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Efficacy of botanical extracts against insect pest of pea (Makhyatmubi) of Manipur

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Abstract
The studies on "Efficacy of botanical extracts against insect pests of pea (Makhyatmubi) in Bishnupur District, Manipur" were carried out at the field of Pandit Deen Dayal Upadhyay Institutes of Agricultural Sciences, Utlou, Manipur to assess the effect of four indigenous plant extracts *viz.*, Neem, Marigold, Periwinkle and Wild sage of two different concentration (5 percent and 10 percent). A control and standard check (Thiamethoxam 25 WG) was also maintained. Three insect pest *viz.,* Aphid (*Acyrthosiphon pisum*), Leaf miner (*Chromatomyia horticola*) and Gram pod borer (*Helicoverpa armigera*) were found infesting the pea crop during the season. Among the botanical tested, Neem 10 percent was found to be the best effective treatment for managing all the insects. Neem 10 percent recorded as the best treatment recording overall mean Aphid population of 3.01 closely followed by Neem 5 percent (3.10). The least effective treatment was recorded in Periwinkle 5 percent with overall 3.59 mean populations. Likewise, in leaf miner and Gram pod borer Neem 10 percent proved to be the best botanical extract reporting 0.87 and 1.22 overall mean population closely followed by Neem 5 percent (0.93 and 1.27), Marigold 10 percent (1.04 and 1.30) and Marigold 5 percent (1.56 and 1.37) respectively. Highest seed yield was recorded in Neem 10 percent (427.73 kg/ha) closely followed by Neem 5 percent (424.96 kg/ha) while lowest was observed in treatment with Periwinkle 5 percent (333.30 kg/ha) closely followed by Periwinkle 10 percent (336.06 kg/ha) and Wild sage 5 percent (363.86 kg/ha). In the present investigation, Neem proved to be the best botanicals for managing the three concerned insect pest of Pea.

Keywords: Pea, botanicals, aphids, leaf miner, pod borer

Introduction
Pea (*Pisum sativum* Linnaeus) is an annual plant and belongs to the family Fabaceae. It is cool season crop mostly grown in all states of the country during *Rabi* season and because of its taste, nutritive value, fast growth and high yield, this crop is patronized throughout the world (Singh *et al*., 1970) [25]. India is one of the major pulse growing countries in the world producing about 22.40 million tonnes from an area of 29.30 million hectare (DES, 2016-17) [1]. India is the second largest producer of pea in the world and account for 21 percent of the world production. Uttar Pradesh is the major field pea growing state. It alone produces about 49 percent of pea produced in India. In Manipur, field pea is the major pulse crop grown in 26,000 hectare area occupying about 85 percent of the total pulses area (Anonymous, 2015) [3]. In Manipur, pea variety Makhyatmubi yields upto 15-20 tonnes per hectare (Bijaya *et al*., 2021) [5]. Insects like Pea pod borer *Etiella zinckenella* Treitschke, (Lepidoptera: Pyralidae); Pea leaf miner *Chromatomyia horticola* Blanchard, (Diptera: Agromyzidae); Aphids *Acyrthosiphon pisum* Harris, *(*Hemiptera: Aphididae); Pea stem fly *Ophiomyia phaseoli* Blanchard, (Diptera: Agromyzidae); Pod fly *Melanagromyza obtuse* Malloch, (Diptera: Agromyzidae) and Tobacco caterpillar *Spodoptera litura* Fabricius, (Lepidoptera: Noctuidae) are serious pests and causes substantial loss to the crop (Mittal and Ujagir, 2007) [19]. Aphids, *Acyrthosiphon pisum* Harris, (Hemiptera: Aphididae) heavy infestations on pea can cause stunting, deformation, wilting and even death of the plant. Aphids can also feed on pods, causing them to curl, shrink and only partially fill (Ali *et al*., 2005) [2]. Pea leaf miner, *Chromatomyia horticola* (Diptera: Agromyzidae) is one of the serious pest of pea causing 90 percent damage to the pea crop by mining young leaves leading to stunted growth of plants resulting in lower flowering and pod formation (Rizvi *et al*., 2015) [22]. Gram pod borer, *Helicoverpa armigera* Hubner, (Lepidoptera: Noctuidae) is polyphagous and one of the most devastating crop pest worldwide (Sigsgaard *et al*., 2002) [27]. It attacks a wide range of food,

fibre, oil and fodder crops as well as many horticultural and ornamental crops (Halder *et al*.,

2009) [15]. Botanical pesticides are biodegradable and their use in crop protection is a partical sustainable alternative (Devlin and Zettel, 1999) [8]. Many botanical products have been found to act as oviposition and feeding deterrents, ovicidal, larvicidal agents against diverse range of insect pests (Ahmad *et al*., 2015). Botanical pesticides are unique because it can be produced easily by farmers and small industries (Roy *et al.*, 2005) [23]. The use of such plant extracts to control pests is not a new innovation, as it has been widely used by small-scale subsistence farmers.

Materials and Method

The present experiment entitled ''Efficacy of botanical extracts against insect pest of local pea of Manipur'' was carried out at the field of Pandit Deen Dayal Upadhyay Institute of Agricultural sciences, Utlou, Manipur, during the *Rabi* season from November 2019 to March 2020. The field trial with Pea local cultivar Makhyatmubi in Randomized Block Design (RBD) consisting of ten treatments and three replications. The treatments were i.e. Neem (*Azadirachta indica*), Marigold (*Tagetes minuta*), Periwinkle (*Vinca rosea*), Wild sage (*Lantana camara*) and Thiamethoxam 25% WG (standard check) and water as a control. Each experiment consists of total 30 plots, 2m × 1.2m (2.4m²) per plot size and the total area covered 10m × 8m (80m²). Row to row and Plant to plant spacing was 30cm and 15cm respectively. All other management practices were done as per the agronomic recommendation.

Table 1: Details of the treatments

Treatment no.	Treatments name	Dose percent
T1	Neem (*Azadirachta indica* A. Juss.)	5
T2	Neem (*Azadirachta indica* A. Juss.)	10
T3	Marigold (*Tagetes minuta* L.)	5
T4	Marigold (*Tagetes minuta* L.)	10
T5	Periwinkle (*Vinca rosea* L.)	5
T6	Periwinkle (*Vinca rosea* L.)	10
T7	Wild sage (*Lantana camara* L.)	5
T8	Wild sage (Lantana camara L.)	10
T9	Thiamethoxam 25% WG (Standard check)	0.0025
T10	Control	-

Preparation of plant extracts

The plant materials used in this experiment were fresh leaves of Neem (*Azadirachta indica)*, Mexican marigold (*Tagetes minuta)*, Periwinkle (*Vinca rosea)* and Wild sage (*Lantana camara).* They were collected from local area near PDDUIAS campus. After collection of leaves they were washed with water and the plant parts were sun dried for 2-3 days. The dried plant materials were grounded to powder with the help of an electrical grinder. 5 gram of each plant powdered sample were mixed with 100ml of water and soaked overnight. After 24 hrs, the mixture was filtered through muslin cloth and the extract thus obtained was made up to the required spray volume of 5% and 10%. From the stock solution, 5ml and 10ml of this solution were taken and further diluted to desired concentration of 5 and 10%. Concentration of 5% and 10% were prepared with water for experimental evaluation. The extract was kept in a glass bottle/jar at room temperature until further used. To obtain different concentration of plant products, the following formula was applied

$$= \frac{\text{Concentration required (\%)} \times \text{Amount required (ml)}}{\text{Concentration technical material (EC)(ml)}} \times 100$$

Determination of amount of insecticides

The required amount of insecticides was calculated by using the formula as given below:

$$V = \frac{C \times A}{\%\ \text{a.i.}}$$

Where,
V = Volume of the insecticide.
C = Concentration required.
A = Amount of spray solution needed.
% a.i. = Percent of active ingredient of the insecticide.

Observation of aphids

The estimation of aphid population was based on the numerical count method adopted by (Dotasara *et al*., 2017) [9]. For recording the aphid population, leaves were grasped at the petiole by thumb and fore figure and twisted until entire underside of the leaves were clearly visible. The observation of aphid populations were recorded at 10 days intervals. The mean number of aphids was recorded by taking the aphid population (Both nymph and adult) per leaf present on each leaf (upper, middle, lower) from each of randomly 10 selected tagged plants per plot. Initially aphids appeared on the plot of pea in second week of December 2019 till the maturing stage of the crop. Count of aphid (nymph and adult) was recorded at 10, 20 Days after spraying. The percentage reduction of pest population over control is calculated by using following formula.

$$\text{Percentage population reduction} = \left(1 - \frac{Ta}{Ca} \times \frac{Cb}{Tb}\right) \times 100$$

Where,
Ta= Number of insects on treated plots after insecticidal application.
Tb = Number of insects on treated plots before insecticidal application.
Ca = Number of insects on untreated plot after insecticidal application.
Cb = Number of insects in untreated plot before insecticidal application.

Observation of pea leaf miner

Five plants per plot were randomly selected and tagged for observation. The observation on total number of leaves as well as number of infested leaves of selected plants were recorded from mid-December to flowering stage of crop. The observation on pea leaf miner population were recorded at 10 days interval. Percent damage caused by leaf miner were count and converted into percent damage by the following formula (Shakur, 2007) [24].

$$\text{Percent damage} = \frac{\text{No.of damage leaves}}{\text{Total number of leaves}} \times 100$$

Observation of Pod borer

Number of larvae were recorded from 10 randomly selected plants in each treatment through visual counting by opening leaves from health pea plants. Count of *H. armigera* larvae were recorded at 10, 20 days after spray. The population peaks generally corresponds to the full bloom and pod

formation stage of pea. The immature as well as the mature stages of insect pests present on them were counted at 10 days interval, starting from week of the month till the maturing crop. The damage due to *H. armigera* could be distinguished by the presence of large size holes on the pods. The grains were partially or wholly eaten by larvae. Data on infested pod for the individual treatments were also recorded using the following formula (Kumar *et al*., 2019) [16].

$$\text{Percent infested pod} = \frac{\text{Number of infested pods}}{\text{Total number of pods}} \times 100$$

Yield

Seed weight per plot was measured from the harvested seeds of pea and then converted into kilogram per hectare.

The grain yield was calculated by using the formula adopted by (FAO. 1995)

$$\text{Grain yield (kg/ha)} = \frac{\text{Plot yield (kg)} \times 10000}{\text{plot size sq.m.}}$$

The avoidable loss and increase in grain yield over untreated check was calculated for each treatment by using the following formula (Pawar *et al*., 1984) [21]

$$\text{Increase in yield (\%)} = \frac{\text{Yield in treatment} - \text{Yield in control}}{\text{Yield in control}} \times 100$$

$$\text{Avoidable losses (\%)} = \frac{\text{Highest yield in treated plot} - \text{Yield in treatment}}{\text{Highest yield in treated plot}} \times 100$$

Results

Occurrence of insect pests in field of pea (Makhyatmubi)

The occurrence of insect pests in the present study were recorded by observing the incidence of the respective insect pests and their nature of damage. Significant population of insect pest's *viz.*, Aphid, Pea leaf miner and Gram pod borer etc. were recorded (Table 1).

Table 1: List of Insect pests of pea found in the field during the study period

Sl. No.	Name of insect pests	Order & Family	Stage(s) of insects	Site of infestation	Status
1.	Aphid *Acyrthosiphon pisum* (Harris)	Aphididae (Hemiptera)	Adult and nymph	Sap sucker on leaves, shoot	Major
2.	Pea leaf miner *Chromatomyia horticola* (Goreau)	Agromyzidae (Diptera)	Larvae	Leaves	Minor
3.	Gram pod borer *Helicoverpa armigera* (Hubner)	Noctuidae (Lepidoptera)	Larvae	Pods	Stray

Effect of different botanicals extracts on Aphids (*A. pisum*) on pea during *Rabi* season 2019-2020

Vegetative stage

Among the botanicals tested, at 7 DAS, the most effective treatment was Neem 10 percent closely followed by Neem 5 percent, Marigold 10 percent, Marigold 5 percent. Neem 10 percent and Neem 5 percent were at par to each other recording mean aphid population of 4.23 and 4.24 respectively. At this stage, least effective treatment was found in Periwinkle 5 percent (4.83). Thiamethoxam 25 WG was found to be significantly superior over all the botanical treatments with aphid population of 4.20.

Flowering stage

At the flowering stage Neem 10 percent and 5 percent were at par (2.96 and 2.98 respectively) in reducing aphid population followed by marigold 10 percent and 5 percent at 7 DAS. Periwinkle 10 percent and Wild sage 10 percent were at par registering mean aphid population of 3.26 and 3.26 respectively. Periwinkle 5 percent and Wild sage 5 percent treatment registered highest mean aphid population of 3.50 and 3.31 respectively.

Pod formation stage

Similar trend was observed at 7 DAS, Neem 10 percent and 5 percent were highly significant registering 1.41 and 1.52 aphid population followed by Marigold 10 percent and 5 percent, Wild sage 10 percent and 5 percent. Periwinkle 10 percent and Periwinkle 5 percent registered highest mean aphid population of 2.10 and 2.10 respectively. Thiamethoxam 25 WG was found to be significantly superior over all the botanical treatments.

Table 2: Effect of different botanical extracts on Aphids in pea during *rabi* season 2019-2020

Sl. No.	Treatments	Vegetative Stage		Flowering Stage		Pod formation		Overall mean
		3 DAS	7 DAS	3 DAS	7 DAS	3 DAS	7 DAS	
1.	Neem 5%	4.67 (2.16)	4.24 (2.05)	3.20 (1.78)	2.98 (1.72)	2.00 (1.41)	1.52 (1.44)	3.10
2.	Neem 10%	4.62 (2.15)	4.23 (2.05)	2.98 (1.72)	2.96 (1.71)	1.90 (1.37)	1.41 (1.18)	3.01
3.	Marigold 5%	4.68 (2.16)	4.46 (2.11)	3.24 (1.80)	3.18 (1.77)	2.11 (1.45)	1.60 (1.26)	3.21
4.	Marigold 10%	4.68 (2.16)	4.38 (2.09)	3.21 (1.79)	3.06 (1.74)	2.10 (1.43)	1.53 (1.23)	3.16
5.	Periwinkle 5%	5.07 (2.25)	4.83 (2.19)	3.45 (1.85)	3.50 (1.87)	2.60 (1.60)	2.10 (1.44)	3.59
6.	Periwinkle 10%	5.05 (2.24)	4.68 (2.16)	3.36 (1.83)	3.26 (1.80)	2.53 (1.59)	2.10 (1.44)	3.49
7.	Wild sage 5%	4.73 (2.17)	4.63 (2.15)	3.40 (1.84)	3.31 (1.81)	2.50 (1.58)	1.83 (1.35)	3.40
8.	Wild sage 10%	4.71 (2.17)	4.56 (2.13)	3.36 (1.82)	3.26 (1.80)	2.23 (1.49)	1.76 (1.32)	3.31
9.	Thiamethoxam 25 WG	4.08 (2.02)	4.20 (2.04)	2.56 (1.59)	2.33 (1.52)	1.62 (1.26)	1.36 (1.16)	2.69
10.	Control	5.43 (2.33)	5.10 (2.25)	6.66 (2.58)	6.83 (2.61)	6.93 (1.63)	6.96 (2.63)	6.31
	SEm±	0.04	0.03	0.03	0.06	0.06	0.06	0.25
	C.D. (0.5)	0.13	0.11	0.11	0.20	0.18	0.19	0.74
	C.V. (%)	3.49	2.97	3.35	5.87	6.13	6.77	17.99

Figures in the parentheses are square root transformed values.
DAS-days after spray.

Effect of different botanical extracts against Leaf miner (*C. horticola*) population

The data pertaining to *C. horticola* population at vegetative and flowering stage after two different spray schedules are presented in Table 3.

Vegetative stage

It is evident from the findings that all the botanicals were effective in reducing the mean population of leaf miner. Observations recorded at 7 days after treatment revealed that among the tested botanicals, highest control was recorded in case of Neem 10 percent with lowest mean population of 1.27 followed by Neem 5 percent (1.32), Marigold 10 percent

(1.36), Marigold 5 percent (1.41), Wild sage 10 percent (1.53) and Wild sage 5 percent (1.55). Periwinkle 5 percent (2.00) was found to be the least effective botanical in controlling miner population.

Flowering stage

Data recorded at 7 DAS revealed Neem 10 percent (0.18) as the most effect plant extract in reducing possesses maximum reduction of leaf miner population closely followed by Neem 5 percent (0.23), Marigold 10 percent (0.28) and Wild sage 10 percent (0.28). These treatments were statistically at par to each other and were significantly superior over remaining treatments. The lowest mean larval population (0.68) was recorded in Periwinkle 5 percent.

Table 3: Effect of different botanical extracts against Leaf miner in pea during *rabi* season 2019-2020

Sl. No.	Treatments	Vegetative Stage		Flowering Stage		Overall mean
		3 DAS	7 DAS	3 DAS	7DAS	
1.	Neem 5%	1.66 (1.28)	1.32 (1.14)	0.53 (0.63)	0.23 (0.47)	0.93
2.	Neem 10%	1.54 (1.23)	1.27 (1.12)	0.49 (0.65)	0.18 (0.42)	0.87
3.	Marigold 5%	2.00 (1.41)	1.47 (1.21)	1.11 (1.05)	0.31 (0.55)	1.22
4.	Marigold 10%	1.80 (1.33)	1.36 (1.16)	0.73 (0.78)	0.28 (0.50)	1.04
5.	Periwinkle 5%	2.17 (1.47)	2.00 (1.41)	1.39 (1.70)	0.68 (0.79)	1.56
6.	Periwinkle 10%	2.13 (1.45)	1.80 (1.34)	1.24 (1.11)	0.62 (0.74)	1.44
7.	Wild sage 5%	2.06 (1.43)	1.55 (1.23)	1.20 (1.09)	0.55 (0.62)	1.34
8.	Wild sage 10%	2.06 (1.43)	1.53 (1.23)	1.18 (1.08)	0.28 (0.49)	1.26
9.	Thiamethoxam 25 WG	1.37 (1.17)	1.20 (1.09)	0.38 (0.61)	0.17 (0.41)	0.78
10.	Control	2.18 (1.47)	2.16 (1.47)	3.06 (1.74)	3.26 (1.80)	2.66
	SEm±	0.06	0.03	0.07	0.06	0.20
	C.D. (0.5)	0.17	0.11	0.23	0.20	0.58
	C.V. (%)	6.70	4.44	10.78	11.42	30.61

Figures in the parentheses are square root transformed values.
DAS-days after spray.

Effect of different botanical extracts on Gram Pod Borer (*H. armigera*) population

Pod formation stage

The data determining the effect of botanicals on pod borer is depicted in Table 4. From the findings, it was observed that at 7 DAS the plot treated with Neem 10 percent registered the lowest pod borer larval population of 1.20 followed by Neem 5 percent (1.27) and Marigold 10 percent (1.29) which were statistically significant to each other. Neem and Marigold were comparatively more toxic since it reduced the mean larval population compared to other botanical treatments. Periwinkle 5 percent (1.45) was the least effective treatment but was significantly superior over control (2.16). Thiamethoxam 25 WG registered as the most effective (1.12) treatment over all the botanical tested.

Effect of different botanicals on yield of pea

The data presented in Table 5 revealed that all the treatments were found statistically significant over control. The overall impact of different treatments with plant extracts could be observed by looking at the yield of the crop. The highest seed yield (427.73 kg/ha) was obtained in plot treated with Neem 10 percent which was significantly superior over all other treatments closely followed by Neem 5 percent (424.96 kg/ha), Marigold 10 percent (391.63 kg/ha), Marigold 5 percent (383.30 kg/ha) and Wild sage 10 percent (373.20 kg/ha). The lowest yiled was recorded in Perwinkle 5 percent (333.30 kg/ha) followed by Periwinkle 10 percent (336.06 kg/ha) and Wild sage 5 percent (363.86 kg/ha). The increase in yield over control was maximum (36.28) in plots treated with Neem 10 percent followed by Neem 5 percent (35.39), Marigold 10 percent (24.77), Marigold 5 percent (22.12) and Wild sage 10 percent (18.58). The minimum increase in yield over control was recorded from the plots treated with Periwinkle 5 percent (6.19) followed by 10 percent (7.10) and Wild sage 5 percent (15.93). The avoidable losses in seed yield of Pea due to the three insects was maximum in control plot followed with that of treated with Periwinkle 5 percent (28.57) and Periwinkle 10 percent (28.98).

Table 4: Effect of different botanical extracts on Pod Borer in pea during *rabi* season 2019-2020

Sl. No.	Treatments	Pod Formation stage		Overall mean
		3 DAS	7 DAS	
1.	Neem 5%	1.27 (1.13)	1.27 (1.13)	1.27
2.	Neem 10%	1.25 (1.11)	1.20 (1.09)	1.22
3.	Marigold 5%	1.41 (1.18)	1.34 (1.16)	1.37
4.	Marigold 10%	1.31 (1.14)	1.29 (1.14)	1.30
5.	Periwinkle 5%	1.68 (1.30)	1.45 (1.20)	1.56
6.	Periwinkle 10%	1.64 (1.27)	1.43 (1.20)	1.53
7.	Wild sage 5%	1.56 (1.24)	1.40 (1.18)	1.48
8.	Wild sage 10%	1.43 (1.20)	1.39 (1.17)	1.41
9.	Thiamethoxam 25 WG	1.20 (1.09)	1.12 (1.06)	1.16
10.	Control	2.13 (1.46)	2.16 (1.47)	2.14
	SEm±	0.04	0.03	0.04
	C.D. (0.5)	0.12	0.09	0.14
	C.V. (%)	4.74	3.71	4.32

**Figures in the parentheses are square root transformed values.
DAS-days after spray.

Table 5: Effect of different botanical treatments on yield in pea during *Rabi* 2019-2020

Sl. No.	Treatments	Yield kg/ha	Increase in yield over control %	Avoidable losses %
1.	Neem 5%	424.96	35.39	8.92
2.	Neem 10%	427.73	36.28	8.33
3.	Marigold 5%	383.30	22.12	17.85
4.	Marigold 10%	391.63	24.77	16.10
5.	Periwinkle 5%	333.30	6.19	28.57
6.	Periwinkle 10%	336.06	7.10	27.98
7.	Wild sage 5%	363.86	15.93	22.02
8.	Wild sage 10%	372.20	18.58	20.23
9.	Thiamethoxam 25 WG	466.63	48.67	0
10.	Control	313.86	0	32.73
	Sem ±	0.01		
	C.D. (0.5)	0.04		
	C.V. (%)	28.92		

Discussion

Effect of biopesticide application on aphid population

In the present study Neem 10 percent was found to be most effective in reducing aphid population on pea and resulted upto 3.01 overall mean population reduction. Neem 5 percent, Marigold 10 percent and Marigold 5 percent were effective next to Neem 10 percent in their efficacy and depicted upto 3.10, 3.16 and 3.21 overall mean in aphid population respectively. The present results are in agreement with that of Megersa (2016) [17] who reported that Neem 10 percent and Neem 5 percent as the most effective botanicals against aphid. Chandel *et al.,* (2012) [7] and Mvumi *et al.,* (2018) [20] also reported that leaf extracts of Lantana showed aphid mortality and can be used as alternatives to chemical which corroborate with the present investigation. *Lantana camara* and Periwinkle were least effective in comparison to Neem.

Effect of botanicals on leaf miner population

Experiments were carried out in the field using different plant extracts to observe its effect on leaf miner. The data presented in Table 3 indicate that the overall impact of plant extract was quite visible in overall mean. Neem 10 percent recorded lowest mean population 0.87 followed by Neem 5 percent (0.93), Marigold 10 percent (1.04) and Marigold 5 percent (1.22). Periwinkle 5 percent (1.56) was found to be the least effective botanical against leaf miner. The present findings are in partial agreement with the findings of Singh and Saravanan (2008) [26] who reported that NSKE (97.35%) and Neem oil (91.41%) reduced leaf miner population. Fitiwy *et al*., (2019) [12] also observed Neem seed extract as the best botanical in controlling leaf miner infestation which supports our present investigation.

Effect of botanicals on gram pod borer population

Results on effect of botanicals on gram pod borer has been presented in Table 4. The data showed the similar trend as far as treatment of botanicals is concerned. The overall mean was lowest (1.22) in Neem 10 percent. This was followed by Neem 5 percent, Marigold 10 percent and Marigold 5 percent which were statistically similar in order of overall gram pod borer infestation recording 1.27, 1.30 and 1.37 mean larval population. Highest infestation was observed at Periwinkle 5 percent (1.56) which was inferior to all other tested botanicals. In control set of experiment 2.14 mean larval population was observed. Kumar *et al*., (2019) [16] also reported NSKE @ 5% (3.50), Neem leaf extract @5% (4.0) and Neem oil @ 2% (4.3) and nimbecidine @ 2% (4.5) to reduced mean larval population of *H. armigera* in chickpea which corroborate our present findings. Bijewar *et al.,* (2018) [6] states that Lantana @ 5% (4.63) was the least effective treatment in reducing damage by gram pod borer which is somewhat similar to our present findings where Lantana 5 percent and 10 percent overall mean population were higher than other botanicals registering 1.48 and 1.41 mean larval population. We noted that lower pod damage was recorded in plots treated with Neem 10 and 5 percent compared to control plots and treatment with Periwinkle 10 and 5 percent. The lower pod damage in these plots might be due to the insecticidal properties of Neem such as repellent, deterrent to oviposition or feeding with unpleasant odour or irritants and having adverse toxicity effects to insect pests making the host unpalatable. Contrary to this, Halder *et al*., (2009) [15] reported that *V. rosea* were more effective in reducing growth larval toxicity as well as inhibiting adult emergence of *H. armigera* in comparison to Neem oil and NSKE which is in contrast to our present investigation.

Effect of different botanicals on yield

In response to lower larval population and pod damage, maximum yield were recorded from plots treated with Neem 10 percent (427.73 kg/ha) except Thiamethoxam 25 WG (Standard check) (466.63 kg/ha) closely followed by Neem 5 percent (424.96 kg/ha) which were statistically significant with one another. This findings collaborate with that of Melesse *et al*., (2012) [18] and Gemmeda *et al*., (2015) [13] who reported highest yield in NSKE 10% (1312 kg/ha) and Neem (2.17 t/ha) treated plots in field pea. Similarly, Bhatta *et al.,* (2019) reported highest yield (2.05 t/ha) from Neem extract treated plots followed by tobacco extract (2.02 t/ha) whereas lowest yield was in untreated (1.13 t/ha) which is in partial agreement with our present investigation. In line with our results, *A. indica* alcoholic seed extract recorded highest yield (1286.0 kg/ha) in chickpea (Fite *et al*., 2020) [11].

Conclusion

Among the botanicals, Neem extracts proved to be the best effective treatment in all the three insects due to its antifeedant and repellent properties. These indigenous plant extracts can be used in the field since they are less toxic, much safer than chemical insecticide which causes pest outbreak and resurgence. So, by incorporating these botanicals the application of chemical insecticides can be reduced to a minimum level. Thus, the locally available indigenous plant extracts would greatly benefit the resource poor farmers of Bishnupur District and further research needs to focus on mechanism of their mode of action, ease of product availability and consideration for implementing as a part of IPM tool in pest management of pea.

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