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Md. Nur Alam Miah
Research Scientist & Head, Planning & Development Division, Bangladesh Sugarcrop Research Institute, Ishwardi-6620, Pabna, Bangladesh

Md. Ramiz Uddin Miah
Professor, Department of Entomology, Bangabandhu Sheikh Mujibur Rahman Agricultural University, Salna, Gazipur-1706, Bangladesh

Md. Zinnatul Alam
Professor, Department of Entomology, Bangabandhu Sheikh Mujibur Rahman Agricultural University, Salna, Gazipur-1706, Bangladesh

Md. Mofazzal Hossain
Professor, Department of Horticulture, Bangabandhu Sheikh Mujibur Rahman Agricultural University, Salna, Gazipur-1706, Bangladesh

Md. Enamul Haque
Department of Agricultural Extension & Rural Development, Bangabandhu Sheikh Mujibur Rahman Agricultural University, Salna, Gazipur-1706, Bangladesh

Correspondence
Md. Nur Alam Miah
Research Scientist & Head, Planning & Development Division, Bangladesh Sugarcrop Research Institute, Ishwardi-6620, Pabna, Bangladesh

Integrated management practices against scale insects and mealybugs of sugarcane

Md. Nur Alam Miah, Md. Ramiz Uddin Miah, Md. Zinnatul Alam, Md. Mofazzal Hossain and Md. Enamul Haque

Abstract

The field experiment was carried out at Bangabandhu Sheikh Mujibur Rahman Agricultural University farm, Gazipur during 2015-16 with four replications and six treatments of biopesticides against scale insects and mealybugs of sugarcane. The package P_6 (Sungor 40EC @ 1ml 5 l^{-1} of water applied) produced maximum tillers (288.25 x10^3 ha^{-1}), millable cane (148.50 x10^3 ha^{-1}) and yield (118.80 t ha^{-1}) followed by P_5 (seed treated with 30% fermented cattle urine and 15% neem seed kernel extract solution and sprayed at fortnight interval starting from vegetative stage to harvesting + detrashing of older leaves) 286.00 x10^3 ha^{-1}, 145.50 x10^3 ha^{-1} and 116.40 t ha^{-1}, respectively. Among the packages, the efficacy might be ranked as $P_6 > P_5 > P_2$.The highest benefit cost ratio (BCR) was obtained from package P_6 (3.47) followed by P_5 (3.42). The study revealed that, the package P_5 was the most profitable considering non-chemical management, yield, low cost, environmental safety and BCR.

Keywords: cattle urine, mealybugs, plant extracts, scale insects, sugarcane

Introduction

The cane yield of sugarcane in Bangladesh is only 41 t ha^{-1} [1], but the yield is 71.5 t ha^{-1} and 78.89 t ha^{-1} in Mexico and USA, respectively [2]. The sugar recovery in Bangladesh is 6.61-8.4% while it is higher in other countries such as Brazil (14.5%), Australia (13.8%), USA (11.7%), India (9.9%) and Pakistan (9.2%) [3]. Among the reasons of low production and recovery, the insect pests constitute a major factor. Insect pest causes about 20% yield and 15% sugar loss in sugarcane every year in Bangladesh [4]. The scale insects cause 11.2 – 33.3% reductions in germination and 2.0 to 43.0% decrease in yield and 0.3 – 41.1% loss of juice. On the other hand, 20% yield loss, 21.1 – 30% loss of sugar recovery and 16.2% loss of brix by mealybugs [5]. Due to the scale insects infestation, the loss in germination, weight of canes, juice sucrose content, bulk and purity were 20%, 13%, 47%, 28% and 26%, respectively [6]. The sucrose content decreases 24.1 percent, while the reduction in brix was 16.2 percent by mealybugs infested canes [7].

The occurrence of scale insects and mealybugs causes problems among sugarcane growers. In order to control these pests, a number of chemical insecticides are liberally applied on sugarcane which leads to several problems like toxic residues, elimination of natural enemies, environmental disharmony and development of resistance. Chemical control of insects has been used for a long time, but has serious drawback [8]. Alternative control methods are needed to replace synthetic pesticides to control pests, while covering the environment [9].

To overcome these problems identification of safe molecules with better insecticidal properties having a lower mammalian toxicity with less non-target effects are necessary to use integrated pest management concept. Scientists are diverting their attention worldwide to the animal and plant products due to their biodegradability and safety to natural enemies [10]. Fifty four plant species have been evaluated in Bangladesh against different insect pests, pathogens and weeds [11]. Animal and plant extracts are broad spectrum materials used in pest control and they are safe to apply, unique in action and easily available. They are cheaper and hazard free in comparison to chemical insecticides. They have defensive compounds, which make difficult or impossible for pests to feed and would neither change the taste or smell of the product, nor threaten the consumers or the environment. Therefore, the present study was designed to develop effective and economically viable management packages against scale insects and mealybugs of sugarcane.

2. Materials and Methods
2.1 Experimental site
The experiment was conducted at Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU) farm, Gazipur during cropping season 2015-16 under the Madhupur Tract (AEZ 28) of Bangladesh. The site was situated at the 24.09^0 N latitude and 90.26^0 E longitude on the sub-tropical climatic zone, characterized by heavy rainfall during May to September and scanty rainfall during the rest of the year. Soil of the experimental field was clay loam in texture and acidic in nature with a pH of 5.9 and poor fertility status [12].

2.2 Design and layout of experiment
The experiment was laid out in randomized complete block design with four replications. The plot size was 5 m x 3 m. Blocks were 2 m apart from each other while the plot border was 1 m. Planting was done using conventional sett placement in the trenches. The variety Isd 36 was used as it is reported to be susceptible for scale insects and mealybugs. Twenty two setts were (two eye budded) placed per line, hence eighty eight setts were placed per plot.

2.3 Preparation of fermented cattle urine
Cattle urine was collected from different breeds of Salna, Gazipur. After collection, it was kept underground in earthen pots for 14 days for fermentation. Then 300 ml of fermented cattle urine was diluted with 1 liter of water to make up the concentration 30%. Then lime was added to neutralize the released possible toxic phenols and acids [13].

2.4 Preparation of plant extracts
One hundred fifty grams of neem (*Azadirachta indica*) and mahagoni (*Swietenia mahogani*) seeds was shade dried, crushed and then soaked overnight in one litre of water to get 15% concentration. Then 150 grams of pieces allamanda (*Allamanda cathertica*) leaves were blended with one litre of water to get 15% concentration. The mixture was then squeezed through a muslin cloth [14].

2.5 Application of prepared solutions
The prepared solutions were sprayed using a knap-sack sprayer at fortnight interval starting from the first initiation of the pest attack from May to November as foliar and stem spray.

2.6 Treatment details
Four effective and promising identified treatments were selected based on the results of previous experiments and other conventional practices (cultural, mechanical and chemical) to use in integrated pest management packages. Thus six packages have been designed with one untreated control in this experiment. The tested packages were as follows: P_1- Untreated; P_2- Fermented cattle urine (FCU) @ 30% + Neem seed kernel extract (NSKE) @ 15% solution sprayed; P_3- FCU @ 30% + Mahagoni seed extract (MSE) @ 15% solution sprayed; P_4- FCU @ 30% + Allamanda leaves extract (ALE) @ 15% solution sprayed; P_5- Seed treated with P_2 and sprayed + detrashing of older leaves and P_6- Sungor 40EC @ 1ml 5 l^{-1} of water applied.

2.7 Data collection
Germination percentage, number of tillers and millable cane were recorded. Germination percentage of sugarcane setts were calculated by counting the number of setts placed in each plot and the number of settlings germinated from each plot after 60 days of planting. The numbers of germinated settlings were converted into germination percentage using the following formula [15]:

$$\text{Germination (\%)} = \frac{\text{Number of settlings}}{\text{Total number of buds}} \times 100$$

The number of tillers in each plot was counted at 20 weeks after planting. Number of total millable cane (healthy stalks) was recorded from each plot at harvesting.

2.8 Infestation of scale insects and mealybugs
Data collection on the number of insects was done at fortnight intervals. Pest infestation was recorded in infested plants, leaves and stems. Percent pest infestation and percent effectiveness were calculated using the following formula [15]:

$$\text{Infestation (\%)} = \frac{\text{Number of infested cane}}{\text{Total number of cane}} \times 100$$

$$\text{Effectiveness (\%)} = \frac{\text{Infestation of untreated plot} - \text{Infestation of treated plot}}{\text{Infestation of untreated plot}} \times 100$$

2.9 Yield of cane
Twenty selected sugarcane stalks were harvested randomly at the ground level from each plot and green top as well as dried leaves were removed. The weight of twenty clean stalks was recorded. The cane yield was expressed in ton per hectare based on weight of 20 cane stalks per plot.

2.10 Economic analysis
Costs of cultivation of all packages were recorded to compute the benefit cost ratio (BCR). The management cost for each treatment was calculated by adding the costs incurred for inputs and its application for each package during the entire cropping season. The monetary returns from the harvested cane were calculated at the prevailing mill gate price. Major parameters of economic analysis were computed using following formula [16]:
Gross return = Yield x Sale price
Gross margin = Gross return – Package cost

$$\text{BCR} = \frac{\text{Gross margin}}{\text{Total variable cost}}$$

2.11 Statistical analysis
The collected data were converted to percent infestation to measure the level of incidence and analyzed for comparison using LSD at 0.05 levels for interpretation by Statistix 10 software.

3. Results and Discussion
3.1 Percent germination of buds
The results presented in Figure 1 revealed that the percent germination had significant level in all the treatment packages as compared to untreated (P_1). The highest germination (61.92%) was recorded in Sungor 40 EC @ 1 ml 5 l^{-1} of water applied plot (P_6) followed by P_5 package (58.09%) (Seed treated with P_2 i.e., Fermented cattle urine @ 30% + Neem seed kernel extract @ 15% solution and sprayed at fortnight interval starting from May to November + detrashing of older leaves).

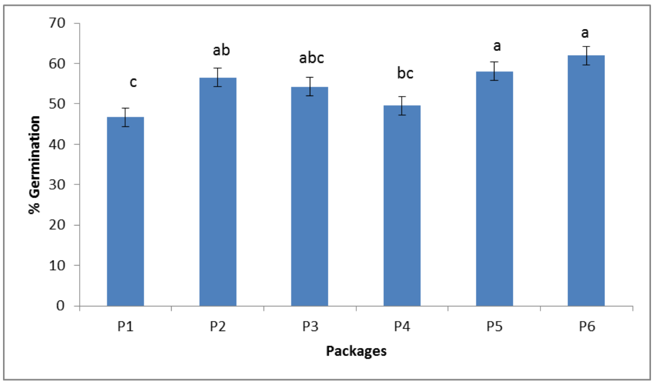

Fig 1: The effects of different packages on germination percentage at BSMRAU research field. [Bars marked with same letter do not differed significantly (P=0.05)]

The lowest germination (46.73%) was recorded in untreated plot (P_1). Package P_2 (FCU @ 30% + NSKE @ 15% solution) 56.53% and P_3 (FCU @ 30% + Mahagoni seed extract (MSE) @ 15% solution) 54.25% also performed better in germinating eye buds of sugarcane by suppressing scale insects and mealybugs. So, package P_5, P_2 and P_3 could be suggested as alternative packages instead of the chemical control package (P_6). Miah *et al.*, 2018 [17] found that spraying of 30% fermented cattle urine solution at 15 days interval is effective against scale insects and mealybugs of sugarcane gave 57.19% germination as compared to untreated plot 43.17%. Akhter, 2014 [16] also found that neem leaf powder 100 Kg ha^{-1} + fermented cattle urine suspension @ 50% gave higher germination (89.72%) while controlling sugarcane termite.

3.2 Effect of different packages on scale insect infestation

Data collected during June to November showed that there was a significant difference among the packages for scale insect infestation compared to untreated. June data showed that the effectiveness of different packages, which ranged from 15.53 – 72.57%, while that of July, August, September, October and November ranged from 10.12 – 60.74%, 14.21 – 52.35%, 13.57 – 47.76%, 20.14 – 49.07% and 18.72 – 46.86% respectively over control. In June to November, better performance was found in P_6 package that gave 72.57, 60.74, 52.35, 47.76, 49.07 and 46.86% effectiveness over control followed by P_5 (60.32, 50.48, 44.50, 41.24, 43.44 and 40.87%) as shown in Table 1. The lowest scale insects infestation was observed in P_6 and it was followed by P_5 in June to November. Miah *et al.*, 2018 [17] found similar effectiveness in 30% fermented cattle urine against scale insects of sugarcane. David and Ananthakrishnan, 2004 [6] suggested that the systematic stripping of leaves reduces incidence of the scale insects.

Table 1: The effect of different packages on scale insects of sugarcane at BSMRAU farm, Gazipur, during cropping season 2014-15

Packages	Pest infestation (%) (mean of 4 replications)					
	June	July	August	September	October	November
P_1	5.47 a	7.21 a	10.20 a	13.19 a	16.18 a	18.69 a
P_2	2.74 b (49.90)	4.32 b (40.08)	6.68 cd (34.50)	8.69 cd (34.11)	10.26 cd (36.58)	12.58 c (32.69)
P_3	3.15 b (42.41)	4.61 b (36.89)	6.94 c (31.96)	9.27 c (29.71)	10.82 c (33.12)	12.70 c (32.04)
P_4	4.62 a (15.53)	6.48 a (10.12)	8.75 b (14.21)	11.40 b (13.57)	12.92 b (20.14)	15.19 b (18.72)
P_5	2.17 bc (60.32)	3.57 bc (50.48)	5.66 de (44.50)	7.75 de (41.24)	9.15 de (43.44)	11.05 cd (40.87)
P_6	1.50 c (72.57)	2.83 c (60.74)	4.86 e (52.35)	6.89 e (47.76)	8.24 e (49.07)	9.93 d (46.86)
LSD (0.05)	1.06	1.03	1.03	1.24	1.45	1.76
CV%	21.55	14.24	9.58	8.65	8.55	8.76

* Figures followed by the same letter (s) are not significantly different at 5% level as per LSD test
* Figures in parentheses are percent effectiveness over control.

3.3 Effect of different packages on mealybugs of sugarcane

The results showed that mealybugs infestation ranged from 2.51 to 6.13% among the treated plots where the untreated plots had 7.47% infestation in May and it was varied significantly over control (Table 2). The lowest mealy bugs infestation (2.51%) was observed in (P_6) with the effectiveness of 66.39% over the control. It was followed by P_5 (52.20%) in May. In June to November, package P_6 gave 66.39, 58.07, 55.69, 50.64, 49.46, 47.43 and 48.33% effectiveness over control followed by P_5 (52.20, 49.94, 45.48, 42.12, 41.37, 40.00 and 40.62%). The efficacy of the treatments can be ranked as $P_6 > P_5 > P_2$. These packages might be applied in suppressing scale insects and mealybugs of sugarcane field. However, the present findings is in agreement with findings of Barapatre and Lingappa, 2003 [18] who found comparable results on effectiveness of cattle urine along with various botanicals against a sorghum shoot fly. David and Ananthakrishnan, 2004 [6] suggested that the systematic stripping of leaves reduces incidence of the mealybugs. Miah *et al.*, 2018 [17] found similar effectiveness in 30% fermented cattle urine against mealybugs of sugarcane.

Table 2: The effect of different packages on mealybugs of sugarcane in the field of BSMRAU farm, Gazipur, during cropping season 2014-15

Packages	Pest infestation (%) (mean of 4 replications)						
	May	June	July	August	September	October	November
P_1	7.47 a	9.97 a	10.97 a	13.96 a	14.96 a	16.95 a	15.95 a
P_2	4.32 cd (42.16)	6.61 c (33.70)	7.39 c (32.63)	9.91 c (29.01)	10.69 c (28.54)	12.27 b (27.61)	11.48 c (28.02)
P_3	4.71 c (36.94)	6.74 c (32.39)	7.52 c (31.44)	10.00 c (28.36)	10.78 c (27.94)	12.33 b (27.25)	11.55 bc (27.58)
P_4	6.13 b (17.93)	8.03 b (19.45)	8.78 b (19.96)	11.41 b (18.26)	12.17 b (18.64)	13.68 b (19.29)	12.93 b (18.93)
P_5	3.57 de (52.20)	5.29 d (46.94)	5.98 d (45.48)	8.08 d (42.12)	8.77 d (41.37)	10.17 c (40.00)	9.47 d (40.62)
P_6	2.51 e (66.39)	4.18 e (58.07)	4.86 e (55.69)	6.89 d (50.64)	7.56 d (49.46)	8.91 c (47.43)	8.24 d (48.33)
LSD (0.05)	1.07	1.02	1.06	1.28	1.35	1.53	1.44
CV%	14.94	10.00	9.30	8.47	8.31	8.23	8.25

* Figures followed by the same letter (s) are not significantly different at 5% level as per LSD test.
* Figures in parentheses are percent effectiveness over control.

3.4 Effect of different packages on tillers, millable cane and yield

No significant difference was observed in number of tillers but significant difference was observed in number of millable cane and cane yield production. From the Table 3, it was observed that the highest number of tillers (288.25 x 10^3 ha^{-1}), millable cane (148.50 x 10^3 ha^{-1}) and yield (118.80 t ha^{-1}) were produced in package P_6 which was statistically similar to package P_5 where number of tillers 286.00 x 10^3 ha^{-1}, number of millable cane 145.50 x 10^3 ha^{-1} and yield 116.40 t ha^{-1}, respectively. The package P_6 performed better in respect to tillers, millable cane and cane yield production. The results of the present findings is comparable with those of Miah *et al.*, 2018 [17] who found that fermented cattle urine @ 30% performed better in respect of yield of sugarcane among different botanical and natural products. Similar results were also reported by Akhter, 2014 [16] incase of neem leaf powder 100 Kg ha^{-1} + fermented cattle urine suspension @ 50% applications.

Table 3: The Effects of different packages on yield parameters during the cropping season 2014-15 at BSMRAU farm, Gazipur

Packages	Tillers (x10^3 ha^{-1})	Millable cane (x10^3 ha^{-1})	Yield (t ha^{-1})
P_1	235.50	100.50 b	80.40 d
P_2	263.75	131.25 a	105.00 abc
P_3	269.00	135.50 a	99.75 bc
P_4	260.75	133.25 a	93.27 cd
P_5	286.00	145.50 a	116.40 ab
P_6	288.25	148.50 a	118.80 a
LSD (0.05)	NS	20.59	17.21
CV%	16.07	10.32	11.17

*Figures followed by the same letter (s) are not significantly different at 5% level as per LSD test.

3.5 Economic analysis

Cost benefit analysis of different tested packages against scale insects and mealybugs is presented in Table 4. The highest BCR was obtained from package P_6 (3.47) and it was founded by P_5 (3.42), while the lowest BCR was found in untreated package P_1 (2.61). Though P_6 was found to be the highest economic package considering yield and BCR, P_5 could be preferred as P_6 included chemical insecticides. Package P_4 was not profitable in compared to other packages. However, package P_2, P_3 and P_5 appears to be more economic and environmentally safer than that of P_6.

Table 4: Cost and return analysis of different packages for sugarcane production against scale insects and mealybugs of sugarcane during the cropping season 2014-15

Packages	Yield (ton ha^{-1})	Gross return (Taka ha^{-1})*	Total production cost (Taka ha^{-1})		Gross margin (Taka ha^{-1})	BCR
			Package cost	Total variable cost		
P_1	80.40	234,768.00	-	89,830.00	234,768.00	2.61
P_2	105.00	306,600.00	7,500.00	97,330.00	299,100.00	3.15
P_3	99.75	291,270.00	6,950.00	96,780.00	284,320.00	3.00
P_4	93.27	272,348.00	5,500.00	95,330.00	266,848.40	2.85
P_5	116.40	339,888.00	9,500.00	99,330.00	330,388.00	3.42
P_6	118.80	346,896.00	10,000.00	99,830.00	336,896.00	3.47

*Price of cane Tk. 2.92/Kg (1USD = 84 Taka)

4. Conclusions

To develop an effective and economically profitable integrated management package (s), current study revealed that the package P_5 is more efficient in controlling scale insects and mealybugs of sugarcane in terms of higher yield, cheaper source, environmental safety and benefit cost ratio. The highest BCR was obtained from package P_6 (3.47) followed by P_5 (3.42). This non-chemical management package P_5, which was almost equally effective to recommended chemical applied package P_6 to ensure higher yield of cane. Though the highest BCR was obtained from package P_6 but package P_5 performed as the second best. However, the fundamental principles of IPM did not support the chemical insecticides only.

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