit for shoot gall maker and chlorpyriphos @ 2ml/lit may be recommended for leaf roller and fruit borer management respectively. However, the next best treatment botanical insecticide azadirachtin 1000 ppm @ 1 ml/lit may also be recommended for the effective management of all the three pests in anola ecosystem. So far, there was no report on the effect of botanicals on the insect pest of aonla.

Keywords: azadirachtin, Chakkaiya, dimethoate, fruit borer, leaf roller, shoot gall maker

Introduction
Aonla (*Emblica officinalis*) the king of arid fruits also known as Indian gooseberry or nelli is the most ancient and common fruit of India which ranks first in the world in area and production. Apart from India, it grows naturally in different parts of the world like Sri Lanka, Cuba, Puerto Rico, USA, Iran, Iraq, Pakistan, China, Malaysia, Bhutan, Thailand, Vietnam, Philippines, Trinidad, Panama and Japan (Meena *et al*., 2019) [4]. It is highly nutritious and one of the richest source of vitamin C. It has good antioxidant properties and can be preserved in many forms like preserve, chutney, candy, sauce, dried chips, tablets, jam, pickle as well as in Ayurvedic medicines like chyawanprash, tripala powder etc. which are preferred by the consumers rather than consuming aonla in raw form. The excellent nutritive and therapeutic values of fruit have great potentiality for processing into various quality products which can get position in national and international markets.

Being a hardy fruit, it can be grown even in an inferior or marginal land. Arid and semi-arid region are marked by abiotic limitations such as high temperature, high potential evapotranspiration, low erratic rainfall, low soil fertility, poor quality of ground water, *etc*., which lead to poor crop growth and yield. Apart from the abiotic precincts, the biotic factors like insect pests are also one of the restrictive factors for crop production in hot arid ecosystem. Though, considered to be a hardy fruit crop, not less than 30 insect and mite species have been recorded feeding on this sacred tree from different places, mostly from India (Sandeep and Kaur, 2015; Thanlass *et al.*, 2018) [5, 10]. Among the various insect pest Shoot gall maker, *Hypolamprus stylophora* (Swinhoe) (=*Betousa stylophora*), leaf folder *Gracillaria acidula* and fruit borer- *Deudorix Isocrates* (Fab.) (=*Virachola isocrates*) are the major one. Shoot gall maker is a specific pest of 'aonla' and it is not known to attack any other host so far (Haldhar *et al*., 2019) [2]. Small yellowish-white tiny larvae of leaf roller [*Gracillaria acidula* (Meyrick) (Gracillariidae: Lepidoptera)] initially mine the leaflets and grown up larvae roll the leaflets and feed on chlorophyll content by scrapping the rolled leaves. The damaged leaflets fall down and only midrib remained on the twig. Anar fruit borer, *Deudorix isocrates* Fabricius is a polyphagous one attacking various fruit crops including aonla.

Shankar *et al*., (2007) [6] highlighted the first record of *D. isocrates* s infesting aonla trees in Jammu region and causing considerable losses during fruiting periods. Considering the therapeutic and economic importance of aonla, managing insect pest is an imperative one. Hence, the present investigation on efficacy of bio rational insecticides against these three major pests of aonla was carried out.

Materials and Methods

Field experiment was conducted at RRS, Aruppukottai (9° 30' 37.8864" N; 78° 5' 44.8620" E) during April 2018 to find out economically effective and eco-friendly control measure for shoot gall maker of aonla. The trial was laid out using the aonla variety Chakkaiya with 7 treatments. Each treatment was replicated thrice in a randomize block design (RBD) with 5 x 4 m plot size. Treatments were imposed twice after the insect pest incidence noticed, using hand sprayer. The treatments are T_1 - Dimethoate 30 EC @ 2 ml/lit T_2 - Azardirachtin 1000 ppm-1ml/lit, T_3 - NSKE 5%, T_4 - Neem oil 3%, T_5 - pungam oil 3%, T_6 - *Metarzhizium arisopilae* $1x10^8$ spores/ml, T_7 - control. Observations were made on percent no. of galls/branch before treatment and after 15, 30, 45 days after imposing the treatment (DAT). For leaf folder damage (%) was taken as pre treatment count on 24 hrs before spray on the basis of number of folded leaflet per leaf and post count was recorded on 10^{th} day after imposing the treatments. For fruit borer, fruit damage (%) was recorded after imposing different treatments. Fruit yield per plot was recorded and converted for tonnes /ha and yield increase (%) over control also recorded.

Statistical analysis

The data were analysed by OPSTAT (Sheoran *et al*., 1998) [7]. Population data were square root transformed and the percentage infestation data were arcsine transformed.

Results and Discussion

Shoot gall maker *Hypolamprus stylophora* (Swinhoe) (=*Betousa stylophora*) For Shoot gall maker, *Betousa stylophora* of aonla, all the treatments were significantly superior over control on 30 and 45 days after first spray. However, dimethoate @ 2 ml / lit was significantly superior in recording minimum number of galls/branch (4.45 and 3.00) followed by azadirachtin1000 ppm (6.5 and 5.33) on 45 days after first and second spray respectively as against control which recorded 13.00 galls/branch. Dimethoate @ 2 ml/ lit recorded a fruit yield of 24.45 t/ha with 94.04% yield increase over untreated control, which recorded only 12.6 t/ha (table 01). Next to dimethoate, following treatments were recorded more yield in the order of azadirachtin 1000 ppm (22.99 t/ha), neem oil 3% (21.79 t/ha) and *M. anisopliae* (19.80 t/ha). This pest attack may result in stunted growth of the trees, affecting flowering and fruiting pattern (Halder *et al*., 2019) [2]. Among the different aonla varieties and germplasms screened against shoot gall maker, chakaiya recorded 34% damage (Thanlass *et al*., 2018 and Halder *et al*., 2019) [10, 2]. Results of the present study indicated that the damage level got reduced (4.45 - 7.0%) due to spraying of insecticides, botanicals and biocontrol agent as against 13% in untreated control (table 01). Hence managing this shoot gall maker by using dimethoate @ 2ml/lit or the botanical insecticides like azadirachtin or neem oil may be recommended.

Leaf folder C*aloptilia* (*Garcillaria) acidula* (Meyrick)

Small yellowish-white tiny larvae of leaf roller initially mined the leaflets and grown up larvae rolled the leaflets. It was found feeding on chlorophyll content by scrapping the rolled leaves. The damaged leaflets fall down and only midrib remained on the twig. In case of heavy incidence, leaves dry and drop leading to drying of twigs. Webbing of leaves may identify the infestation; they are withering and dropping.

For managing the leaf folder in aonla, chlorpyriphos spray @ 2 ml/lit was found be an effective one in recording least leaf folder damage (6.47%) which was also found as equally effective as neem oil 3% (7.24) and azadirachtin 1000 ppm (7.86) on 10 days after application. The next best performing treatment was NSKE 5% against leaf folder which recorded (8.26%) as against 26.62% damage in untreated control. Different forms of neem products showed their effectiveness against leaf folder indicates that the pest population reduction or reduction in damage (%) might be due to the highest biological activity, antifeedant property and developmental abnormalities in pest insect (Subramaniyan, 1990) [8].

Fruit borer- *Deudorix Isocrates* (Fab.) (=*Virachola isocrates*)

Its common names include pomegranate or anar butterfly found all over India and adjoining countries feeding on one or other host fruits. The larva of this pest bores the fruit and feeds on seeds, making this portion hollow from inside. Affected fruits are deformed at the point of entry of larvae. Frass have been seen exuding out of the borer hole. The entrance hole was spotted out by the presence of offensive smelling excreta which gets stuck around the hole on the fruit surface. The affected fruits are subject to bacterial and fungal infections leading to fruit rots. Such fruits weaken, rot and the fell down before maturation (Haldhar *et al.*, 2019) [2]

Earlier studies, it was reported that the damage caused by fruit borer ranged from 26.25 to 35% (Shankar *et al*., 2007) [6]. A single caterpillar damage several fruits, shifting from one fruit to another adjoining one during the course of its development. Usually only one larva feeds inside a single fruit. In case of severe infestation, the borer has been reported damaging about 40-70 per cent fruits of aonla during rainy season in some areas (Atwal 1976; Khan 2016) [1, 3]. In the present study, after imposing the different treatments showed that the level of damage reduced, which was ranged from 6.26 to 17.72% after first spray. Still more reduction (2.86 to 13%) in fruit borer damage was recorded on 21 day after II spray (Table 02). It was evident that chlorpyriphos @ 2 ml/lit was found to be an effective treatment against fruit borer and recorded minimum of 6.26% and 2.86% fruit damage as against 33.0% and 36.32% fruit damage in control, after first and second rounds of treatments respectively. The treatment azadirachtin 1000 ppm was next promising treatments, which recorded 10.20% fruit damage as against 33.0% in control on 21 DAT. In aonla ecosystem, release of an egg parasitoid, *T. chilonis* (2,50,000 eggs/ha) at an early stage of pest attack when egg lying takes place and repetition of four times at 10 days interval reduces fruit borer population (Suchithra Kumari *et al*., 2018) [9]. Hence, the use of botanical insecticide azadirachtin would suits for managing the fruit borer in aonla as the botanicals are not harmful to the biocontrol agents prevailing in the cropping ecosystem. Khan (2016) [3] reported the effect of chlorpyriphos along with field sanitation against fruit borer damage in other fruit crops. Hence, in aonla the tested chemicals and botanical may give expected reduction in fruit borer damage aonla production.

Table 1: Efficacy of different insecticide sprays as preventive measure for the control of shoot gall maker, *Betousa stylophora* of Aonla

Treatments	PTC Galls (no. /branch)	Galls (no./branch) after I spray			Galls (no./branch) after II spray		Yield (t/ha)	Yield increase over control (%)
		15 DAS	30 DAS	45 DAS	30 DAS	45 DAS		
T_1 -Dimethoate 30 EC@ 2 ml/lit	7.00	9.06 (3.51)	8.25 (3.37)	4.45 (2.60)	3.33 (1.81)	3.00 (1.73)	24.45	94.04
T_2 - Azardirachtin 1000 ppm@1ml/lit	8.00	9.00 (3.50)	11.25 (3.85)	6.50 (3.04)	6.00 (2.9)	5.33 (2.8)	22.99	82.46
T_3 -NSKE 5% @	8.75	11.75 (3.92)	11.75 (3.92)	8.50 (3.41)	7.66 (3.26)	8.66 (3.44)	16.99	34.84
T_4 - Neem oil 3% @	8.50	11.00 (3.81)	10.50 (3.74)	7.00 (3.14)	6.66 (3.08)	6.00 (2.94)	21.79	72.93
T_5 -Pungam oil 3% @	7.50	9.75 (3.62)	9.50 (3.58)	9.00 (3.5)	8.33 (3.38)	12.00 (3.96)	13.80	9.52
T_6 - *Metarhiium anisopliae* @1x10 ^{8}spores/ml	8.00	8.75 (3.45)	8.50 (3.41)	7.00 (3.14)	6.33 (3.01)	8.00 (3.32)	19.80	57.14
T_7 -Control	7.75	12.00 (3.96)	12.75 (4.07)	13.00 (3.61)	16.00 (4.5)	20.00 (4.97)	12.60	-
SE+/-	0.86	0.88	0.91	0.68	0.76	0.89	-	-
CD	NS	NS	2.82	2.14	1.96	2.02	-	-

PTC- Pre treatment count; Value are mean of three replications. Values in the paranthesis are square root transformed values for population.

Table 2: Efficacy of different insecticides for the control of leaf folder and fruit borer on Aonla

Treatments	Leaf folder damage (%)		Fruit borer damage (%)					
	PTC (leaf folds/leaf let) 24 hrs before spray	PST Mean of two sprays (10 DAT)	After I spray				After II Spray	
			PTC	7 DAS	14 DAS	21 DAS	14 DAS	21 DAS
T_1 -Chlorpyriphos @ 2 ml/lit	21.0	6.47 (2.54)	25.94	16.40 (43.89)	10.48 (18.89)	6.26 (14.49)	3.64 (10.99)	2.86 (9.72)
T_2 - Azardirachtin 1000 ppm@1ml/lit	18.00	7.86 (2.81)	26.75	25.26 (30.17)	17.25 (24.54	10.20 (18.62)	9.60 (18.07)	7.67 (16.06)
T_3 -NSKE 5% @	19.50	8.26 (2.86)	30.44	28.50 (32.27)	19.75 (26.38)	14.25 (28.17)	14.23 (22.06)	13.00 (21.18)
T_4 - Neem oil 3% @	19.00	7.24 (2.69)	27.65	18.60 (25.5)	14.26 (22.18)	12.28 (20.51)	11.29 (19.63)	8.65 (17.10)
T_5 -Pungam oil 3% @	20.00	12.26 (3.51)	25.66	28.05 (32.17)	20.42 (26.86)	18.68 (25.60)	15.72 (23.36)	15.36 (23.10)
T_6 - *Metarhiium anisopilae* @1x10 ^{8}spores/ml	20.50	18.82 (4.35)	26.66	26.42 (30.94)	20.56 26.96)	17.72 (24.89)	17.10 (24.49)	14.67 (22.48)
T_7 -Control	21.00	26.62 (5.16)	31.00	34.42 (35.93)	33.62 (35.45)	33.0 (35.06)	34.22 (35.83)	36.32 (36.42)
SE+/-	NS	1.62	2.80	1.88	1.72	1.32	0.49	1.16
CD	NS	3.84	5.86	4.26	4.29	3.36	1.07	2.54

PTC- Pretreatment count; PST- Post treatment count. Values are mean of three replications. Values in the paranthesis are arc sine transformed values for damage (%).

Conclusion

It could be observed that the chemical insecticide dimethoate @ 2ml/lit and Chlorpyriphos @2 ml/lit found to be effective against shoot gall maker; leaf roller and fruit borer. However, next best performing insecticides originated from neem *viz*., azadirachtin 1000 ppm @ 1 ml/lit or other forms like neem oil/NSKE 5% may be recommended for aonla ecosystem by considering the eco-friendly mode of action. This may be imposed individually or a component of management module for managing the three major insect pest in anola ecosystem.

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