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Screening of jute varieties against jute apion (*Apion corchori* Marshall) and its management using chemical and botanical pesticides

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ABSTRACT

The experiment was conducted in the field laboratory of the Department of Entomology, Bangladesh Agricultural University, Mymensingh on the screening of resistant variety against jute apion, *Apion corchori* (Marshall) and its management by using some chemical and botanical pesticides during April to August 2014. Eleven jute varieties were selected to conduct varietal preference and tested against jute apion in field condition. Among the eleven varieties, O-9897 showed the higher leaf infestation than others showing statistically similar result with O-72 and O-795. Mean percent of leaf infestation was 55.64 in O-9897 while 28.07 in BJRI Deshi pat-5, 24.89 in CVL-1, 22.11 in BJRI Deshi pat-7, 29.64 in CC-45, 24.08 in BJRI Deshi pat-8, 27.99 in D-154, 51.42 in O-795, 26.37 in BJRI Deshi pat-6, 55.53 in O-72 and 39.45 in CVE-3. The lowest leaf infestation was found in BJRI Deshi pat-7 (22.11%) which was statistically similar to BJRI Deshi pat-8 (24.08%). The same trend of results was observed in case of the number of knot plant^{-1} and the highest knot was recorded in O-795 followed by O-72. Data revealed that the variety O-9897 was highly susceptible to jute apion followed by O-72 and O-795 whereas BJRI Deshi pat -7 had the resistant potentiality against jute apion followed by BJRI Deshi pat-8 and CVL-1. The overall preference rank of the varieties based on their resistance against jute apion was in the following order: BJRI Deshi pat-7>BJRI Deshi pat-8>CVL-1 > BJRI Deshi pat-6> D-154>BJRI Deshi pat-5> CC-45>CVE-3>O-795>O-72>O-9897. In the management study, two synthetic insecticides *viz.,* Limper 10EC, Diginol 60EC and two botanicals *viz.,* Neem oil and Mahogany oil were evaluated. Considering different parameters, comparatively less leaf infestation percent, number of hole leaf^{-1} and number of knot plant^{-1} was found with Diginol 60EC treated plot followed by Limper 10EC treated plot. The highest infestation was found in the control plot followed by Mahogany oil applied plot. The rank of the efficacy of the treatments was Diginol>Limper>Neem oil>Mahogany oil>control. It could be concluded that BJRI Deshi pat-7, BJRI Deshi pat-8 and CVL-1 was comparatively more resistant variety considering both leaf damage and number of knot plant^{-1} and local variety O-9897 followed by O-72 and O-795 was highly susceptible to Jute apion. This finding would be helpful to motivate the people to use botanical insecticides *i.e.,* Neem oil for the management of jute apion in environmentally safe condition.

Introduction

Jute (*Corchorus capsularis* L. and *Corchorus olitorius* L.) is an important cash-cum fibre crop in Bangladesh which plays a vital role in our national economy. Bangladesh ranks the second position after India in area coverage and production of jute (Sinha *et al*., 2004). This sector creates upgrowing empowerment of the people in agriculture, trade, industries and also helps in food security by earning lion's share of the foreign currency (6%) by exporting raw jute and jute products (Chowdhury and Hassan, 2013). Generally, it is called "The Golden Fibre of Bangladesh" because of its golden and silky shine natural fibre. The present production of jute fiber of the country is about 9.16 lac tons (Chowdhury and Hassan, 2013) which is reducing day by day. Among the reasons, insect pest is the major constraint to fibre production. Major insect pests infesting jute includes jute

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stem weevil (*Apion corchori* Marshall), jute hairy caterpillar (*Spilarctia obliqua* Wlk.), jute semilooper (*Anomis sabulifera* Guen) and jute yellow mite (*Polyphagotarsonemus latus* Banks) (Rahman and Khan, 2010).

Damage caused by insect pests to jute is very noteworthy because of increasing more and more resistant to pesticides (Roy, 2014). Among the insect pests of jute, *Apion corchori* popularly known as jute apion or jute stem weevil is a very destructive pest in Bangladesh. The weevils damage the fibre quality mainly by producing the oviposition holes. Female insects make a number of such holes in stem before lying their egg which accordingly damage the stems numerously. It damages jute plants by forming knot by disrupting the continuation and the uniformity of fibre along with the thickness as well. The weevil attacks the jute plants at the nodal region near the base of the petiole and produces knot. The fibre having such a knot is known as "knotty fibre". Apion knot causes break in the yarn during spinning, winding and weaving. The weevil attacks both the cultivated species of jute *i.e.* *Corchorus capsularis* and *Corchorus olitorius*. The incidence of *Apion corchori* was found causing a minimum of 5.09 percent plant infestation of olitorius jute *var.* JRO-524 (Rahman and Khan, 2010).

Effective control of this pest is very crucial as because of the insect passes there most of the life time inside the stem and thus escapes from the direct contact of the applied pesticides (Das *et al*., 1986). The farmers use synthetic pesticides to control stem weevil and since now, no control measures using botanical pesticides have been recommended. But pesticides are hazardous and kill beneficial parasites and predators which may create ecological imbalance. Moreover, continuous use of pesticide may help in developing resistance to target pests. To avoid all these problems cultivation of resistant varieties is the best and easy solution which can provide an inherent control of target pest without extra cost for pest control avoiding undesirable side effects. To minimize the use of synthetic insecticides in pest control, the importance of biodegradable substitutes is now strongly felt in many developed countries. Again, the cost of production of the botanical pesticides is also less than that of synthetic insecticides. Therefore, it is an urgent need to screen the resistant jute variety and to ascertain a sustainable and safe management strategy for jute apion. Thus, the present study was undertaken to screen out the resistant variety against jute apion and to develop a suitable management strategy comparing the efficacy of botanical and chemical pesticides.

Materials and Methods

Experimental site

The research work was conducted in the Entomology Field Laboratory of Bangladesh Agricultural University, Mymensingh located at 24.75^0N latitude and 90.5^0E longitudes and a mean elevation of 7.9 to 9.1 m above the sea level. The soil of the experimental field belongs to Old Brahmaputra Alluvial Soil and was grey in colour and loamy with fine texture. The pH of the soil was between 5.5 to 6.8 and the content of N, P_2O_5, K_2O and Ca was 0.12%, 0.09%, 1.05% and 0.62%, respectively with organic matter content of 0.8 to 1.6%. The experimental area was characterized by tropical rainfall with high temperature and humidity and heavy precipitation with occasional gusty winds in kharif season (April - September) and scanty rainfall with moderately low temperature during the rabi season (October - March).

Experimental layout and design

Experimental layout and design for varietal preference

Varietal preference test was conducted with randomized complete block design (RCBD) in the field. The whole experimental field was 16.76 m length and 5.48 m breadth, which was divided into 3 equal blocks having eleven plots of each. The unit plot size was 152.4 × 121.92 cm^2. Each of the unit plots had 3 rows separated by 25 cm. The plots were exposed to natural infestation and no protective measures were taken against any insect pest. Every single variety was considered as a treatment in this experiment.

Experimental layout and design for pest management

The experiments were conducted using five treatments including two of synthetic pesticide, two of botanical pesticide and a control; *i.e.*, T_1 = Limper 10EC, T_2= Diginol 60EC, T_3 = Neem oil, T_4 = Mahogany oil and T_5 = control following RCBD. Plot size, plant to plant and plot to plot distance were maintained as varietal preference test. The total number of plots was 15.

Growing of jute plants in the field

Land preparation

Soil of the experimental field was prepared thoroughly by ploughing and cross ploughing followed by laddering to have a good tilth using power tiller. Clods were broken down with a hammer and the stubbles of the crops and uprooted weeds were removed from the field. The plots were raised by 10 cm from the soil surface keeping the drain around the plots.

Fertilizer application

Fertilizers were applied once at the time of final land preparation at the rate of 38, 25 and 30 kg ha^{-1} urea, triple super phosphate and muriate of potash, respectively. In addition, 5 ton cow dung ha^{-1} was applied along with top dressing of urea 37 kg ha^{-1} at six weeks after sowing.

Seed collection, sowing and intercultural operations

Seeds of eleven jute varieties *viz.*, O-9897, BJRI Deshi pat-5, CVL-1, BJRI Deshi pat-7, CC-45, BJRI Deshi pat-

8, D-154, O-795, BJRI Deshi pat-6, O-72 and CVE-3 were collected from the germplasm of Entomology Division, Bangladesh Jute Research Institute (BJRI), Dhaka and were sown in the previously prepared plots in line sowing method for varietal preference test. For the pest management experiment, only BJRI Deshi pat-5 was used. The seeds for varietal preference were sown on 26 April 2014, whereas the seeds for management experiment were sown on 3 May 2014. The plant spacing was maintained as 15 cm × 20 cm. Necessary intercultural operations such as irrigation, thinning of seedlings and weeding were done as and when necessary for the better growth and development of the jute plants in the field.

Collection and application of botanicals and synthetic insecticides

Neem oil (*Azadirachta indica*) and Mahogany oil (*Swietenia mahagoni*) were used as botanicals in jute apion management experiment. Neem and Mahogany oil were collected from a company "MATI Organics Ltd." situated at, Uttara, Dhaka. Spray suspensions of Neem oil and Mahogany oil were prepared by mixing emulsifier and sprayed once at 7 days interval @ 5 ml L^{-1} water + Trix @ 1ml L^{-1}, with three replications in the field. Two chemical insecticides Limper 10EC and Diginol 60EC were used @ 1ml L^{-1} water and 3.5 ml L^{-1} of water, respectively. Spray suspensions of the insecticides were prepared using fresh tap water and sprayed once at 7 days interval with hand sprayer on upper and lower surfaces of the leaves to ensure complete coverage of the plants. A total of three spray was done with proper precautions.

Data collection and calculation

Varietal preference of jute apion was investigated at different stages of the plants. To find out the preference of jute apion to jute plants the following parameters- the number of total leaves, infested leaf and number of knot plant^{-1} were considered. Five plants were randomly selected from each plot and were considered as one replication from where leaf infestation (%), number of knot plant^{-1} and the number of hole leaf^{-1} were counted. Data were collected at every 10 days interval on the mentioned parameters. In case of pest management experiment, before application of botanicals and synthetic insecticides in the jute field, a pre-treatment data of different parameters was collected from each field. Data were counted four times as pre-treatment, first, second and third counting maintaining seven days interval after spraying of botanicals and chemical insecticides. Five plants were randomly selected from each field to count leaf infestation percent, knot plant^{-1} and 10 leaves were considered for counting the number of hole leaf^{-1}. Percent leaf infestation was calculated by using the following formula:

$$LI = \frac{L_I}{L_T}$$

Where, LI = leaf infestation (%), L_I and L_T represent number of infested and total leaves.

Cumulative mean percentage leaf infestation and hole leaf^{-1} were calculated from three different means of first, second and third counting. Percentage protection of leaf infestation was calculated with the following formula:

$$PI_C = \frac{CMI_C - CMI_T}{CMI_C}$$

Where, PI_C = Protection against leaf infestation over control (%), CMI_C, and CMI_T represent cumulative mean infestation (%) in control and treatment respectively.

Similarly, percentage protection of number of hole leaf^{-1} was calculated with the following formula

$$PH_C = \frac{CMH_C - CMH_T}{CMH_C}$$

Where, PH_C = Protection against leaf hole over control (%), CMH_C, and CMH_T represent cumulative mean number of hole leaf^{-1} (%) in control and treatment respectively.

Data Analysis

The recorded data from both the varietal preference test and management experiment were compiled and tabulated for statistical analysis. Analysis of variance was done with the help of computer package MSTAT-C. The mean differences among the treatments were adjudged as per test with Duncan's Multiple Range Test (DMRT) and least significant difference (LSD) when necessary.

Results and Discussion

Varietal screening for resistance to jute apion

Leaf infestation (%) by jute apion

Leaf infestation by jute apion among eleven jute varieties differed significantly (Table 1). At 30 days after sowing (DAS), the highest percentage of infested leaf was found in O-72 (51.48%) followed by O-9897 (48.68%) and O-795 (45.39%). The lowest infestation was observed in BJRI Deshi pat-7 (19.15%). Similarly, at 40 DAS, BJRI Deshi pat-7 showed a remarkable performance of leaf infestation (20.80%). On the contrary, the highest percentage of infested leaf was observed in O-9897 (53.75%) followed by O-72 (53.68%), O-795 (49.25%) and CVE3 (38.68%) which was significantly differed from other varieties. At 50 DAS, the highest percentage of infested leaf was noticed in O-9897 (58.05%) which was statistically identical with O-72 (57.30%) and O-795 (54.26%), but was significantly different from rest of the varieties. The lowest percentage of infested leaf was observed in BJRI Deshi pat-7 (22.55%) followed by BJRI Deshi pat-8 (24.63%) (Table 1). The highest percentage of infested leaf was found in O-9897 (62.09%) at 60 DAS followed by O-72 (59.64%) and O-795 (56.78%).

Table 1. Mean percentage leaf infestation caused by jute apion on different jute varieties in the field

Variety	Mean percent leaf infestation at different days after sowing (DAS)				Rank
	30DAS	40DAS	50DAS	60DAS	
O-9897	48.68a	53.75a	58.05a	62.09a	11
BJRI Deshi pat-5	23.84cd	25.84cd	29.48c	33.11cd	6
CVL-1	21.38cd	23.65cd	26.78cd	27.73de	3
BJRI Deshi pat-7	19.15d	20.80d	22.55d	24.95e	1
CC-45	26.23c	28.32c	29.24c	34.78c	7
BJRI Deshi pat-8	21.83cd	23.07cd	24.63d	27.30de	2
D-154	24.66cd	26.37cd	29.86c	31.07cde	5
O-795	45.39a	49.25a	54.26a	56.78a	9
BJRI Deshi pat-6	22.85cd	24.91cd	26.44cd	31.26cde	4
O-72	51.48a	53.68a	57.30a	59.64a	10
CVE-3	36.56b	38.68b	39.61b	42.96b	8
±SE	2.07	1.83	1.36	1.97	

SE= Standard error of means; Different letters in a column indicate significant variation significant at 5% level of probability in mean % leaf infestation among the varieties.

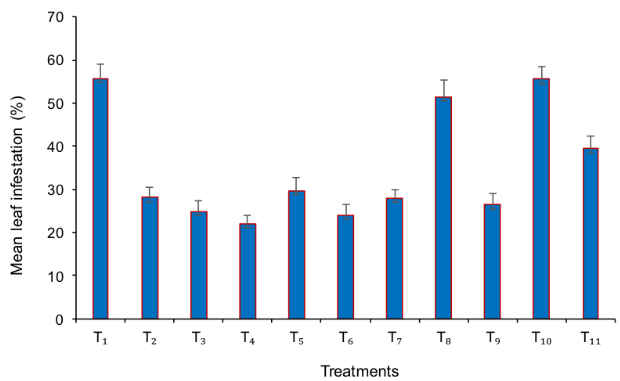

Fig.1 Percentage of mean leaf infestation found in eleven varieties of jute. The error bars indicate the standard error (±SE) of means. T_1= O-9897, T_2= BJRI Deshi pat-5, T_3= CVL-1, T_4= BJRI Deshi pat-7, T_5= CC-45, T_6= BJRI Deshi pat-8, T_7= D-154, T_8=O-795, T_9= BJRI Deshi pat-6, T_{10}=O-72, T_{11}=CVE-3]

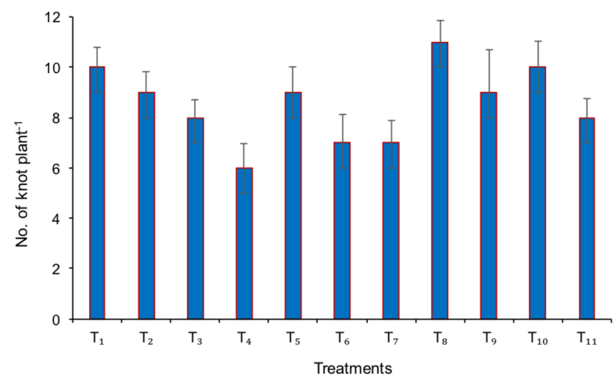

Fig. 2 Number of knot plant^{-1} found in eleven varieties of jute. The error bars indicate the standard error (±SE) of means. T_1= O-9897, T_2= BJRI Deshi pat-5, T_3= CVL-1, T_4= BJRI Deshi pat-7, T_5= CC-45, T_6= BJRI Deshi pat-8, T_7= D-154, T_8=O-795, T_9= BJRI Deshi pat-6, T_{10}=O-72, T_{11}=CVE-3]

Table 2. Effect of different chemical and botanical pesticides on leaf infestation

Treatments	Leaf infestation (%) at different time intervals				Cumulative mean leaf infestation (%)
	Pre- treatment	1st counting	2nd counting	3rd counting	
Limper 10EC	15.78	17.30c	18.07bc	19.53c	17.67
Diginol 60EC	15.39	16.20d	17.73c	18.33d	16.91
Neem oil	15.79	17.67bc	19.10bc	20.13c	18.17
Mahogany oil	16.08	18.33b	20.00b	22.03b	19.11
Control	17.13	19.67a	22.67a	24.97a	21.11
±SE	0.138	0.264	0.405	0.189	

NS = Non significant, SE= Standard error of means; Different letters in a column indicate significant variation significant at 5% level of probability in mean % leaf infestation among the varieties.

Screening of jute varieties and its management

The lowest percentage of infested leaf was recorded in BJRI Deshi pat-7 (24.95%), which was statistically similar to BJRI Deshi pat-8 (27.30%), but significantly different from all other varieties (Table 1). In case of cumulative mean, numerically the highest percentage of leaf infestation was recorded in O-9897 (55.64%) followed by O-72 (55.53%), but different from other varieties (Table 1). This highest percentage of leaf infestation indicated the lowest resistance of these varieties. Comparatively high rate of percent leaf infestation was observed in O-795 (51.42%) and CVE-3 (39.45%) (Figure 1) which indicated their less resistance capability in these varieties. The average of all five observations revealed that BJRI Deshi pat-7 exhibited outstanding performance by receiving the lowest percentage of leaf infestation (22.11%). From the results, it can be said that BJRI Deshi pat-7 and BJRI Deshi pat-8 were the more resistant to jute apion than others. CVL-1, BJRI Deshi pat-6, and D-154 also showed comparatively low leaf infestation which expressed their better resistance in their genomes. So, the overall resistance rank to jute apion among eleven jute varieties was in the following order: BJRI Deshi pat-7> BJRI Deshi pat-8>CVL-1> BJRI Deshi pat-6>D-154>BJRI Deshi pat-5> CC-45>CVE-3>O-795>O-72>O-9897. Jalil and Banu (1990) evaluated seven jute varieties for resistance to jute stem weevil and jute yellow mite and reported that none of the varieties were resistant to jute stem weevil. That finding was different from the present findings.

Number of knot plant^{-1} among the varieties

The highest number of knot plant^{-1} was observed in O-795 (11), which was numerically similar to O-72 (10) and O-9897 (9) but significantly different from rest of the varieties. The lowest number of knot plant^{-1} was observed in CVE-3 (6) followed by D-154 (7) which had performed consistently better throughout the season, but significantly different from all other varieties (Figure 2). BJRI Deshi pat-6 and BJRI Deshi pat-5 showed moderate number of knot plant^{-1} (Figure 2). BJRI Deshi pat-7, BJRI Deshi pat-8 and CVE-3 showed the highest resistance to jute apion. On the other hand, O-795, O-72 and O-9897 showed the least resistance to jute apion. The present result was in line with Islam (2003) who studied the pest status of infestation of 3 deshi and 26 tossa advanced lines of jute in field condition and found that BJRI Deshi pat showed the lowest percentage of apion infestation (60%) with lowest number of insects plants^{-1} (1.19). A contradictory result was reported previously (Anonymous, 1993) in a study conducted to screen out three mutants namely C-204, C-278 and C-443 and two varieties, namely D-154 and CVL-1 for resistance to jute apion and reported the maximum and the minimum plant infestation by jute stem weevil in D-154 and C-278, respectively. Bhuiyan and Kabir (1986) screened thirty strains (twenty *C. olitorius* and ten *C. capsularis)* for resistance to *A. corchori* under greenhouse condition and found 30-40% as resistance.

Management of jute apion

Efficacy of different chemical and botanical pesticides on leaf infestation

Significant variation was found in the percentages of leaf infestation under different treatments in comparison to control (Table 2). The highest percentages of leaf infestation were found as 19.67%, 22.67% and 24.97% after first, second and third application of treatments, respectively. During pre-treatment counting, the percentages of infested leaf were 15.78%, 15.39%, 15.79%, 16.08% and 17.13% with the treatment of Limper, Diginol, Neem oil, Mahogany oil and control, respectively (Table 2). After seven days of pre-treatment counting i.e., first counting, the percentages of infested leaf for Limper, Diginol, Neem oil, Mahogany oil and control treatments were 17.30%, 16.20%, 17.67%, 18.33% and 19.67%, respectively. The lowest percentage of infested leaf was recorded in Diginol and the highest percentage of infested leaf was exhibited in control plots (19. 67%). During second counting, the lowest percentage of infested leaf was recorded in Diginol (17.73%) treated plot followed by Limper (21.35%) treated plot. The highest percentage of infested leaf was found in control plots (22.67%) and the second highest percentage of infested leaf was observed in Mahogany oil treated plot (20.00%). But all the treatments showed significant higher efficacy than control in case of percentage of leaf infestation. After seven days of second application i.e., third counting, the percentages of infested leaf under Limper, Diginol, Neem oil, Mahogany oil and control plot varied significantly. The lowest percentage of infested leaf was recorded in Diginol (18.33%) treated plot followed by Limper (19.53%) and the highest percentage of infested leaf was exhibited in control plots (24.97%) (Table 2).

The cumulative mean leaf infestation under Limper, Diginol, Neem oil, Mahogany oil and control plots were 17.67, 16.91, 18.17, 19.11 and 21.11%, respectively (Table 2). Numerically minimum mean leaf infestation was observed when plants were treated with Diginol 60EC (16.91%) followed by Limper 10EC treated plot (17.67%) and maximum mean leaf infestation was found under control condition (21.11%) followed by Mahogany oil treated plot (19.11%). Therefore, the rank of efficacy of the treatments over control was Diginol (19.90%) > Limper (16.30%) > Neem oil (13.93%) > Mahogany oil (9.47%) (Fig. 3). Similar result was found by Korat and Dabhi (2009) who found superior efficacy of synthetic insecticide than neem formulations to control jute pests. Rahman and Khan (2010) found maximum infestation by jute stem weevil in the control plot. The infestation level of this study was in line with Prasad *et al.* (2002) who found the infestations caused by jute apion ranging from 9.74 to 29.84% during 2001–2002 in various IPM treatments as compared to 15.39–39.43% during 2000–2001.

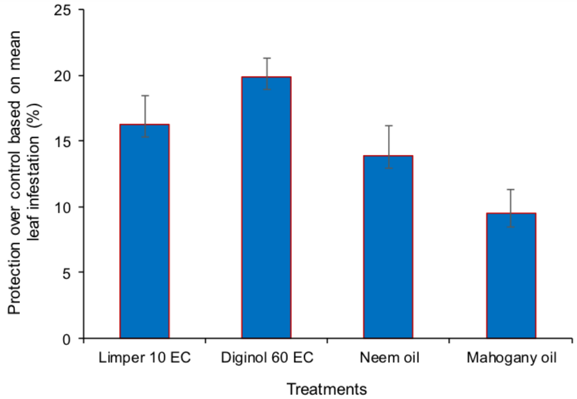

Fig. 3 Effect of different chemical and botanical pesticides on percentage protection over control based on cumulative mean number of leaf infestation (%). The error bars indicate the SE of means. The error bars indicate the standard error (±SE) of means.

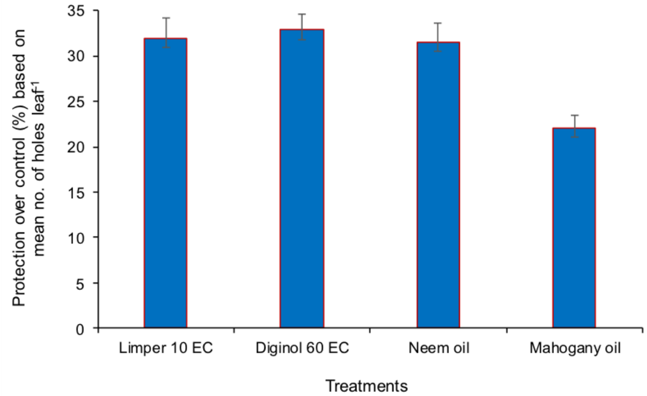

Fig. 4 Effect of different chemical and botanical pesticides on percentage protection over control based on cumulative mean number of holes leaf^{-1}. The error bars indicate the standard error (±SE) of means.

Table 3. Effect of different chemical and botanical pesticides on number of holes leaf^{-1}

Treatments	Mean number of holes leaf^{-1}				Cumulative mean number of hole leaf^{-1}
	Pre-treatment	1st counting	2nd counting	3rd counting	
Limper 10EC	5.67	6.92	7.33b	8.33bc	6.92
Diginol 60EC	6.33	6.83	7.00b	7.33c	6.83
Neem oil	6.33	6.96	7.35b	8.35bc	6.96
Mahogany oil	6.67	7.92	8.00b	9.67b	7.92
Control	7.33	10.17	11.33a	12.67a	10.17
±SE	0.198	0.269	0.387	0.353	

NS = Non significant, SE= Standard error of means; Different letters in a column indicate significant variation significant at 5% level of probability in mean % leaf infestation among the varieties.

Effect of different chemical and botanical pesticides on number of holes leaf^{-1}

The number of holes in jute leaf caused by jute apion was counted under the application of different chemical and botanical pesticides and have been presented in Table 3. Significant variation was found in number of hole leaf^{-1} under different treatments of chemical and botanical pesticides in comparison to control. It was observed that before application of treatments the number of hole leaf^{-1} for Limper, Diginol, Neem oil, Mahogany oil and control plots were 5.67, 6.33, 6.33, 6.77 and 7.33, respectively. The highest number of holes leaf^{-1} (9.33, 11.33 and 12.67) was recorded from control plots during first, second and third counting. After application of all treatments, percent leaf infestation in jute plants decreased significantly in comparison to control. After seven days of pre-treatment counting, during first counting, the lowest percentage of number of hole leaf^{-1} was recorded in Limper (6.33) sprayed plot followed by Diginol (6.67) treated plot and the highest number of hole leaf^{-1} was exhibited in control plots (9.33) followed by Mahogany oil treated plot (7.33). It was also remarked that at first counting of all the treatments were statistically similar in their efficacy except the control. During second counting, after seven days of first application of treatments, the lowest percentage of number of hole leaf^{-1} was recorded in Diginol (7.00) sprayed plot followed by Limper (7.33) sprayed plot and the highest number of hole leaf^{-1} was exhibited in control plots (11.33) followed by Mahogany oil treated plot (8.00). Similar to the first counting it was also observed that at second counting all the treatments showed statistically similar effect except the control against jute apion.

During third counting, the number of hole leaf^{-1} under Limper, Diginol, Neem oil, Mahogany oil and control plot were 8.33, 7.33, 8.35, 9.67 and 12.67, respectively (Table 3). The lowest number of hole leaf^{-1} was recorded in Diginol (7.33%) treated plot followed by Limper (8.33%) applied plot and the highest number of hole leaf^{-1} was exhibited in control plots (12.67%) followed by Mahogany oil treated plots (9.67%). At the third counting, Diginol showed higher efficacy than Neem oil and Limper but Neem oil and Limper showed statistically similar effect against jute apion. But it was mentionable that all the treatments were significantly effective in comparison to control against jute apion based on the mean number of holes leaf^{-1}.

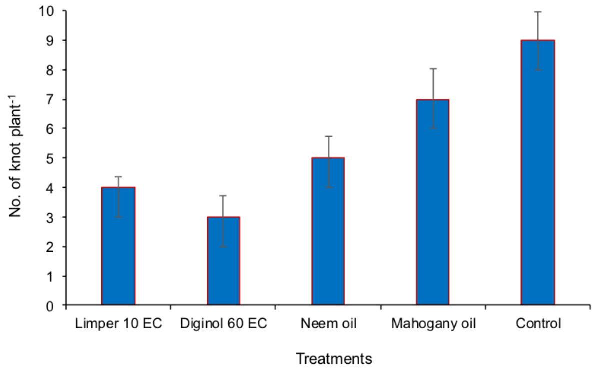

Fig. 5 Number of knot plant^{-1} under different chemical and botanical pesticides. The error bars indicate the standard error (±SE) of means.

The overall mean number of hole leaf^{-1} under Limper, Diginol, Neem oil, Mahogany oil and control plots were 6.92, 6.83, 6.96, 7.92 and 10.17, respectively (Table 3). The rank of efficacy of treatments over control was Diginol (32.84%) > Limper (31.96%) > Neem oil (31.56%) > Mahogany oil (22.12%) (Figure 4). In this study it was revealed that Diginol 60EC spraying at 7 days interval could control the pest very effectively. It reduced the number of hole leaf^{-1} significantly. So, it would be better to use this chemical insecticide for management of jute apion. Similarly, the percent protection on number of hole leaf^{-1} was highest in Diginol treated plot (32.84%) and the lowest in Mahogany oil treated plot (22.12%). Among the treatments the efficacy of insecticides was better than the botanical insecticides. Most effective synthetic insecticide was Diginol followed by Limper and of the two botanicals Neem oil was the most effective followed by Mahogany oil (Table 3). Among the treatments used Chari *et al.* (1999) also found neem oil as a highly effective control measure to reduce the infestation of yellow mite. But different result was found by Anil (2001) who showed that mahogany oil was more effective to reduce the damage of jute leaves by yellow mite.

Effect of different chemical and botanical pesticides on number of knots plant^{-1}

Significant variation was found in the collected data under different treatments in comparison to control (Figure 5). The highest number of knot (9/plant) was always recorded from control plots. It was observed that in treated plots the lowest number of knot was found in Diginol 60EC treated plot (3/plant) followed by Limper 10EC treated plot (4/plant). The highest number of knot was found in control plot (9/plant) followed by Mahogany oil treated plot (7/plant). Neem oil showed moderate control (5/plant). It was found that Diginol 60EC could control the pest to cause knot in jute plant very effectively. Similar result was observed by Yeasmin *et al.* (2013) who found increased plant height and fibre yield with the application of Neem oil. Kabir and Maleque (1974) studied the toxicity of diazinon, dimecron, nogos, birlane and anthio to the larvae of different jute insects. Birlane, nogos and diazinon showed a relatively high order of toxicity and presented similar LD_{50} values.

Conclusion

From the present research three varieties were found comparatively resistant to jute apion among the varieties tested. So, the result of the present research work would be of great importance in controlling jute apion and it could be possible to reduce the use of hazardous chemical insecticides. Therefore, botanicals might be used as an environmentally safe bio-pesticide for management of jute apion in the IPM package.

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