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Efficacy of plant and aboriginal preparations against diamondback moth, *Plutella xylostella* (L.) (Lepidoptera: Plutellidae)

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Abstract
Diamondback moth, *Plutella xylostella* (Linnaeus.) is a key pest on *Brassicaceae* crops causing severe yield loss worldwide. Its regular incidence often incited the farmers to spray insecticides. Despite of such efforts, growers are unable to control the damage. Due to ineffectiveness of insecticides, impelled the growers in India towards organic farming. Present study was designed to study the efficacy of plant and indigenous preparations against *P. xylostella*, as an alternative to insecticides. Among the extracts tested, panchagavya, cow urine, dasagavya, chilli + garlic extract were exhibited repellent and antifeedant activity, but, were less effective in causing larval mortality. Extracts of neem fruit + red chilli + custard apple leaves and neem seed kernel + *Vitex negundo* L. + *Aloe vera* Mill. + *Calotropis gigantean* Ait. + *Clerodendron inerme* (Linnaeus) Gaertn were more detrimental to the *P. xylostella* larvae. These extracts caused not only repellent, antifeedant activity and larval mortality but also morphogenic deformities.

Keywords: Antifeedant, Indigenous extracts, Organic farming, Repellent.

1. Introduction
Currently, eco-friendly agriculture and demand for organic foods are gaining worldwide attention due to drawbacks associated with the agricultural chemicals [1, 4]. The undesirable effects of synthetic insecticides encouraged the present researchers to look for alternative management practices [5, 6]. Organic farming is one such convincing methodology being widely followed in modern agriculture [7, 6]. In India, organic farmers use preparations containing plants extract, cattle urine, cow dung and other local preparations for suppressing the crop pests [8]. Though the farmers were successful in growing organic crops, the practices undertaken in plant protection were not scientifically validated. In view of hidden advantages, indigenous plant protection practices that are in practice need to be validated against the major crop pests.

Diamondback moth, *Plutella xylostella* (L.) (Lepidoptera: Plutellidae) is an important pest of cruciferous crops in India and also in other regions of the world [9, 10]. In India, growers mainly depend on insecticides for *P. xylostella* management [11]. However, recurrent and extensive use of insecticides proved their futility against *P. xylostella*. In India, on an average of 10 to 15 insecticides sprays were dispensed on cabbage and cauliflower, starting from sowing to harvest. This unscientific way of insecticide application generated the *P. xylostella* population resistance to insecticide [12, 13]. Insecticides act as a driving force for the multiplication of insect pests not only by enhancing their reproductive ability, but also through killing their natural enemies [14]. So that, insecticide resistant population caused more yield loss than normal conditions [10]. Considering these shortcomings along with the intention to develop suitable alternatives to manage *P. xylostella*, the present case was intended to study the biological properties of selected plant and aboriginal preparations against *P. xylostella*. Among the traditional plant protection practices documented in south Karnataka, India panchagavya, cow urine, dasagavya, chilli + garlic extract, neem fruit + red chilli + custard apple leaf extract, neem seed kernel + *Vitex negundo* L. + *Aloe vera* Mill. + *Calotropis gigantean* Ait. + *Clerodendron inerme* (L) Gaertn leaf extract were more prevalent in the farming community [15]. Hence, this study was conducted to unravel insecticidal, repellent and antifeedant properties of the above preparations on *P. xylostella*.

2. Materials and Methods

2.1. Insect Culture

Liu and Sun (1984) [16] method with suitable modifications was followed for *P. xylostella* rearing. The larvae, collected from cabbage and cauliflower fields around Bangalore (12.97°N, 7.56°E, 920m AMSL), India were reared on mustard seedlings under laboratory conditions (25 ± 2 °C; RH: 80 %; L13:D11). Three to four days old-mustard seedlings raised in plastic Petri plates (10 cm diameter) were provided to the moths for oviposition in the wooden cage measuring 35 × 10 × 35 cm (L x B x H). After 24 hours, seedlings were then transferred to rearing trays. When the seedlings were completely consumed, the larvae were transferred to fresh seedlings by gently tapping them with the help of a camel hair brush. The paper folds were placed in the rearing trays to facilitate pupation. The pupae were then collected from paper folds carefully and were kept in the cage for adult emergence. The laboratory reared fourth instar larvae were used for the present studies. All the studies were conducted during 2010 at Toxicology laboratory, Department of Agricultural Entomology, University of Agricultural Sciences, Bangalore.

2.2. Preparation of Indigenous Extracts

Panchagavya was prepared by mixing indigenous products, namely cow dung, ghee (butter), milk, yogurt, cow urine, jaggery (panela), well ripen banana and tender coconut water [17]. Firstly, 700 g of fresh cow dung, and 100 g of ghee were mixed in a clean plastic cylinder (10 lt). After 48 h, one liter each of cow urine and water were added. All the contents were stirred well and incubated at room temperature (25 ± 2 ^{0}C) for 13 d. Further, 300 ml cow milk, 200 ml yogurt, 300 ml fresh tender coconut water, 300 g jaggery and one well-ripen banana fruit (100 g) were added to the mixture and stirred well. The mixture was fermented for 6 d at room temperature (25 ± 2 ^{0}C). Fermented mixtures was filtered and stored in a refrigerator at 4 ^{0}C. For cow urine treatment, freshly collected cow urine (1.5 liter) was fermented for 15 d in an airtight plastic container, and stored in a refrigerator at 4 ^{0}C for further use.

Dasagavya was prepared by mixing leaf extracts with panchagavya. Chopped leaves (200 g each) of *Lantana camara* L., *Datura stramonium* L., *Calotropis gigantia* L., *Artemisia absinthium* L. and *Ocimum basilicum* L. were soaked in cow urine at 1:1 proportions (1 kg leaves in 1 lt cow urine) for 10 days. The filtered crude extract was diluted by adding water (10 lt). The diluted leaf extract was mixed with panchagavya in a ratio of 5:1 (5 lt plant extract: 1 lt panchagavya) to obtain dasagavya and stored in a refrigerator at 4 ^{0}C.

Green chillies and garlic bulbs (100 g each) were macerated to paste in a meat grinder. The grinded paste was mixed with 200 ml of distilled water. The mixture was filtered using a muslin cloth and stored in a refrigerator at 4 ^{0}C.

Mature neem fruits (100 g) were crushed using a meat grinder, and soaked in 200 ml of water for 24 h. The contents were filtered using a muslin cloth. 50 g dry chilli soaked in water (24 h) was ground separately and soaked in 50 ml water. Leaves of *Annona reticulata* (200 g) were ground to fine paste and mixed with 50 ml of water in a separate container. The extracts of mature neem fruit, dry chilli and custard apple leaves were mixed in the proportion of 1:1:1 to get a final mixture.

Neem seed kernels, leaves of *C. gigantean*, *V. negundo*, *A. vera* and *C. inerme* (100 g each) were ground separately in a meat grinder, and mixed altogether in a plastic container (2 lt). Later, 500 ml of water was added to the mixture and fermented at room temperature (25 ± 2 ^{0}C). After 7 days, the contents were filtered through muslin cloth and the filtrate was stored in a refrigerator at 4 ^{0}C.

2.3. Repellent, antifeedant and effect on developmental activity

Approximately 4×4 cm fresh mustard leaves [collected from mustard seedlings raised in the glass house (28 ± 2 ^{0}C)] were treated with test products by leaf-dip method. The treated leaves (n=4 per treatment per replication) were allowed to dry and then leaves were placed in a circular pattern at equal distances in a plastic circular tray (30 cm diameter). Untreated leaves were placed alternatively in between the treated leaves. Fourth instar (n=25), 6 hours starved larvae were released at the center of the tray and allowed to settle for 20 minutes. The time taken and number of larvae settled on treated and untreated leaf discs were recorded. Each treatment was replicated three times. Per cent repellency was calculated using the formula; Per cent repellency = {(A-B)/A} x100 where A = Average number of larvae on untreated leaves; B = Average number of larvae on treated leaves. The scale of per cent of repellency was categorized into five classes (class 0 = > 0.01-0.10 %; class I = 0.10 - 20.00 %; class II = 20.10 - 40.00 %; class III = 40.10 - 60.00 %; class IV = 60.10 - 80.00 %; class V = 80.10 - 100.00 %) [18].

To study the antifeedant activity, leaf discs of 16 cm^2 were measured prior to the treatment. Fourth instar larvae (n=2) were starved for 6 h, weighed and introduced into a petri dish (10 × 1.5 cm) containing a treated leaf to feed for 48 h. A control was maintained for each treatment and all treatments were replicated for fifteen times. The area of leaf left unfed after 24 h was measured using leaf area meter, and change in the larval weight (gain/loss) were recorded (mg). The per cent antifeedant activity was calculated using a formula [19]. Per cent antifeedant activity was calculated using the formula = {(X-Y)/100-Y} x100 where X = leaf area left unfed in treatment; Y = leaf area unfed in control. Per cent reduction in weight gain = {(C-D)/C} x100 where C = Weight gain in control larvae; D = Weight gain in treated larvae.

To determine the effects on larval development, mustard plants grown in plastic pots (20 plants) were treated uniformly with 50 ml of test extracts using a hand atomizer. After 24 h, ten 4th instar larvae (starved for 6 h) were transferred to the treated mustard leaves in a petri dish (10 cm × 1.5 cm). The treatments were replicated thrice and for each treatment control (untreated leaves) was maintained. The fed leaves were replaced with fresh treated leaves to their respective treatments. Observations were recorded on larval and pupal mortality and morphogenic deformities on pupae and adults. Abbott's formula [20] was used to correct the mortality and morphogenic effects.

2.4. Statistics

The per cent repellence, antifeedant and mortality were calculated for the pre- and post- treatment data. The data in percentages were subjected to arc-sine transformation and analyzed by Analysis of Variance (ANOVA) (One-Way ANOVA) (IBM SPSS statistics 20). Statistical significant means were separated by Duncan's multiple range test (P < 0.01).

3. Results

Repellent activity differed significantly among the extracts ($F_{2, 28}$ = 119.24; p < 0.01) (Fig. 1). Increased repellency with the increase in concentration was evident in all the extracts against fourth instar larvae of *P. xylostella*. Behavioral observations revealed that the larval orientations were more or less straight

towards the untreated leaves, whereas, undirected towards treated leaves. Larvae took more time to settle on treated leaves (ranged from 15 to 40 min) compared to untreated leaves (ranged from 3 to 12 min). Among the treatments, neem seed kernel + *A. vera* + *V. negundo* + *C. gigantean* + *C. inerme* leaf extract showed the strongest repellence to *P. xylostella*. Panchagavya, dasagavya, neem fruit + red chilli + custard apple leaf extract and chilli + garlic extract ($P < 0.01$) were also exhibited fairly high degree of repellent activity at higher concentrations. Based on the level of repellent activity exhibited by the test products at 10 %, neem seed kernel + *Aloe vera* + *Calotropis* + *Vitex* + *Clerodendron* leaf extract was grouped into the Repellency Class V (80 - 100 %), panchagavya into Repellency Class IV (60 – 80.0 %), whereas dasagavya, neem fruit + red chilli + custard apple leaf extract, cow urine and chilli + garlic extract were categorized as Repellency Class III (40 - 60.00 %). Remaining treatments were grouped under Repellency Class I and II.

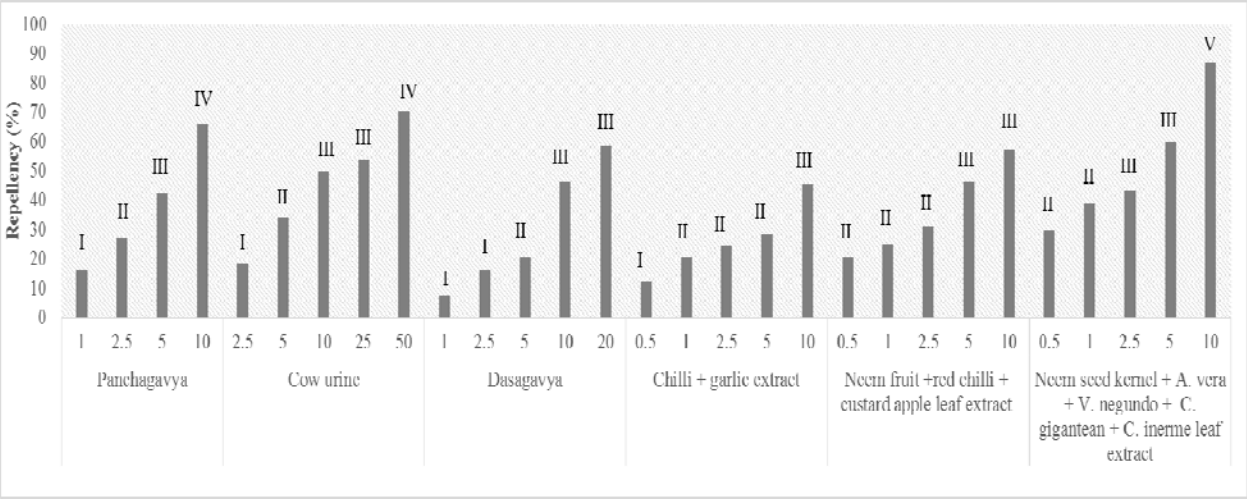

Fig 1: Repellent activity (%) of different test extracts and the superscripts with repellent scale as given by Rahman *et al*. 2007 [18]. Repellency class of 0 = > 0.01 to 0.10 %; class I = 0.10 to 20.00 %; class II = 20.10 to 40.00 %; class III = 40.10 to 60.00 %; class IV = 60.10 to 80.00 %; class V = 80.10 to 100.00 %.

The antifeedant activity increased with increase in concentrations ($P < 0.01$) (Table 1). Neem seed kernel + *A. vera* + *V. negundo* + *C. gigantean* + *C. inerme* leaf extract at 10 % and 5 % exhibited the strong antifeedant activity ($P < 0.01$) against *P. xylostella* larvae. These were followed by cow urine alone at 50 %, panchagavya at 10 % and 5 %, and neem seed kernel + *A. vera* + *V. negundo* + *C. gigantean* + *C. inerme* leaf extract at 2.5 %.

The feeding deterrence caused by the test products was quantified in terms of reduction of larval weight gained after 48 h of feeding. Neem seed kernel + *A. vera* + *V. negundo* + *C. gigantean* + *C. inerme* leaf extract at 10 % caused a maximum of 59.46 % larval weight reduction. However, this concentration was on par with 5 % of neem seed kernel + *A. vera* + *V. negundo* + *C. gigantean* + *C. inerme* leaf extract, panchagavya at 10 %, cow urine at 50 % and panchagavya at 5 % (Table 1). The observed larval weight reduction was in accordance with the level of feeding deterrence caused by the test products. Greater levels of antifeedant activity at higher concentrations resulted greater reduction in the larval weight and vice-versa (Table 1). A mixture contained chilli + garlic extract of 0.5 and 1 % had least effect on larval weight, though a slight feeding deterrence was observed at these concentrations (Table 1).

Table 1: Repellent and antifeedant activity of indigenous products against fourth instar larvae of *P. xylostella.*

Indigenous products	Conc. (%)	Antifeedant activity* (%)	Reduction in weight gained over control ** (%)
Panchagavya	1.00	23.20 (28.79)^{efgh}	24.00 (29.33)^{bcd}
	2.50	35.15 (36.27)^{bcdef}	33.30 (35.24)^{bc}
	5.00	45.22 (42.25)^{ab}	43.22 (41.09)^{ab}
	10.00	51.37 (45.75)^{ab}	55.43 (48.04)^{a}
Cow urine	2.50	15.35 (23.03)^{ghij}	06.60 (14.89)^{gh}
	5.00	22.45 (28.25)^{fghi}	10.55 (18.91)^{efgh}
	10.00	28.34 (32.28)^{cdefg}	24.00 (29.33)^{bcd}
	25.00	39.07 (38.70)^{bcde}	30.50 (33.21)^{bc}
	50.00	54.32 (47.47)^{ab}	50.32 (45.15)^{a}
Dasagavya	1.00	09.68 (18.15)^{ijk}	09.09 (17.46)^{fgh}
	2.50	15.19 (22.95)^{ghij}	09.09 (17.46)^{fgh}
	5.00	23.62 (29.13)^{efgh}	18.18 (25.18)^{cdef}
	10.00	28.56 (32.27)^{cdefg}	27.27 (31.48)^{bc}
	20.00	38.37 (38.23)^{bcdef}	36.36 (37.05)^{ab}
Chilli + garlic extract	0.50	04.43 (10.06)^{k}	00.00 (0.00)^{i}
	1.00	06.43 (12.31)^{k}	00.00 (0.00)^{i}
	2.50	16.36 (24.19)^{ghij}	05.55 (13.56)^{h}
	5.00	17.05 (22.98)^{ghij}	09.09 (17.46)^{fgh}
	10.00	20.30 (25.20)^{ghij}	18.18 (25.18)^{cdef}

Neem fruit + red chilli + custard apple leaf extract	0.50	09.43 (17.85)^{jk}	05.50 (13.56)^{h}
	1.00	14.25 (22.09)^{ghij}	11.20 (19.55)^{defgh}
	2.50	16.78 (24.32)^{ghij}	16.66 (24.04)^{cdefgh}
	5.00	26.01 (30.66)^{defgh}	22.50 (28.32)^{bcde}
	10.00	40.92 (39.76)^{bcd}	36.52 (37.17)^{ab}
Neem seed kernel + *A. vera* + *V. negundo* + *C. gigantean* + *C. inerme* leaf extract	0.50	28.14 (32.08)^{cdefg}	08.83 (17.26)^{fgh}
	1.00	35.25 (36.34)^{bcdef}	16.66 (24.04)^{cdefg}
	2.50	43.22 (41.25)^{abc}	23.50 (29.20)^{bcd}
	5.00	58.16 (49.60)^{a}	53.21 (46.85)^{a}
	10.00	64.45 (53.31)^{a}	59.46 (50.42)^{a}
SEm ±		3.06	2.95
CD at 5%		8.50	8.44

*Based on leaf area consumed; **Mean of 15 replications 2 larvae each after 48 h of feeding (n=30); Mean values with the same alphabetical superscript within a column are not significantly different at 5 per cent level of significance

Two neem based products *viz*., neem seed kernel + *Aloe vera* + *Calotropis* + *Clerodendron* leaf extract and neem fruit + red chilli + custard apple leaf extract caused higher levels of larval and pupal mortality compared to other products. Neem seed kernel + *Aloe vera* + *Calotropis* + *Clerodendron* leaf extract at 5.00 % and 10.00 % caused 73.33 and 100 per cent larval mortality. The total larval + pupal mortality was 49.99, 73.32, 96.99 and 100 per cent at 1 %, 2.5 %, 5 % and 10 % of the extract, respectively (Table 2). The other product, neem fruit + red chilli + custard apple leaf extract caused total larval + pupal mortality of 33.32 % to 90.00 % at 1.0 % to 10.00 % concentrations. Dasagavaya at 5 % to 20 % exhibited moderate insecticidal property causing 20.00 % to 29.99 % larval + pupal mortality. Panchagavya and cow urine exhibited the least level of insecticidal activity, cow urine caused 16.66 percent larval + pupal mortality at 50 per cent concentration.

Exposure of fourth instar larvae to two indigenous products affected the adult emergence to a greater extent (Table 2). None of the treated larvae developed into adults when exposed to 10 % neem seed kernel + *Aloe vera* + *Calotropis* + *Clerodendron* leaf extract, at 5 % also only 3.33 per cent of larvae reached the adult stage.

Treatment of neem fruit + red chilli + custard apple leaf extract (10 % and 5 %) reduced the adult emergence to 10.00 % and 43.33 %, respectively. Dasagavya at 20 % and 10 % restricted the adult emergence to 70.00 % and 76.66 %, respectively. The remaining products *viz*., chilli + garlic extract, cow urine and panchagavya had only marginal effect on adult emergence when fourth instar larvae were exposed to different concentrations.

Four test products *viz*., panchagavya, cow urine, dasagavya and chilli + garlic extract did not have any morphogenic effects on second instar larvae of the test insect. Two products containing neem fruit or seed extract produced the abnormal adults (Table 2). In case of neem seed kernel + *Aloe vera* + *Calotropis* + *Clerodendron* leaf extract, out of the 66.66 %, 50.33 % and 26.66 % adults that emerged at 1 %, 2.5 % and 5.00 % concentration, nearly 6.66 %, 3.33 % and 3.33 % of adults were abnormal with twisted wing, respectively. Similarly, out of 76.66 %, 66.66 %, 56.66 %, 43.33% and 10.00 % of the moths that emerged from fourth instar larvae treated with neem fruit + red chilli + custard apple leaf extract (0.5 %, 1.0 %, 2.5 %, 5.0 % and 10.0 %) nearly 3.33 %, 6.66 %, 13.33 %, 13.33 % and 6.66 % per cent of the adults were malformed, respectively.

Table 3: Effect of indigenous products on development when second instar larvae of *P. xylostella* were treated.

Indigenous products	Conc. (%)	Larval mortality* (%)	Pupal mortality* (%)	Normal adults (%)	Abnormal adults (%)
Panchagavya	1.00	6.66 (14.48)^{efg}	3.33 (10.46)^{de}	90.00 (71.56) ^{bc}	0.00 (0.00) ^{c}
	2.50	6.66 (14.48)^{efg}	3.33 (10.46)^{de}	90.00 (71.56) ^{bc}	0.00 (0.00) ^{c}
	5.00	10.00 (18.42)^{def}	0.00 (0.00)^{e}	90.00 (71.56) ^{bc}	0.00 (0.00) ^{c}
	10.00	16.66 (24.05)^{def}	6.66 (14.89)^{cde}	76.66 (61.71) ^{bcd}	0.00 (0.00) ^{c}
Cow urine	2.50	0.00 (0.00)^{g}	0.00 (0.00)^{e}	100.00 (90.00) ^{a}	0.00 (0.00) ^{c}
	5.00	0.00 (0.00)^{g}	3.33 (10.46) ^{de}	96.66 (79.53) ^{ab}	0.00 (0.00) ^{c}
	10.00	6.66 (14.48)^{efg}	0.00 (0.00) ^{e}	93.33 (75.08) ^{ab}	0.00 (0.00) ^{c}
	25.00	6.66 (14.48)^{efg}	0.00 (0.00)^{e}	93.33 (75.08) ^{abc}	0.00 (0.00) ^{c}
	50.00	16.66 (24.05)^{def}	0.00 (0.00)^{e}	83.33 (65.14) ^{abc}	0.00 (0.00) ^{c}
Dasagavya	1.00	10.00 (18.44) ^{def}	0.00 (0.00) ^{e}	90.00 (71.56) ^{bc}	0.00 (0.00) ^{c}
	2.50	13.33 (21.39)^{def}	0.00 (0.00)^{e}	86.66 (68.85) ^{bc}	0.00 (0.00) ^{c}
	5.00	16.66 (24.04)^{def}	3.33 (10.46)^{de}	80.00 (63.92) ^{bcd}	0.00 (0.00) ^{c}
	10.00	16.66 (24.04)^{def}	3.33 (10.46) ^{de}	80.00 (63.92) ^{bcd}	0.00 (0.00) ^{c}
	20.00	26.66 (31.05)^{d}	3.33 (10.46)^{de}	70.00 (56.78) ^{cd}	0.00 (0.00) ^{c}
Chilli + garlic Extract	0.50	3.33 (10.47)^{fg}	3.33 (10.46)^{de}	93.33 (75.00) ^{abc}	0.00 (0.00) ^{c}
	1.00	3.33 (10.47)^{fg}	6.66 (14.89)^{cde}	90.00 (71.56) ^{bc}	0.00 (0.00) ^{c}
	2.50	6.66 (14.28)^{efg}	3.33 (10.46)^{de}	90.00 (71.56) ^{bc}	0.00 (0.00) ^{c}
	5.00	6.66 (14.28)^{efg}	6.66 (14.89)^{cde}	86.66 (68.53) ^{bc}	0.00 (0.00) ^{c}
	10.00	6.66 (14.28)^{efg}	6.66 (14.89)^{cde}	86.66 (68.53) ^{bc}	0.00 (0.00) ^{c}
Neem fruit + red chilli +	0.50	7.46 (15.28)^{ef}	13.73 (20.88)^{abcd}	68.81 (56.04) ^{cd}	10.00 (18.44) ^{a}
	1.00	22.30 (28.18)^{de}	13.73 (21.51)^{abcd}	57.31 (49.20) ^{de}	6.66 (14.89) ^{ab}

custard apple leaves extract	2.50	26.00 (30.66)[d]	27.06 (31.31)[ab]	36.93 (37.41) [ef]	10.00 (18.44) [a]
	5.00	51.90 (46.09)[c]	31.13 (33.70)[a]	13.63 (21.64) [fg]	3.33 (6.14) [bc]
	10.00	66.70 (54.79) [bc]	20.76 (27.10) [abc]	9.21 (17.66) [gh]	3.33 (6.14) [bc]
neem seed kernel + *A. vera* + *V. negund* + *C. gigantean* + *C. inerme* leaf extract	0.50	60.00 (50.76)[c]	21.16 (27.35)[abc]	8.67 (17.05) [gh]	10.00 (18.44) [a]
	1.00	66.66 (54.07)[bc]	21.16 (27.35)[abc]	8.84 (17.28) [h]	3.33 (6.14) [bc]
	2.50	83.33 (65.88)[b]	7.46 (15.79)[bcde]	9.20 (17.66) [gh]	0.00 (0.00) [c]
	5.00	100.00 (90.00)[a]	0.00 (0.00)[e]	0.00 (0.00) [h]	0.00 (0.00) [c]
	10.00	100.00 (90.00)[a]	0.00 (0.00)[e]	0.00 (0.00) [h]	0.00 (0.00) [c]
SEm ±		4.44	4.95	5.61	3.40
CD at 5%		12.59	14.02	15.91	9.64

Mean of three replications containing 10 larvae per replication (n=30); Figures in parentheses are angular transformed values; *Corrected

4. Discussion

Present study revealed that the application of plant and aboriginal preparations on larvae of *P. xylostella* exhibited the repellent, antifeedant and insecticidal activities. Among the different extracts tested on *P. xylostella*, the relatively more repellent, antifeedant and insecticidal properties were observed in neem seed kernel + *A. vera* + *V. negundo* + *C. gigantean* + *C. inerme* and neem fruit + red chilli + custard apple leaf extract. But, only repellent and antifeedant activities were noticed in the remaining extracts. Biological properties exhibited by these extracts could be attributed to the presence of secondary metabolites. Most of the secondary metabolites were phenolic acids, flavonoids and aromatic compounds (terpenoids, steroids, alkaloids and organic cyanides) [21, 22]. The presence of insecticidal activities in several plant families were demonstrated by the many scientist [21, 23]. A compilation revealed the occurrence of insecticidal properties, major active moiety and effectiveness against the target insects in 1800 plants worldwide [24]. Out of 1,800 plants, only 82 were reported to be effective against *P. xylostella* [24]. The effect of plants extract mixtures and / or combination with aboriginal preparations was poorly recorded in India and other parts of the world. This is also certainly challenging task to estimate what might have occurred physiologically when these extracts entered into the insect.

Panchagavya essentially a plant growth promoter contains macro and micro nutrients, fatty acids, alcohols, alkanes, growth hormones, fermentative micro-organisms, metabolites and antibiotics [25]. Dasagavya was the mixture of leaf extracts of *L. camara*, *D. stramonium*, *C. gigantia*, *A. absinthium* and *O. basilicum* and panchagavya. Similarly, cow urine also contains minerals, acids, vitamins, hormones and enzymes [26]. Dasagavya was abstemiously active against *P. xylostella* compared to panchagavya and cow urine. This might be due to secondary metabolites, release from botanicals or increased microbial activity when combined with different ingredients. Panchagavya in combination with NSKE, exhibited more antifeedant activity against *Spodoptera litura* Fab. as compared to combination of *Adathoda vesica* L. and panchagavya [26]. Other scientists reported that cow urine and cow dung were moderately effective in reducing the *P. xylostella* incidence on cabbage [27]. Combination of cow urine with NSKE, *C. gigantean*, *V. negundo*, *Argemone mexicana L.* (Bhatkatai) and *A. vasica* were more effective against *S. litura* than when used individually [27]. Similar results were also reported by other workers when cow urine along with NSKE, *Pongamia pinnata* Vent. *V. negundo* and *A. vera* were used against *S. litura* and *Helicoverpa armigera* Hub. [28]. Cow urine as a standalone acts as a repellent to many pests and also as an attractant to beneficial insects, like wasps [29].

Chilli + garlic extract (10 %) extract exhibited less insecticidal and antifeedant activity, however, repellent activity was fairly high. The chilli fruits contain capsaicin, and the roots, cortex and seeds contain saponin-capsicidin which might be responsible for biological properties against *P. xylostella* [30, 31]. Leaf extracts of neem seed kernel + *A. vera* + *V. negundo* + *C. gigantean* + *C. inerme* leaf and neem fruit + red chilli + custard apple showed a wide range of biological activity against *P. xylostella*. The morphogenic effects were also evident in the adult stage. The insecticidal, antifeedant and repellent activities of neem against caterpillars were documented worldwide [32]. Acaricidal and insecticidal activities were also recorded on *Tetranichus urticae* Koch, and *P. xylostella* and *Aphis craccivora* Koch [17, 33]. The observed effect against *P. xylostella* might be due to the joint effect of various plant extracts. These contain defensive phytochemicals (non-protein amino acids, phenols, alkaloids, glycosides, terpenes, flavonoids, etc.) and were basically repugnant and poisonous to many insects [30, 31, 34].

From this study, it is clear that the extract of neem seed kernel + *A. vera* + *V. negundo* + *C. gigantean* + *C. inerme* and neem fruit + red chilli + custard apple were more effective against *P. xylostella*. These extracts are highly valuable to the growers for the management of crop pests under organic farming system. Because of their effectiveness, eco-friendly nature and cost-effectiveness, these products can be recommended as a potential alternative to synthetic insecticide in the organic farming system.

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