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Evaluation of Botanical Soaps for the Management of Pigeonpea Insect Pests

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Abstract

A two year consecutive trial was conducted during *kharif* 2014-15 and *kharif* 2015-16 to evaluate neem and pungam soaps @ 10 g l^{-1} in alone and in combination with indoxacarb (0.5 ml l^{-1}). First spray was given during flowering and second spray was given after fifteen days of the first spray. In both the field trials, neem soap followed by indoxacarb was effective against pigeonpea pod damaging insects followed by pungam soap and indoxacarb. During *kharif* 2014-15, two sprays of neem soap was on par in efficacy with pungam soap followed by indoxacarb against *H. armigera* and *M. vitrata*. When the damage of the pod damaging insects in botanical sprays alone treatments and untreated control was compared, these treatments were effective and good control was achieved. During *kharif* 2015-16, two sprays of neem soap was on par with NSKE followed by indoxacarb and pungam soap followed by indoxacarb in reducing the damage of *H. armigera*. In case of *M. vitrata*, two sprays of neem soap and two sprays of NSKE recorded 50.4 and 44.9% reduction over control and were on par with NSKE followed by indoxacarb in effectiveness. Against plume moth, two sprays of neem soap (4.3% damage) and two sprays of NSKE (5% damage) were on par with pungam soap followed by indoxacarb (4.7% damage).

Keywords: Indoxacarb, Neem soap, Pod damaging insects, Pungam soap

Introduction

In India, pigeonpea is one of the most important pulse crops particularly under rainfed conditions in many parts of India. As it is a hardy crop and requires low inputs, small and marginal farmers naturally choose pigeonpea cultivation under rainfed situations. Globally, India ranks first in production and area under pigeonpea cultivation. In the country, the crop is extensively grown in Maharashtra, Karnataka, Madhya Pradesh, Andhra Pradesh, Uttar Pradesh and Gujarat. Maharashtra has a unique distinction of contributing about 29.68% production in the country followed by Karnataka and Madhya Pradesh (Tiwari and Shivhare, 2016). After chickpea, pigeonpea is the most widely grown legume in India and is mainly grown in Tamil Nadu, West Bengal, Assam, Maharashtra, Uttar Pradesh, Bihar, Karnataka and Rajasthan.

Pigeonpea can thrive under various climatic conditions and soils. It is having the innate ability to withstand several abiotic stresses. It improves soil fertility by fixing the atmospheric nitrogen besides providing nutritive food, fodder and fuel wood. Hence, it is a preferable crop among the dry land farmers. However, biotic constraints *i.e.,* insect pests are the major reason for the low yields in pigeonpea. Pigeonpea is succumbed to various insect pests particularly from the initiation of flowering. They include pod borer complex (gram pod borer, *Helicoverpa armigera,* spotted pod borer, *Maruca vitrata,* plume moth, *Exelastis atomosa* and blue butterfly, *Lampides boeticus*), pod fly, *Melanagromyza obtuse*, pod bug complex (*Riptortus pedestris, Clavigrella gibbosa* and *Nezara viridula*) and pod wasp, (*Tanaostigmodes cajaninae*).

Among the borer complex, spotted pod borer, *M. vitrata* is considered to be noxious and unmanageable because its larvae feed by remaining inside the flowers, webbed mass of flowers and pods. This concealed feeding complicates the management of this pest as pesticides and natural

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enemies have difficulty in penetrating the shelter to reach the larvae (Sharma, 1998). *H. armigera* is considered to be the key insect pest because their larvae prefers to feed on the nitrogen rich plant parts *i.e.,* reproductive structures (flowers) and growing tips. Pod fly, *Melanagromyza obtusa* infested pods shows no external evidence of damage until the fully grown larvae makes window like holes on the pod wall for the exit of the adult fly. This concealed mode of life within the pod makes it difficult to manage (Subharani and Singh, 2010). The nymphs and adults of pod bug complex (*Riptortus pedestris, Clavigrella gibbosa* and *Nezara viridula*) suck sap from leaves, flowers and tender shoots, but pods are most preferred. Damaged seeds are dark, shrivelled, do not germinate and are not acceptable as human food. On an average it causes 25.20% pod and 28.38% grain damage (Veda, 1993).

To manage these insect pests, farmers mainly rely on repeated application of synthetic insecticides. It is a well known fact that the extensive usage of these chemical insecticides in insect management programmes resulted in environmental disturbances, detrimental effects on non target organisms, pest resurgence, pest resistance, insecticide residues *etc*. When we probe through the alternate insect management measures of pest control that minimizes the complications in insect pest management in long run, insecticides of botanical origin are the best, effective and important alternatives. Hence, an attempt was made for exploring the use of botanical soaps (neem and pungam soaps) in the management of pigeonpea insect pests.

Materials and Methods

This two season trial was conducted consecutively during *kharif* 2014-15 and *kharif* 2015-16 at National Pulses Research Centre, Vamban. The trial was laid out with the pigeonpea variety VBN 3 in a completely randomized block design with seven treatments and three replications. The treatments included two sprays of neem soap (10 g l^{-1}), two sprays of pungam soap (10 g l^{-1}), two sprays of NSKE (5%), first spray with neem soap (10 g l^{-1}) and second spray with indoxacarb (0.5 ml l^{-1}), first spray with pungam soap (10 g l^{-1}) and second spray with indoxacarb (0.5 ml l^{-1}), first spray with NSKE (5%) and second spray with indoxacarb (0.5 ml l^{-1}) and untreated control.

First spray was given at full flowering stage when the population of pod borer complex was appeared in the field. Second spray was given after fifteen days of the first spray. Before the first spray, pretreatment count was taken on total number of pod borers in all the replications and expressed as mean population per 5 rachis (redgram inflorescence of 30 cm length). After each spray, observations were recorded on number of pod borers per 5 rachis at seven and fourteen days in all the treatments and replications.

At harvest, matured pods were collected from each treatment and percentage damage was recorded individually for each pod borer. For assessing the *H. armigera* and *M. vitrata* damage, pods with large and round holes and pods with small holes at the base of the pod were counted respectively. For assessing the plume moth and blue butterfly damage, pods with small holes in the middle portion of the pods and pods with irregular holes at the base of the pod were counted respectively. Pigeonpea pod fly seed damage was assessed. For assessing the pod bug complex damage, shriveled pods with shriveled seeds were counted. For assessing the pod wasp damage, single seeded pods were counted.

Results and Discussion

Field Observations (Kharif 2014-15)

Before spraying, pre-treatment count of pod borers ranged from 13.3 to 15.7 per 5 rachis. During the first spraying, all the treatments received botanical sprays (neem soap, pungam soap and NSKE) only. After seven days of first spraying, pod borer population was less (3.7 to 4.0 per 5 rachis) in the treatments received neem soap (10 g l^{-1}) sprays. Remaining treatments which received pungam soap (10 g l^{-1}) and NSKE (5%) sprays recorded the pod borer population of 6.7 to 8.0 per 5 rachis while in untreated control it was 15 per 5 rachis. At 14 days after first spraying, neem soap (10 g l^{-1}) sprayed plots recorded the pod borer population of 4.0 to 5.7 per 5 rachis. In rest of the treatments, 7.0 to 8.7 pod borers were recorded and in the untreated control, 14.3 pod borers per 5 rachis were noted.

At seven days after second spraying, neem soap (10 g l^{-1}) followed by indoxacarb 15.8 EC (0.5 ml l^{-1}) spray recorded less pod borer population (1.0 per 5 rachis) and was on par with NSKE (5%) followed by indoxacarb 15.8 EC (0.5 ml l^{-1}) which recorded 1.7 pod borers per 5 rachis. After 14 days of first spraying, neem soap (10 ml l^{-1}) followed by indoxacarb 15.8 EC (0.5 ml l^{-1}) and NSKE (5%) followed by indoxacarb 15.8 EC (0.5 ml l^{-1}) were found to be equally on par in efficacy by recording 1.0 pod borer per 5 rachis while it was 13.0 in untreated control (Table 1). Pungam soap (10 g l^{-1}) followed by indoxacarb 15.8 EC (0.5 ml l^{-1}) was ranked to be the next best (2 per 5 rachis). Among the treatments, when overall percentage reduction over control was taken in to consideration, neem soap (10 g l^{-1}) followed by indoxacarb 15.8 EC (0.5 ml l^{-1}) was effective in reducing the population of pod borers (82.3% reduction) followed by two sprays of neem soap (10 g l^{-1}) (70.2% reduction). Jackai *et al.* (1992) reported the efficacy of neem seed powder and neem seed kernel extract (NSKE) in the management of spotted pod borer, *Maruca vitrata*.

Post Harvest Observations (Kharif 2014-15)

Observations at harvest revealed that the gram pod borer, *H. armigera* pod damage was less (2.7%) in the plots sprayed with neem soap followed by indoxacarb. NSKE followed by indoxacarb was the next best with 4.7% pod damage and pungam soap followed by indoxacarb treatment was on par with this treatment (5.0%). In untreated control, 14.3% gram pod borer damage was noted. Less damage (3.7%) (Table 3) of spotted pod borer, *M. vitrata* was recorded in the plots sprayed with neem soap followed by indoxacarb and this was on par with the treatment, NSKE followed by

Table 1: Efficacy of botanical soaps against pod borers of pigeonpea (field observations: 2014-15)

Sl. No.	Treatment	No. of pod borers per 5 rachis								
		Pre-treatment count	I spraying			II spraying			Overall Mean	% reduction over control
			7 DAS	14 DAS	Mean	7 DAS	14 DAS	Mean		
1	Neem soap (10 g l^{-1}) - 2 sprays	14.7	4.0 (2.00)^{a}	5.7 (2.39)^{ab}	4.9	4.0 (2.00)^{cd}	3.0 (1.73)^{bc}	3.5	4.2	70.2
2	Pungam soap (10 g l^{-1}) - 2 sprays	13.7	7.7 (2.77)^{b}	8.7 (2.95)^{c}	8.2	6.3 (2.51)^{e}	4.7 (2.17)^{d}	5.5	6.9	51.1
3	NSKE (5%) - 2 sprays	15.0	6.7 (2.59)^{b}	8.0 (2.83)^{c}	7.4	5.7 (2.39)^{de}	4.3 (2.07)^{cd}	5.0	6.2	56.0
4	Neem soap (10 g l^{-1}) followed by Indoxacarb 15.8 EC (0.5 ml l^{-1})	14.0	3.7 (1.92)^{a}	4.0 (2.00)^{a}	3.9	1.0 (1.00)^{a}	1.0 (1.00)^{a}	1.0	2.5	82.3
5	Pungam soap (10 g l^{-1}) followed by Indoxacarb 15.8 EC (0.5 ml l^{-1})	13.3	8.0 (2.83)^{b}	7.0 (2.65)^{bc}	7.5	3.0 (1.73)^{bc}	2.0 (1.41)^{ab}	2.5	5.0	64.5
6	NSKE (5%) followed by Indoxacarb 15.8 EC (0.5 ml l^{-1})	15.7	7.3 (2.70)^{b}	7.7 (2.77)^{c}	7.5	1.7 (1.30)^{ab}	1.0 (1.00)^{a}	1.4	4.5	68.1
7	Untreated control	15.7	15.0 (3.87)^{c}	14.3 (3.78)^{d}	14.7	14.0 (3.74)^{f}	13.0 (3.61)^{e}	13.5	14.1	-
	CD (P < 0.05)	-	1.43	1.28	-	1.19	1.06	-	-	-

Figures in parenthesis are square root transformed values. Mean followed by the same letter in a column are not significantly by LSD.

indoxacarb (5.3%). In the plots received no sprays, 13% spotted pod borer damage was observed.

Plume moth damage was less in the treatment, NSKE followed by indoxacarb (2%). This was on par with the treatment, neem soap followed by indoxacarb which recorded 3% pod damage while in the unsprayed plots it was 11.7%. Blue butterfly pod damage ranged from 2.3 to 2.7% in the plots sprayed with botanicals in alternation with the insecticides. In efficacy, these were followed by the treatments in which only botanicals were sprayed (5.3 to 6.3%). In the control treatment, 9% pods were damaged by the blue butterfly. Similar trend was noticed with the pod bug damage. In the treatments which received botanical sprays in alternation with the indoxacarb, pod bug damage was comparatively less and ranged between 8.0 to 9.3%. In the treatments in which only botanicals were sprayed, pod bug damage was 12.3 to 14.3% and in the unsprayed plots it was 20.7%.

Pod fly damage was less (6.7%) (Table 4) in the plots sprayed with neem soap followed by indoxacarb, followed by NSKE, followed by indoxacarb (9.7%) and pungam soap, followed by indoxacarb (11%). In only botanicals sprayed plots, 17.3 to 18.7% pod fly damage was noted and in the untreated control, it was 20.7%. Pod wasp damage was comparatively less in the treatments in which botanicals were alternated with indoxacarb (8.7 to 9.3%) and all were on par with each other. In only botanicals sprayed plots pod wasp damage ranged between 11 and 13% and in unsprayed plots, 17% pods were attacked by pod wasp.

Field Observations (Kharif 2015-16)

Pre-treatment count of the pod borers before spraying, ranged between 20.7 and 23.3 per 5 rachis. Observations at seven days after first spraying revealed that, all the treatments received botanical sprays were on par with each other by recording 13.0 to 14.7 pod borers per 5 rachis while in untreated control, their population was 24 per 5 rachis. At 14 days after first spraying, NSKE (5%) spray recorded less number of pod borer population (13.3 per 5 rachis) while in untreated control, it was 24.7.

At seven days after second spraying, neem soap followed by indoxacarb and NSKE followed by indoxacarb recorded less number of pod borers *i.e.,* 5.7 and 6.3 per 5 rachis respectively and both were on par with each other. Pungam soap followed by indoxacarb stood next with 7.3 pod borers per 5 rachis. In unsprayed plots, 21 pod borers were recorded per 5 rachis. At 14 days after first spraying, neem soap followed by indoxacarb was found to be effective

Table 2: Efficacy of botanical soaps against pod borers of pigeonpea (field observations: 2015-16)

Sl. No.	Treatment	No. of pod borers per 5 rachis								
		Pre-treatment count	I spraying			II spraying			Overall Mean	% reduction over control
			7 DAS	14 DAS	Mean	7 DAS	14 DAS	Mean		
1	Neem soap (10 g l^{-1}) - 2 sprays	23.0	13.7 (3.70)^{a}	14.7 (3.83)^{ab}	14.2	8.7 (2.95)^{bc}	7.3 (2.70)^{c}	8.0	11.1	50.4
2	Pungam soap (10 g l^{-1}) - 2 sprays	22.3	14.3 (3.78)^{a}	15.0 (3.87)^{ab}	14.7	10.0 (3.16)^{c}	9.0 (3.00)^{d}	9.5	12.1	46.0
3	NSKE (5%) - 2 sprays	21.3	13.0 (3.61)^{a}	13.3 (3.65)^{a}	13.2	9.0 (3.00)^{bc}	7.7 (2.77)^{cd}	8.4	10.8	51.8
4	Neem soap (10 g l^{-1}) followed by Indoxacarb 15.8 EC (0.5 ml l^{-1})	22.0	13.0 (3.61)^{a}	14.0 (3.74)^{ab}	13.5	5.7 (2.39)^{a}	2.7 (1.64)^{a}	4.2	8.9	60.3
5	Pungam soap (10 g l^{-1}) followed by Indoxacarb 15.8 EC (0.5 ml l^{-1})	21.3	14.7 (3.83)^{a}	15.3 (3.91)^{b}	15.0	7.3 (2.70)^{ab}	4.3 (2.07)^{b}	5.8	10.4	53.6
6	NSKE (5%) followed by Indoxacarb 15.8 EC (0.5 ml l^{-1})	23.3	13.3 (3.65)^{a}	14.3 (3.78)^{ab}	13.8	6.3 (2.51)^{a}	3.7 (1.92)^{ab}	5.0	9.4	58.0
7	Untreated control	20.7	24.0 (4.90)^{b}	24.7 (4.97)^{c}	24.4	21.0 (4.58)^{d}	19.7 (4.44)^{e}	20.4	22.4	-
	CD (P < 0.05)	-	2.22	2.00	-	1.85	1.65	-	-	-

Figures in parenthesis are square root transformed values. Mean followed by the same letter in a column are not significantly by LSD.

with 2.7 pod borers per 5 rachis (Table 2) followed by NSKE followed by indoxacarb (3.7 per 5 rachis). Neem soap followed by indoxacarb recorded 60.3% reduction in pod borer population and was found to be the best and followed by NSKE followed by indoxacarb (58% reduction).

Post Harvest Observations (Kharif 2015-16)

At harvest, observations were recorded on the damage percentage of pod damaging insects individually in various treatments. Percentage pod damage due to *H. armigera* was less (2.3 to 3.3%) (Table 5) in the treatments which received both botanical and insecticide sprays and all those three treatments were on par with each other. In untreated control, *H. armigera* damage was 10.7%. Among the treatments, *M. vitrata* damage was less (3.0%) in the plots sprayed with neem soap followed by indoxacarb and closely followed by the treatment, pungam soap followed by indoxacarb which recorded 4.3% pod damage. In unsprayed plots, 12.7% spotted pod borer damage was noted.

The treatments, neem soap followed by indoxacarb and NSKE followed by indoxacarb recorded comparatively less plume moth damage of 2.3 and 3.0% respectively. Two sprays of neem soap recorded 4.3% plume moth damage and was on par with the treatment, NSKE followed by indoxacarb. Percentage plume moth pod damage was 9.0 in unsprayed treatment. With regard to the pod damage due to blue butterfly among the treatments, no much difference was observed and all were on par with each other. Among the treatments, damage percentage ranged from 2.0 to 3.3%. In untreated control, 4.7% pod damage was recorded and this was on par with the treatments that received two sprays of botanicals. When botanicals were used in alternation with the insecticides, those treatments were found to be better in reducing the blue butterfly damage and the difference is statistically significant.

Pod bug damage was comparatively less (10.3 to 11.7%) (Table 6) in the treatments which combined both the botanical and insecticidal sprays and all those three treatments were on par with each other. Next to these, treatments that included two sprays of botanicals were effective in reducing the pod bug damage and recorded 17.0 to 18.3% pod damage as against 23.7% in untreated control. Among the treatments, pod damage due to pod fly was less

Table 3: Efficacy of botanical soaps against pod borers of pigeonpea (post harvest observations: 2014-15)

Sl. No.	Treatment	*H. armigera*		*M. vitrata*		Plume moth		Blue butterfly	
		% damage at harvest	% reduction over control	% damage at harvest	% reduction over control	% damage at harvest	% reduction over control	% damage at harvest	% reduction over control
1	Neem soap (10 g l^{-1}) - 2 sprays	5.7 (13.81)^{bc}	60.14	7.7 (16.11)^{cd}	40.8	5.0 (12.92)^{c}	57.3	5.3 (13.31)^{b}	41.1
2	Pungam soap (10 g l^{-1}) - 2 sprays	6.3 (14.54)^{cd}	55.94	8.0 (16.43)^{cd}	38.5	5.3 (13.31)^{c}	54.7	6.3 (14.54)^{b}	30.0
3	NSKE (5%) - 2 sprays	7.3 (15.68)^{d}	48.95	9.3 (17.76)^{d}	28.5	5.3 (13.31)^{c}	54.7	5.3 (13.31)^{b}	41.1
4	Neem soap (10 g l^{-1}) followed by Indoxacarb 15.8 EC (0.5 ml l^{-1})	2.7 (9.46)^{a}	81.12	3.7 (11.09)^{a}	71.5	3.0 (9.97)^{ab}	74.4	2.7 (9.46)^{a}	70.0
5	Pungam soap (10 g l^{-1}) followed by Indoxacarb 15.8 EC (0.5 ml l^{-1})	5.0 (12.92)^{bc}	65.03	7.0 (15.34)^{bc}	46.2	4.0 (11.53)^{bc}	65.8	2.7 (9.46)^{a}	70.0
6	NSKE (5%) followed by Indoxacarb 15.8 EC (0.5 ml l^{-1})	4.7 (12.52)^{b}	67.13	5.3 (13.31)^{ab}	59.2	2.0 (8.13)^{a}	82.9	2.3 (8.72)^{a}	74.4
7	Untreated control	14.3 (22.22)^{e}	-	13.0 (21.13)^{e}	-	11.7 (20.00)^{d}	-	9.0 (17.46)^{c}	-
	CD (P < 0.05)	0.95	-	1.10	-	1.17	-	1.14	-

Figures in parenthesis are square root transformed values. Mean followed by the same letter in a column are not significantly by LSD.

in the treatments *i.e.,* neem soap followed by indoxacarb (17.3%) and NSKE followed by indoxacarb (18.0%) and both were on par with each other. Two sprays of neem soap treatment recorded 21.3% pod fly damage and it was on par with pungam soap followed by indoxacarb (19.7%). In unsprayed plots, pod fly damage was 26%.

In the treatments in which botanical sprays (neem soap, pungam soap and NSKE) were alternated with the indoxacarb spray, 4.0 to 5.0% pod wasp damage was recorded. This reduction in damage was significantly superior than the control in which 9.3% damage was observed. Treatment in which two sprays of neem soap (6.7%) was given was on par with the pungam soap followed by indoxacarb (5.0%).

In this two year trial, botanical soap sprays (neem soap, pungam soap and NSKE) followed by indoxacarb was found to be effective in reducing the damage of pigeonpea pod damaging insects when compared to botanical sprays alone. However the treatment, two sprays of neem soap was also found to be effective and was on par with any one of the botanical + insecticide treatments. During *kharif* 2014-15, two sprays of neem soap (60.14% reduction over control) was on par in efficacy with pungam soap followed by indoxacarb (65.03% reduction over control) in reducing the damage of *H. armigera*.

Similar trend was noticed with the another important pod borer, *M. vitrata.* In this case, two sprays of neem soap recorded 40.8% reduction over control and was on par with pungam soap followed by indoxacarb treatment which recorded 46.2% reduction of *M. vitrata* over control. With regard to the management of rest of the pod damaging insects *i.e.,* plume moth, blue butterfly, pod bug, pod fly and pod wasp, botanical soap sprays followed by indoxacarb spray were effective. However, when percentage damage of these insects in botanical sprays alone treatments and untreated control was compared, these treatments were effective and good control was achieved. The present findings are in agreement with Jackai and Oyediran (1991), who reported the efficacy of neem oil emulsifiable concentrate (NOEC) at a percentage of 5, 10 and 20 in inhibiting the activity of *M. vitrata*.

During *kharif* 2015-16, two sprays of neem soap was effective in reducing the damage of *H. armigera* and recorded 59.8% reduction over control. In efficacy, this was on par with the treatments *i.e.,* NSKE followed by indoxacarb and pungam

Table 4: Efficacy of botanical soaps against pod bug, pod fly and pod wasp of pigeonpea (post harvest observations: 2014-15)

Sl. No.	Treatment	Pod bug		Pod fly		Pod wasp	
		% damage at harvest	% reduction over control	% damage at harvest	% reduction over control	% damage at harvest	% reduction over control
1	Neem soap (10 g l^{-1}) - 2 sprays	12.3 (20.53)^{b}	40.6	17.3 (24.58)^{c}	16.4	13.0 (21.13)^{b}	23.5
2	Pungam soap (10 g l^{-1}) - 2 sprays	12.7 (20.88)^{b}	38.6	18.7 (25.62)^{c}	9.7	11.7 (20.00)^{b}	31.2
3	NSKE (5%) - 2 sprays	14.3 (22.22)^{b}	30.9	18.0 (25.10)^{c}	13.0	11.0 (19.37)^{b}	35.3
4	Neem soap (10 g l^{-1}) followed by Indoxacarb 15.8 EC (0.5 ml l^{-1})	8.0 (16.43)^{a}	61.4	6.7 (15.00)^{a}	67.6	9.0 (17.46)^{a}	47.1
5	Pungam soap (10 g l^{-1}) followed by Indoxacarb 15.8 EC (0.5 ml l^{-1})	9.3 (17.76)^{a}	55.1	11.0 (19.37)^{b}	46.9	8.7 (17.16)^{a}	48.8
6	NSKE (5%) followed by Indoxacarb 15.8 EC (0.5 ml l^{-1})	9.0 (17.46)^{a}	56.5	9.7 (18.15)^{b}	53.1	9.3 (17.76)^{a}	45.3
7	Untreated control	20.7 (27.06)	-	20.7 (27.06)^{d}	-	17.0 (24.35)^{c}	-
	CD (P < 0.05)	1.47	-	1.15	-	1.23	-

Figures in parenthesis are square root transformed values. Mean followed by the same letter in a column are not significantly by LSD.

Table 5: Efficacy of botanical soaps against pod borers of pigeonpea (post harvest observations: 2015-16)

Sl. No.	Treatment	*H. armigera*		*M. vitrata*		Plume moth		Blue butterfly	
		DH (%)	ROC (%)	DH (%)	ROC (%)	DH (%)	ROC (%)	DH (%)	ROC (%)
1	Neem soap (10 g l^{-1}) - 2 sprays	4.3 (11.97)^{bc}	59.8	6.3 (14.54)^{cd}	50.4	4.3 (11.97)^{bc}	52.2	3.3 (10.47)^{ab}	29.8
2	Pungam soap (10 g l^{-1}) - 2 sprays	6.3 (14.54)^{d}	41.1	7.7 (16.11)^{d}	39.4	6.3 (14.54)^{d}	30.0	3.3 (10.47)^{ab}	29.8
3	NSKE (5%) - 2 sprays	4.7 (12.52)^{c}	56.1	7.0 (15.34)^{cd}	44.9	5.0 (12.92)^{cd}	44.4	3.0 (9.97)^{ab}	36.2
4	Neem soap (10 g l^{-1}) followed by Indoxacarb 15.8 EC (0.5 ml l^{-1})	2.3 (8.72)^{a}	78.5	3.0 (9.97)^{a}	76.4	2.3 (8.72)^{a}	74.4	2.3 (8.72)^{a}	51.1
5	Pungam soap (10 g l^{-1}) followed by Indoxacarb 15.8 EC (0.5 ml l^{-1})	3.3 (10.47)^{abc}	69.2	4.3 (11.97)^{ab}	66.1	4.7 (12.52)^{bcd}	47.8	2.0 (8.13)^{a}	57.4
6	NSKE (5%) followed by Indoxacarb 15.8 EC (0.5 ml l^{-1})	3.0 (9.97)^{ab}	72.0	5.3 (13.31)^{bc}	58.3	3.0 (9.97)^{ab}	66.7	2.0 (8.13)^{a}	57.4
7	Untreated control	10.7 (19.09)^{e}	-	12.7 (20.88)^{e}	-	9.0 (17.46)^{e}	-	4.7 (12.52)^{b}	-
	CD (P < 0.05)	1.48		1.71		1.82		1.78	

DH: % damage at harvest; ROC: % reduction over control; Figures in parenthesis are square root transformed values. Mean followed by the same letter in a column are not significantly by LSD.

soap followed by indoxacarb. In case of *M. vitrata*, two sprays of neem soap and two sprays of NSKE recorded 50.4 and 44.9% reduction over control and was on par with NSKE followed by indoxacarb in effectiveness. In the management of plume moth, two sprays of neem soap (4.3% damage) and two sprays of NSKE (5.0% damage) were on par with pungam soap followed by indoxacarb (4.7% damage). With regard to blue butterfly, no significant difference was observed between the treatments but all of them are significantly superior than the untreated control.

When the pod borer population was present in the field, first spray of neem soap followed by second spray of indoxacarb effectively checked their population. In efficacy, next to this treatment, pungam soap followed by indoxacarb was effective. Reduction of pod borer population in these treatments further reduced the population build up of these insects in the field. This has reflected through the low damage of these insects in these particular treatments in the harvested pods. Bottenberg and Singh (1996) reported the efficacy of some neem based formulations *i.e.,* neem oil (3%), neem oil slurry emulsifiable concentrate (NOSEC) and 5% neem oil emulsifiable concentrate (NOEC) in exhibiting insecticidal activity against redgram pod borers. Mohapatra and Srivastava (2002) reported significant reduction of *M. vitrata* larval population on pigeonpea with the sprays of neem seed kernel extract (NSKE) @ 5%. Sambath *et al.* (2015) evaluated some botanicals against pod borers infesting redgram variety CO6. They have reported that *M. vitrata* webbings and population of *H. armigera* were less in neem soap (1 kg ha^{-1}) followed by indoxacarb (0.5 ml) treatment.

Among the botanicals alone treatments, two sprays of neem soap was found to be effective. This treatment was on par with the pungam soap followed by indoxacarb and NSKE followed by indoxacarb in the management of pod borers *i.e., H. armigera*, *M. vitrata* and plume moth. The present findings were in accordance with Pandey and Das (2016), who reported that neem soap @ 1 kg ha^{-1} (10 g l^{-1}) and pungam soap @ 1 kg ha^{-1} (10 g l^{-1}) were effective against gram pod borer (*Helicoverpa armigera* Hub.) on pigeon pea. The effectiveness of plant extracts of *Azadirachta indica* seeds in reducing the pod damage by *Maruca vitrata* on cowpea as much as 75.3-81.5% was reported by Ameh and Ogunwolu (2000). No consistent results were obtained in case of other pod damaging insects.

Conclusion

Two sprays of neem soap were on par with NSKE followed by indoxacarb and pungam soap followed by indoxacarb in reducing the damage of *H. armigera*. In case of *M. vitrata*, two sprays of neem soap and two sprays of NSKE recorded 50.4 and 44.9% reduction over control and were on par with NSKE followed by indoxacarb in effectiveness. Against plume moth, two sprays of neem soap (4.3% damage) and two sprays of NSKE (5% damage) were on par with pungam soap followed by indoxacarb (4.7% damage). Neem soap and Pungam soap can be used as alternatives for insecticides against pigeonpea pod damaging insects.

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