Annals of Plant and Soil Research 25(3): 373-380 (2023)
https://doi.org/10.47815/apsr.2023.10281

Formulation and validation of IPM module of sugarcane insect pests in current climatic scenario

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Received:
Received: May, 2023; Revised accepted, July, 2023

ABSTRACT

The experiment was conducted with variety BO-154 at Pusa Farm, Sugarcane Research Institute, RPCAU, Pusa during cropping season of 2018-19 and 2019-20 to study the formulation and validation of IPM module of sugarcane insect-pests. The IPM module significantly improved germination, number of millable canes/ha and cane yield (kg/ha) by15.04%, 19.5% and 16.8%, respectively, over farmer practices. Similarly, in growth parameters, millable cane height (4.0 %) and number of internodes (3.07 %) increased over farmer practices. The incidence percentage of borer pests were reduction over farmer practices varied from 16.4 to 59.2 and maximum (59.2 %) incidence reduction was noticed with stalk borer. In case of sucking pests, maximum (52.27) reduction in incidence of pyrilla and minimum (21.34%) reduction with mealy bug over farmer practices. Quality parameters, viz, brix, sucrose, purity and CCS improved over farmers practice by 3.31%, 3.79%, 1.71% and 3.34%, respectively. Hence, it may be inferred from the results that the IPM module has potential to increase yield, growth and quality parameters and reduction in insect-pests incidence in sugarcane crop.

Keywords: Formulation, validation, IPM, module, sugarcane

INTRODUCTION

Sugarcane, *Saccharum officinarum* L. belonging to the family Poaceae and can be cultivated under diverse agro climatic conditions. It is an important commercial crop of Indian agriculture, providing raw material to sugar industry, the second largest agro-based industry after textiles. Sugarcane also supports two important rural and cottage industries, namely jaggery and khandsari (unrefined raw white) sugar. In addition, some by-products of sugar industry, such as molasses, bagasse and press-mud, serve as raw material for alcohol-based industry, power generation and organic fertilizers, respectively. Green tops of cane are good source of fodder for cattle. Sugarcane area, production and productivity figures have steadily increased over the decades alongside the growth of sugar industry. It has contributed significantly to the growth of Indian Agriculture and National Gross Domestic Products. India occupies an important position among the sugarcane producing countries and has a neck to neck race with Brazil for the first position. There are two distinct agro-climatic regions of sugarcane cultivation in India, viz., tropical and subtropical. Tropical region has about 45% area and contributes 55% of the total sugarcane production in the country. Thus, sub-tropical region accounts for 55% area and shares 45% of total production of sugarcane. It productivity is generally limited by abiotic and biotic stresses as it has to face vagaries of nature all the year around in the field. Among these, pests are known to inflict considerable loss in cane yield as well as sugar output (David and Nandagopal, 1986).

The pest management in the sugarcane crop is very challenging; the crop is of long duration and attacked by wide range of insect-pests throughout the growth stages (Williams, 1931; Box, 1953; Williams *et al.,* 1969). Though the majority of these are minor pests, a few major pests exist and cause significant damage to all parts of the crop (i.e. root, stalks, and foliage) (Williams *et al.,* 1969; Hall, 1988). Sugarcane crop is affected by approx 125 major insect pests throughout the world (Shivashankara and Kumar, 2018). According to Dhaliwal *et al.* (2015), 20% yield loss which is 88.04 million tonnes yield loss caused by insect-pests in sugarcane.Integrated Pest Management (IPM) is an ecological approach to pest management which carefully considers the suitable pest management techniques to keep

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the pest population below economic threshold level. It uses traditional crop cultivating practices combined with the knowledge on life cycle and ecology of the pest (Ahmed *et al.,* 2016). It is an adaptation to the behavioral cycles and the life of insects from various IPM approaches (Petit *et al.,* 2003). The reason IPM has gained momentum in its popularity because this approach is cheaper and ecologically sound. IPM takes into account the entire methods, namely chemical, biological, bio-technical, agronomic practices, physical procedures and plant quarantine. Sugarcane crop is attacked by a wide range of insect pests all through its crop growth stages (Williams, 1931; Box, 1953; Williams *et al.,* 1969).Application and exposure of broad-spectrum pesticides significantly minimize natural enemies in field conditions and continuous and indiscriminate use of pesticides over many decades led to a negative impact on the environment as well as in human health due to residues of pesticide. As pesticides are very costly, farmers spend a major portion of the amount to purchase synthetic pesticides. Therefore, an eco-friendly approach to control pests was a better alternative for chemical control. So, developing Integrated Pest Management package with effective physical, cultural, mechanical, biological methods and safer insecticides facilitate to achieve sustainable yield, quality and monitory benefits to farmers and sugar mills and brings out green environment.

MATERIALS AND METHODS

To study Formulation and validation of IPM module of sugarcane insect pests in current scenario, field experiments were conducted at Dr.Rajendra Prasad Central Agriculture University, Pusa, Samastipur district of Bihar during the period of 2018-19 and 2019-20 under All India Coordinated Research Project on sugarcane. The Experimental site is located at bank of Burhi Gandak River, a tributary of the Ganga River which flows throughout the year and is a major source of irrigation. It is situated at altitude of 53 meter from mean sea level, $25^{0}98^{'}$ N latitude and $85^{0}64^{'}$ E longitude. Climate of this region is semi-humid and subtropical region. Field layout was designed with two blocks i.e. IPM practices and farmer practices. Ridges and furrows were prepared with half acre plot size for treated and untreated separated by keeping 100 meter distance. Variety BO 154 was selected for planting of sugarcane and followed all recommended practice of SRI, Pusa. The details of IPM practices and farmer practices are given below:

Table 1: Practices carried out for the treatment-1: IntegratedPest Management block

Stage of the cultivation/Period	Target pest	Activities need to be carried out
Seed selection	Borer comples, Mealy bug, Scale insect	➢ Selection from uninfested field. ➢ Rejecting infested pieces.
Pre-planting	Borer comples, Mealy bug, Scale insect	➢ Dipping the setts for 2 minutes in the solution of chlorpyriphos 20 EC @ 40 ml in 10 litre of water. ➢ Ploughing for exposure of different stages of insect for predation.
At planting	Borer complex	➢ Soil application of chlorantraniliprole 0.4 G @ 22.5 kg/ha at the time of planting.
At 45 day	Borer complex	➢ Collection and destruction of egg masses and damaged shoots. ➢ Setting up of sex pheromone traps two weeks after planting @ 27/ha (Lure change at an interval of 45 days).
At 60 day	Borer complex Pyrilla, scale insect, mealy bug	➢ Spraying of chlorantraniliprole 18.5 SC @ 375 ml/ha at 60 DAP
At 90 day	Borer complex, Pyrilla, scale insect, mealy bug	➢ Detrash the lower leaves, remove egg masses and infested canes.
At 150 day	Stem borer, Plassey borer, Mealy bug, Scale insect, Whitefly, Pyrilla	➢ Release of *Epiricania (=Fulgoreica) melanoleuca* @ 2000 cocoons and 250 egg mass/ha for the management of pyrilla. ➢ Detrash the lower leaves after 150 days of planting
At 180 day	Stem borer,Plassey borer	➢ Removal of water shoots of the crop.
At 210 day	Stem borer,Plassey borer	➢ Removal of water shoots of the crop.
At 240 day	Stem borer,Plassey borer	➢ Removal of water shoots of the crop.
June-July	Pyrilla, whitefly, Scale insect, Mealy bug	➢ Installation of 'Biological-cum-Mechanical' traps @ 20/ha during first fortnight of June for management of whitefly. ➢ Spray clothionidin 50 WDG @ 250 g/ha after detrash lower leaves.

Treatment 2. Farmer's practices

- Soil application of carbofuran @ 1 kg ai/ha at pre-planting
- Soil application of carbofuran @ 1 kg ai/ha at 30 and 150 DAP.
- Application of insecticide Quinalphos 25 EC @ 300 g ai/ha through ground spraying at the appearance of pest.

Observation and calculation of percentage incidence of borer

Observations were taken from second week of March and percentage incidence of early shoot borer, top borer, root borer and stalk borer were calculated as per following procedure.

Early Shoot borer

Early shoot borer incidence was monitored from 30 days after germination up to 120 days after germination at 30 days interval (*i.e.,* 60, 90 and 120 DAP). Regular observations done randomly in the middle rows of each plot. Dead heart symptom and shot holes at base of the canes were observed and recorded out of the total number of shoots observed.

Top borer

Top borer observations were recorded during last week of June to first week of July Observations were done at each plot for minimum three-meter row length. Dead heart and bunchy top symptoms were observed in top borer infected canes. Total number of canes observed and number infected canes were noted down for further investigation.

Plassey borer and Stalk borer

Younger stage feeds on the leaf and tunnels towards the stem, this is gregarious stage which feeds voraciously and makes tunnel into cane, sometimes extending up to eight internodes. Fresh wet shiny frass material, entry and exit holes were seen under the leaf sheath. Observations were made twice per week from July to harvest. Randomly selected plants were observed and infected numbers of plants were noted down for further investigation. At the time of harvest twenty-five canes were randomly splitted and internally damaged internodes were noted down.

Root borer

Root borer feed underground portion of the cane which causes dead heart symptom, the cane cannot be pulled out easily. Minimum 25 canes were chosen randomly from each plot at monthly interval *viz.,* 60, 90 and 120 DAP and total number of cane with dead heart and infected underground portion of were counted.

Borer incidence were calculated using following formula

$$\text{Borer incidence (\%)} = \frac{\text{Number of affected canes}}{\text{Total Number of canes observed}} \times 100$$

Observation and calculation of sucking pest

Observations of sucking pests like Pyrilla/ leaf (Upper, middle, lower), white fly /sq.cm (Upper, middle, lower), % mealy bug and % scale insect infestation were recorded from 25 cane randomly selected at four different corners and average per plant was noted.

Germination percentage (%)

Germination was observed at 60 DAP from different sample area and result was expressed in per cent.

Number of millable cane ('000/ha)

All canes from randomly selected plots of each treatment module were harvested, detrashed, counted and computed for whole experimental area and result was expressed as number of millable cane per hectare.

Cane yield (kg/ha)

All canes from randomly selected sample units from each treatment module were harvested, detrashed, weighed and result was expressed in kg per hectare.

Quality parameters

For each treatment randomly three canes were selected and juice was extracted. Brix percentage was calculated with the help of hand refractometer.

RESULTS AND DISCUSSION

Impact on Yield parameter

The data presented in Table 1 revealed that germination (%), number of millable canes (000/ha) and cane yield (kg/ha) being 39%, 122795 and 8915, respectively in IPM block whereas in Farmer practices block 33.9%, 102709 and 7630. This shows an increment over farmer practices under yield parameter characters by 15.04 %, 19.5 % and 16.8%, respectively.

Table 1 : Impact of treatments on yield parameter of sugarcane

Treatment	Yield parameter (Mean of 2018-19 & 2019-20)					
	Germination (%)	% increase over farmer practices	No. of millablecane (000/ha)	% increase over farmer practices	Cane yield (kg/ha)	% increase cane yield over farmer practices
IPM block	39.0	15.04	122795	19.5	8915	16.8
Farmer practices	33.9	-	102709	-	7630	-

Impact on Growth parameter

In growth parameters (Table 2), mean millable cane height (271.5 cm) and number of internodes (20.80) were recorded in IPM block whereas in Farmer practices block 261 cm and 20.18. IPM block compared to Farmer practicesshows an increment of 4.0 % and 3.07 % with respect to millable cane height and number of internodes, respectively.

Table 2: Impact of treatment on growth parameter of sugarcane

Growth parameter (Mean of 2018-19 & 2019-20)			
Millable cane height (cm)	% increased over farmer practices	No. of internodes	% increase over farmer practices
271.5	4.0	20.80	3.07
261	-	20.18	-

Impact on borer pest

The percent incidence of borer complex i.e. root, shoot, top, stalk and plassey borer were observed being 6.13, 7.3, 9.7, 2.01 and 4.5, respectively in IPM block whereas Farmer practices block 8.04, 8.5, 11.9, 3.2 and 5.9.The incidence percentage of borer pests were reduction over farmer practices being 31.15 % (root borer), 16.4% (shoot borer), 22.7% (top borer), 59.2% (stalk borer) and 31.1% (plassey borer) respectively.

Table 3: Impact of treatment on borer pest of sugarcane

Treatment	Per cent incidence of borer pest(Mean of 2018-19 & 2019-20)									
	Root borer	% reduction farmer practice	Shoot borer	% reduction over farmer practices	Top borer	% reduction over farmer practices	Stalk borer	% reduction over farmer practices	Plassey borer	% reduction over farmer practices
IPM block	6.13	31.15	7.3	16.4	9.7	22.7	2.01	59.2	4.5	31.1
Farmer practices	8.04	-	8.5	-	11.9	-	3.2	-	5.9	-

Impact on sucking pest

The incidence of sucking pests i.e.pyrilla (number of pyrilla/leaf), whitefly (number of whitefly/sq. cm), Mealy bug (% incidence) and Scale insect (% incidence) observed being 4.4, 1.1, 8.9 and 4.8, respectively in IPM block whereas in Farmer practices block 6.7,1.5,10.8 and 6.7.The IPM block shows reduction in infestation of sucking pest over farmer practices by 52.3% (pyrilla), 36.4 % (white fly), 21.34% (mealy bug) and 39.6 % (scale insect) respectively.

Table 4: Impact of treatment on sucking pest of sugarcane

Treatment	Incidence of sucking pest (Mean of 2018-19 & 2019-20)							
	No. of Pyrilla/ leaf	% reduction over farmer practices	No. of Whitefly/ sq. cm	% reduction over farmer practices	Mealy bug (%) incidence)	% reduction over farmer practices	Scale insect (%incidence)	% reduction over farmer practices
IPM block	4.4	52.3	1.1	36.4	8.9	21.34	4.8	39.6
Farmer practices	6.7	-	1.5	-	10.8	-	6.7	-

Impact on quality parameters

IPM block shows improvement in quality parameters as compared to farmer practices. The quality parameters like brix %, sucrose %, purity % and CCS % were recorded 18.7,16.4,88.9 and 11.28, respectively in IPM block, whereas in farmer practices block 18.1,15.8,87.4 and 10.9. The percentincrement in quality parameter viz brix %, sucrose %, purity % and CCS % in IPM block showed an improvement over farmer practices by 3.3%,3.8%,1.7% and 3.34%, respectively.

Table 5: Impact of treatment on quality parameters of sugarcane

Treatment	Quality parameters (Mean of 2018-19 & 2019-20)							
	Brix (%)	% increased over farmer practices	Sucrose (%)	% increased over farmer practices	Purity (%)	% increased over farmer practices	CCS (%)	% increased over farmer practices
I PM block	18.7	3.3	16.4	3.8	88.9	1.7	11.28	3.34
Farmer practices	18.1	-	15.8	-	87.4	-	10.9	-

Hence, it may be inferred from the results that the IPM module has potential to increase yield, growth and quality parameters and reduction in insect pests incidence in sugarcane crop. Present finding fully supports the findings of Jaipal (2000) who adopted six ecology-based approaches viz. timing irrigation and urea application, mechanical removal of damaging stages of pests and crop residues, earthing up, propping of cane stalks, liberation of egg parasitoid (*Trichogramma chilonis*) and foliar N application. In Chain Zeng, 2004 described management of sugarcane pests using plant quarantine, cultural control, physical control, biological control, chemical control and use of semiochemicals, where cultural control has been regarded as the basis, natural enemies are conserved and effectively utilized and both biological control and chemical control are well co-ordinated for creating such an environment that is suitable for sugarcane growth but not for pest occurrence resulting in high yield and sugar recovery.

The extent of damage done by the mealy bugs can be very severe and reduce the yield significantly. Germination, cane growth, cane yield, percentage juice extraction, juice quality and jaggery production can be affected by sucking insects. Similar study had done by Kalra and Sindhu (1964) found that cane infested with mealy bugs can reduce the sucrose content by 24.1 per cent and reduction in brix by 16.2 per cent. Gupta (1948) found that a severe infestation of Pyrilla results in poor quality jaggery and jaggery production is reduced by 2.2-4.5 per cent. The scale insect reduced the germination 11.3 per cent in Co 740 and 21.4 per cent in Co 419 (Thontadarya and Govindan, 1976). Scale insect infestation also reduces cane growth, Sathiamoorthy and Muthukrishnan (1978) found a decrease in cane height by 5.5 per cent and cane girth reduced by 19.1 per cent in Co 419 variety. Khanna (1957) observed a reduction of 43 per cent in cane weight and 8 per cent in sucrose content in variety BO 11 in Bihar. A healthy seed selection helped in reducing the infestation of scale insect, (Thontadarya and Govindan, 1976). Detrashing helps to reduce the incidence of scale insect to a great extent (Khanna, 1957). Prabhakara *et al.,* (1976) found that infestation of scale insect can be reduced up to an extent of 70 %. *Epiricannia melanoleuca* is a parasitoid which successfully controls the population of *Pyrilla perpusilla* (Kalra, 1973).

Seneviratne and Kumarasinghe (2002) released the eggs of the ecto-parasitoid *Epiricania melanoleuca* in sugarcane plantations and found that within a period of 2 years the population of the Pyrilla reduced from 68 individuals per leaf to just 1 individual per leaf. Sharma and Shera (2021) studied the exposure of this parasitoid to the different nymphal stage of the Pyrilla and found that exposure of parasitoid to the first, second, third, fourth and fifth nymphal stage resulted in 100.0, 94.0, 75.0, 38.0 and 41.0 per cent mortality of the nymphs.

The borer pest of sugarcane is a major problem in sugarcane production, because the stem is the economical part of the plant. Throughout the growth period, one or the another borer pest infests the crop. The shoot borer, *Chilo infuscatellus* Snellen arrives early and can damage up to 26-65 per cent damage to the mother shoot and 6.4, 27.1 and 75 per cent damage to the primary, secondary and tertiary tillers, respectively (Krishnamurthy Rao, 1954). The top borer in Bihar may appear in severe form and may cause 100 per cent mortality of the young shoots however, with the growth of the crop the damage due to top borer decreases (Agarwala and Prasad, 1956). Gupta and singh (1951), observed that with infestation of 29 per cent cane yield is reduced by 17-33 per cent and sugar recovery is reduced by 1.7-3.7 unit. Gupta and Sarma (2007) found that Plassey borer infestation caused reduction in cane weight, juice weight and bagasse weight by 28.0, 29.6 and 24.0%, respectively. This damage also resulted in maximum reduction in brix, sucrose, glucose, and CCS was 14.1, 18.4, 58.1 and 20.4%, respectively. Biological control is a major component in the IPM module. The extent of control over pest population can be increased by using biocontrol agents. Ullah *et al.,* (2012) compared the efficacy of insecticides viz. Basudin 60 EC (T1) and Furadan 3G (T2) compared with *Trichogramma chilonis* (T3) against sugarcane stem borer, *Chilo infuscatellus* Snellen. He found that all the three treatments were effective for the management of stem borer. However, the percent parasitism by T*. chilonis* in T1, T2, T3 and control plot was 8.70, 7.91, 50.46 and 12.54, respectively. This shows that pesticides affect the biocontrol agents in the field. Also, the cost and benefit analysis show that maximum return was obtained from trichocard released plot (84.78). A similar result was obtained by Rao *et al.,* (2006) by adoption of integrated pest management practices, a lower incidence of shoot borer, internode borer and scale insect wasobserved. Detrashing, trash mulching, use of *Trichogramma chilonis* and chemical control was followed in the IPM package of practice. The IPM module increased the yield by 20.86 t/ha. Similarly, Visalakshi *et al.,* (2016) obtained an enhanced yield of 14.34 t/ha in IPM module as compared to farmer’s plot. The IPM package included trash mulching @ 3 t ha^{-1} at the time of planting and field release of *Trichogramma chilonis*@ 50, 000 ha^{-1} four times at an interval of 7-10 days starting from 30 DAP and twice after node formation which reduced the incidence of shoot borer and internode borer by 78.31 % and 88.38 %, respectively.

CONCLUSION

The IPM practice followed has the potential to increase yield, growth and quality parameters and reduce the incidence of insect-pests in sugarcane crop. It is desired to know the complete ecology of the crop and the pest and attack the weakest link of the pest. IPM not only target to manage the pest population but also reduce the cost of cultivation. Thus it is desirable that IPM will become more researched topic in near future because it is cheaper and ecofriendly.

ACKNOWLEDGEMENT

We are thankful to Director SRI, RPCAU, Pusa for providing all the necessary facilities during the study and his extensive support.

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