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Combined Use of Chemical Insecticides and Nitrogen Fertilizer on Growth, Juice Quality and Yield of Sugarcane in Bangladesh

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ABSTRACT

An experiment was carried out at Regional Sugarcane Research Station, Thakurgaon, Bangladesh and Mohan farm, TSM Ltd. Plain (AEZ 1) soils to examine the effects of chemical insecticides viz. Furadan 5G, Lorsban 15G and Razex 4G applied with different levels of nitrogen fertilizer on pest infestation and yield of sugarcane. Among the test chemicals, whether mixed or not mixed with fertilizer Furadan 5G @ 2.0 kg ai ha^{-1}, Lorsban 15G @ 2.25 kg ai ha^{-1} and Razex 4G @ 3.0 kg ai ha^{-1} significantly reduced Top shoot borer and white grub, Rootstock borer and Stem borer respectively at Mohan farm. At RSRS farm, Lorsban 15G @ 2.25 kg ai ha^{-1} and Furadan 5G @ 2.0 kg ai ha^{-1} were more effective in controlling RSB and WGs. Application of nitrogen fertilizer @ N_{180} with three tested chemicals were found superior to other treatments in controlling major pests of sugarcane at both locations. At RSRS farm, Thakurgaon, millable cane (81.04 x 10^3), percent brix (19.99) and cane yield (62.82 t ha^{-1}) recorded with application of nitrogen fertilizer @ N_{180} combined with three test insecticides were statistically similar with those at Mohan Farm.

Key words: Chemical insecticides, nitrogen fertilizer, insect pests, yield, sugarcane.

INTRODUCTION

Sugarcane (*Saccharum officinarum* L.) is one of the most important agro-industrial crops in Bangladesh. It is cultivated on an area of about 0.17 million hectares annually in the north-western part of the country as the only local source of white sugar in Bangladesh. According to BBS (2000), cane yield for the country is about 41 tones ha^{-1}. Sugarcane is a long durable exhaustive crop and depletes a considerable amount of nutrients from soil. The crop is mainly grown under rainfed upland conditions. Most of the soils in Bangladesh are low in organic matter, generally containing less than 1.5%. Bhander *et al.* (1998) reports that 2.5 to 3.0% organic matter are necessary for suitable crop production. Fertilizers play an important role in increasing sugar production mainly because of their influence on cane tonnage. Most cane growers use fertilizers regularly to maintain or gain further increases in cane yield per hectare. Increased yield of sugarcane has been obtained from application of N, P, K to most soils (Tabayoyong and Robeniol, 1962). Raghavaiah and Singh (1980) obtained maximum yield with the application of 100 kg and 150 kg N ha^{-1} in Variety Co 1136 and Co 1148, respectively. Yield potentiality of a crop would not reach a maximum unless proper fertilizer management is made. An eighty five ton cane crop absorbs 122 kg N, 24 kg P, 142 kg K and 48 kg S ha^{-1} from soil

(Bokhtiar *et al.*, 2001). Sugar accumulation in sugarcane is influenced by many factors viz. variety, physiological maturity, management practices and biotic/ biotic stresses (Bata *et al.*, 1997). Due to heavy depletion of soil nutrients, sugarcane soils become less fertile and fail to produce higher yield. Nutrient depletion as well as heavy pest attack are barriers to expected cane yield, which become the major thrust for research. Reviewing the prevailing situation of the locality the present experiment was designed to quantify the magnitude of nutritional deficiencies as well as to recommend suitable insecticides to overcome the cane production problem separately or in combination package of technologies.

MATERIALS AND METHODS

Experimental Site and Soil Characteristics

The experiments were set up in the cropping season of 2005 - 2006 at Mohan farm and RSRS (Regional Sugarcane Research Station) farm, Thakurgaon. The objective was to find out an economically suitable combination of some nitrogen fertilizers and chemical insecticides in reducing the pest infestation to get higher sugarcane yield. Location in sub-tropical region, the soil was sandy loam with pH 4.5 to 5.0, low organic matter (OM) (1.00 to 1.05%), very low total N (0.07 to 0.08 %), exchangeable K 0.15 to 0.17 meq/100g soil and Mg 0.11 to 0.12 meq/100g soil and available P, Zn and S 9 to 11, 0.9 to 1.00 and 7 to 9 (ppm) respectively.

Treatment Details and Fertilizer Application

The experiment comprised two factors, where nitrogen was considered as main factor with 4 levels as follows:
N_0 - Zero kg Nitrogen ha^{-1}
N_{60} - 60 kg Nitrogen ha^{-1}
N_{120} - 120 kg Nitrogen ha^{-1}
N_{180} - 180 kg Nitrogen ha^{-1}
The other factor was chemical insecticides applied in sub-plots with 7 treatments as given in details under the sub-head "Chemical Application'. The treatment combinations were 28 and replicated thrice in Split Plot Design. The sugarcane variety Isd 32 was used as planting material. Urea, Triple superphosphate (TSP), Muriate of potash (MOP) and Gypsum were used as the source of N ,P, K and S respectively. The urea was applied in three equal splits, the first split at the settling establishment stage, the second at tiller completion stage (90 DAP) and the third at grand growth phase (180 DAP) as per schedule. Full amount of Triple superphosphate (TSP), Gypsum and one third of Muriate of potash (MOP) were applied in trenches and thoroughly mixed with soil prior to sett plantation. The rest amount of nitrogen fertilizer and MOP was applied as first and second top dressing at 90 DAP and 180 DAP (days after plantation) respectively. Fertilizers as top dressing were applied at the root zone in furrrows made by spade on both sides of cane rows and then covered with soils.

Planting Technique

Planting was done through conventional sett placement in the trenches. Fertilizer application, irrigation, weeding, mulching and earthing-up were done as per normal cultural practices. Each plot had an area of 5m x 6m in which 6 rows of cane were planted at an interrow spacing of 1m, and 0.45m interplant spacing. Block to block distance was 2m and plot to plot distance was 1m. Plantation was done in November 2005 and harvesting was completed in January 2007 after full maturity of the crop. Pre-germinated settlings of 35-45 days old were transplanted for gap-filling.

Plant Sampling

The number of tillers was counted at 120 days after planting (DAP) and millable cane stalks during harvesting period. Sugarcane yield and its related parameters viz. tiller, millable cane, height, girth, % brix and yield of cane were taken (Table 1 and 2). Data on percent infestation by top shoot borer, rootstock borer, stem borer and white grub population (per 5 clump/ plot) were also recorded at harvest (Table 3 & 4).

Assessment of sugar quality criteria

Juice quality was estimated through brix percent in randomly selected ten canes from each plot. The parameters was recorded from the extracted juice under field condition from standing canes.
Brix refers to the soluble solids present in cane juice. Brix was measured using a hand Refractometer in the field.

Application of Chemical Insecticides:

Insecticides viz. Lorsban 15G @ 2.25 kg ai ha^{-1}, Furadan 5G @ 2.0 kg ai ha^{-1} and Razex 4G @ 3.0 kg ai ha^{-1} were applied in furrows made on both sides of cane rows and incorporated with soils with the help of spade followed by irrigation. The treatment details are:

T_0 - Control
T_1 - Lorsban 15G @ 2.25 kg ai ha^{-1} mixed with fertilizer at planting
T_2 - Lorsban 15G @ 2.25 kg ai ha^{-1} not mixed with fertilizer at planting
T_3 - Furadan 5G @ 2.0 kg ai ha^{-1} mixed with fertilizer at first top dressing
T_4 - Furadan 15G @ 2.0 kg ai ha^{-1} not mixed with fertilizer at first top dressing
T_5 - Razex 4G @ 3.0 kg ai ha^{-1} mixed with fertilizer at second top dressing
T_6 - Razex 4G @ 3.0 kg ai ha^{-1} not mixed with fertilizer at second top dressing

Data collection and analysis:

Data were taken thrice, once in May, once in June and other in August. The yield of canes per plot was recorded at harvest. The data obtained were statistically analyzed by using least significant difference (LSD) test at P=0.05% following analysis of variance.
Data on borer infestation was recorded by counting total and infested canes for individual plot and the borer percent infestation were computed for interpretation and discussion of the result. For white grubs, 5 clumps per plot were dug out 40cm X 15cm to count the number of grubs and beetle (if present) to make a composite sample per plot.

RESULTS AND DISCUSSION

Effects of nitrogen fertilizer

Sugarcane yield and its component viz. tiller, millable cane, height, girth, % brix and yield of cane are shown in (Table 1 and 2). Results recorded at Mohan farm (Table 1) indicate that the treatment N_{180} produced significantly higher number of tillers (187.37 x 10^3 ha^{-1}) followed by N_{120} (170.98 x 10^3 ha^{-1}), which are significantly identical. Higher number of millable cane (78.54 x 10^3 ha^{-1}) in N_{120} followed by N_{180} (77.06 x 10^3 ha^{-1}) and N_{60} (70.04 x 10^3) were observed showing no significant difference with N_o plot. Higher plant height (2.79 m) and cane girth (2.56 cm) were found in N_{180}, which differed significantly from other levels of nitrogen. Brix percentage (19.99%) in N_{180} was statistically and significantly higher than other treatments. The highest cane yield (62.82 t ha^{-1}) was found in the treatment N_{180} followed by N_{120} and N_{60}, which were statistically insignificant. N_0 treatment produces the lowest yield of 48.15 t ha^{-1}, which was statistically insignificant over other treatments. At RSRS farm, N_{180} (181.07 x 10^3 ha^{-1}), N_{120} (176.31 x 10^3 ha^{-1}) produced tillers which were statistically identical followed by N_{60}. Millable cane (81.04 x 10^3 ha^{-1}) produced by N_{180} followed by N_{60} (79.37 x 10^3 ha^{-1}) were significantly higher than N_0 level (73.86 x10^3 ha^{-1}).The treatment N_{180} played important role in increasing plant height of 2.77m that differed significantly from other treatments. In case of cane girth, the highest girth was 2.34cm N_{180} which was identical to N_{120} (2.33 cm).The nitrogen level N_{180} produce higher brix percentage (19.75), which differed significantly from all level of nitrogen including N_0. Treatment N_{180} produced highest cane yield (62.15 t ha^{-1}) that significantly differed over N_{120} (56.56 t ha^{-1}), N_{60} (55.15 t ha^{-1}) and N_0 (41.86 t ha^{-1}) but the levels N_{120} and N_{60} were identical and produced significantly higher yield over N_0 level. Production of higher number of tillers and millable canes might be due to inorganic nutrients applied in combination with organic sources than inorganic sources alone. The findings of the present experiment have some similarities with the results of Chatterjee *et al.*, (1979).

Effects of chemical insecticide

Experiment at Mohan farm, TSM, (Table 1) shows that Lorsban 15G and Furadan 5G whether mixed or not mixed with fertilizer produced tillers, which are statistically similar ranging from 178.47 x 10^3 ha^{-1} to 163.38 x 10^3 ha^{-1}.The treatment Lorsban not mixed with fertilizer produced higher millable cane (83.20 x 10^3 ha^{-1}), than other treatments followed by Lorsban 15G @ 2.25 kg ai ha^{-1} mixed with fertilizer (78.44X10^3 ha^{-1}).Razex 4G treated plot produced significantly taller (2.66m) plant when applied alone followed by Razex 4G mixed with fertilizer (2.61m). Other treatments though showed significant difference in plant height, the plant height yet could not reached that of Razex 4G applied singly. In case of plant girth, no significant difference was observed among the treatments. Significant differences were observed among the treatments in case of brix percentage although Furadan 5G applied alone produced higher percentage (19.75) followed by Furadan 5G mixed with fertilizer (19.50%). Significantly higher cane yield (61.60 t ha^{-1}) was found in Lorsban 15G not mixed with fertilizer followed by Furadan 5G (61. 54 t ha^{-1}) and (61.47 t ha^{-1}) either applied singly or in combination with fertilizer showed 33.53-33.39% yield increase over control.

Tiller production significantly increased with the application of Lorsban 15G mixed or not mixed with N-fertilizer followed by Furadan 5G mixed with fertilizer (Table 2). Control plot produced the lowest (116.04) number of tillers compared to other treatments. Lorsban 15G mixed with fertilizer produced the highest number of millable cane (87.80 x 10^3 ha^{-1}) followed by alone application of Lorsban 15G. Plant height was almost similar among the treatments, which were statistically different from control (T_0). Higher girth (2.42 cm) was found in Furadan 5G mixed with fertilizer followed by Lorsban 15G (2.36 cm) mixed with fertilizer. Though Brix percentages were identical among the treatments, higher brix was recorded in Furadan treated plots, but the difference was insignificant. The highest cane yield 61.43 t ha^{-1} was found in Lorsban 15G not mixed with fertilizer followed by Furadan 5G (61. 16 t ha^{-1}) and these were statistically identical. Result indicated that Furadan 5G mixed with fertilizer or not mixed had similar response giving no differences in yield.

Results presented in Table 3 and 4 show that all the insecticides significantly reduced TSB infestation over control where the efficacy ranged from 37.66-73.78% and 52.09-86.40% at RSRS farm and Mohan Farm respectively. Furadan 5G (mixed or not mixed with fertilizer) performed better in top shoot borer control, which gave 71.56-73.78% efficacy at RSRS farm and 84.57-86.40% efficacy at Mohan farm in controlling TSB. Biswas *et al.*, (2005) suggested that application of carbamate insecticides against white grubs @2.0 kg ai ha^{-1} and the same dose rate was also recommended for the control of TSB. Lorsban 15G mixed with fertilizer also performed better that gave 81.17% reduction of TSB over control at Mohan farm. Lorsban 15G at two level of application gave 81.10-81.35% efficacy reducing Rootstock borer infestation which is enough to be recommended for pest control (Table 4). Alam *et al.*, (2006) reported that Pyriban 15G @ 2.25 kg ai ha^{-1} had showed better performance against rootstock borer, which is in conformity with the present findings. For the control of Stem borer, Razex 4G either mixed or not mixed had positive response giving 79.53-83.66% effectiveness over control plot at Mohan farm it gave 72.99-76.64% effectiveness at RSRS farm. Abdullah *et al.* (2005) found that the cartap insecticides applied at 3.0 kg ai ha^{-1} significantly controlled stem borer. Furadan 5G produced satisfactory reduction of white grub population showing 80.89-81.49% effectiveness at RSRS farm while in Mohan farm it showed 74.82-76.95% effectiveness over control. The present work is at par with the findings of Miah *et al.*, (1986) who reported that the effects of different insecticides on white grubs, among which Furadan (carbofuran) at 2.00 kg ai ha^{-1} significantly controlled white grubs. Lorsban 15G not mixed with N-fertilizer recorded 82.87% reduction of white grub at Mohan farm. All the insecticides either mixed or not with different N-level of fertilizer at RSRS and Mohan farm showed better performance in lowering the target pests at significant level.

Conclusion

- Based upon the present findings following conclusion can be made for the control of major pests particularly TSB, RSB, SB and WG thereby securing the cane production for the pest prone/endemic locality.
- Application of nitrogen fertilizer @ 180 kg ha^{-1} was found effective in increasing sugarcane yield and thus in minimizing the cost of production.

- Application of insecticides like Furadan 5G @ 2.0 kg ai ha^{-1}, Lorsban 15G @ 2.25 kg ai ha^{-1} and Razex 4G @ 3.0 kg ai ha^{-1} were found effective in controlling TSB, WG, RSB and SB of sugarcane respectively.
- Further experimentation may be needed before final recommendation of the insecticides.

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Table 1. Yield and yield attributing characters as affected by nitrogen fertilizer levels and chemical insecticides applied in sugarcane at Mohan farm, Thakurgaon Sugar Mills Ltd., 2005-2006

Treatments	Tiller (x 10^3 ha^{-1})	Millable cane (x 10^3 ha^{-1})	Height (m)	Girth (cm)	% Brix	Yield (t ha^{-1})
Nitrogen fertilizer levels (kg ha^{-1})						
N_0	123.72 b*	64.74 c	2.14 c	1.87 d	18.15 b	48.15 c
N_{60}	132.75 b	70.04 b	2.16 c	2.28 c	18.78 b	55.23 b
N_{120}	170.98 a	78.54 a	2.53 b	2.41 b	18.98 b	57.27 b
N_{180}	187.37 a	77.06 ab	2.79 a	2.56 a	19.99 a	62.82 a
LSD (5%)	17.78	5.83	0.19	0.12	0.95	2.26
Chemical Insecticides						
T_0	126.99 c	59.92 d	2.05 f	1.97 b	18.21 c	40.94 d
T_1	178.47 a	78.44 b	2.25 e	2.45 a	19.31 ab	59.45 ab
T_2	173.35 a	83.20 a	2.38 d	2.40 a	19.02 abc	61.60 a
T_3	172.86 a	67.68 c	2.49 c	2.44 a	19.50 ab	61.47 a
T_4	169.38 a	65.61 c	2.54 bc	2.46 a	19.75 a	61.54 a
T_5	141.57 b	61.37 d	2.61 ab	2.32 a	18.94 abc	56.71 bc
T_6	144.02 b	60.75 d	2.66 a	2.39 a	18.90 bc	56.10 c
LSD (5%)	12.92	3.40	0.11	0.15	0.85	2.78

Table 2. Yield and yield attributing characters as affected by nitrogen fertilizer levels and chemical insecticides applied in sugarcane at RSRS farm, Thakurgaon Sugar Mills Ltd., 2005-2006

Treatments	Tiller (x 10^3 ha^{-1})	Millable cane (x 10^3 ha^{-1})	Height (m)	Girth (cm)	% Brix	Yield (t ha^{-1})
Nitrogen fertilizer levels (kg ha^{-1})						
N_0	137.66 b*	73.86 b	2.09 d	2.01 c	18.18 b	41.86 c
N_{60}	162.83 ab	79.37 a	2.41c	2.20 b	18.69 b	55.15 b
N_{120}	176.31 a	77.60 a	2.55 b	2.33 ab	18.81 b	56.56 b
N_{180}	181.07 a	81.04 a	2.77 a	2.34 a	19.75 a	62.15 a
LSD (5%)	28.95	11.85	0.12	0.13	0.85	2.46
Chemical Insecticides						
T_0	116.04 d	67.64 d	2.07 b	2.02 d	18.59	41.09 d
T_1	207.97 a	87.80 a	2.56 a	2.36 ab	19.23	57.28 b
T_2	206.49 a	85.07 b	2.49 a	2.23 bc	18.87	61.43 a
T_3	171.60 b	74.65 c	2.48 a	2.42 a	19.46	61.02 a
T_4	163.72 bc	74.69 c	2.50 a	2.17 cd	19.28	61.16 a
T_5	156.07 c	68.53 d	2.56 a	2.20 bcd	18.95	54.19 c
T_6	160.60 c	69.70 d	2.51 a	2.25 abc	18.87	55.77 bc
LSD (5%)	10.11	3.39	0.17	0.18	NS	2.91

* In a column, means followed by the same letters are not significantly different at 0.05 level (LSD)

Table 3. Effectiveness of chemical insecticides in controlling some major pests of Sugarcane at RSRS farm, Thakurgaon Sugar Mills Ltd., 2005-2006

Treatments	% pest infestation/ population (Mean of 3 replications)							
	TSB		RSB		SB		WG	
	Mean	% efficacy	Mean	% efficacy	Mean	% efficacy	Mean	% efficacy
T_0	35.13 a*	-	85.90 a	-	13.44 a	-	13.50 a	-
T_1	19.55 b	44.35	15.39 d	82.08	5.09 bc	62.13	3.58 d	73.48
T_2	17.84 b	49.22	21.37 d	75.12	4.82 bcd	64.14	3.58 d	73.48
T_3	9.21 c	73.78	49.31 c	42.60	5.95 b	55.73	2.50 d	81.49
T_4	9.99 c	71.56	64.57 b	24.83	3.87 cd	71.21	2.58 d	80.89
T_5	20.53 b	41.56	71.40 b	16.88	3.14 d	76.64	5.41 c	59.93
T_6	21.90 b	37.66	71.40 b	16.88	3.63 cd	72.99	6.75 b	50.00
LSD (5%)	4.11	-	8.08	-	1.82	-	1.25	-

TSB = Top shoot borer, SB = Stem borer, RSB = Rootstock borer and WG = White grub
* In a column, means followed by the same letters are not significantly different at 0.05 level (LSD)

Table 4. Effectiveness of chemical insecticides in controlling some major pests of Sugarcane at Mohan farm, Thakurgaon Sugar Mills Ltd., 2005-2006

Treatments	% pest infestation/ population (Mean of 3 replications)							
	TSB		RSB		SB		WG	
	Mean	% efficacy	Mean	% efficacy	Mean	% efficacy	Mean	% efficacy
T_0	4.78 a*	-	63.37 a	-	15.73 a	-	12.67	-
T_1	0.90 c	81.17	11.82 d	81.35	6.32 b	59.82	2.92	76.95
T_2	1.11 c	76.78	11.98 d	81.10	5.59 b	64.46	2.17	82.87
T_3	0.74 c	84.57	21.37 c	66.28	6.25 b	60.27	3.19	74.82
T_4	0.65 c	86.40	27.38 c	56.79	4.94 b	68.60	2.92	76.95
T_5	2.06 b	56.90	41.56 b	34.42	2.57 c	83.66	6.11	51.78
T_6	2.29 b	52.09	39.08 b	38.33	3.22 c	79.53	6.22	50.91
LSD (5%)	0.73	-	7.32	-	1.55	-	NS	-

TSB = Top shoot borer, SB = Stem borer, RSB = Rootstock borer and WG = White grub
* In a column, means followed by the same letters are not significantly different at 0.05 level (LSD)