ISBN 81-85871-83-3

STAI

PROCEEDINGS

74th Annual Convention

28th - 30th July 2016, Delhi

THE SUGAR TECHNOLOGISTS' ASSOCIATION OF INDIA

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A SETT TREATMENT DEVICE FOR FUNGAL DISEASE MANAGEMENT AND HEALTHY NURSERY PROGRAMME IN SUGARCANE

R. Viswanathan[1*], P. Malathi[1] & Ravindra Naik[2]

ABSTRACT

A practically feasible mechanized means of sett treatment in comparison with conventional overnight soaking for the management of red rot with fungicides were standardized earlier at ICAR-Sugarcane Breeding Institute (SBI). Further, larger size sett treatment devices (STD) were fabricated and validated for fungal disease management and healthy nursery programme. Results of the present investigation clearly established that the sett treatment in combination with other delivery methods viz., spraying and soil application/ micro irrigation were highly effective against major fungal diseases of sugarcane such as red rot, smut and wilt. The efficacy of fungicide treatment was validated under disease endemic locations in Cauvery delta in Tamil Nadu with disease susceptible varieties. Sett treatment alone was able to protect the setts from sett and soil borne inocula of all the three diseases and along with other delivery methods significantly improved plant survival and correspondingly a higher yield. Also the applicability of sett treatment device in delivering various other inputs viz. fungicide, insecticide, biofertilizers, macro- and micro nutrients was validated at two sugar factories in Erode and Namakkal Districts in Tamil Nadu and standardized the combinations for healthy nursery programme in sugarcane. The study indicated that the mechanized treatment has several advantages such as possible to treat different kinds of sugarcane planting materials, simultaneous delivery of compatible inputs before planting, economical in terms of chemical usage as it requires less quantity of chemical/ input with repeated use, rapid

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and less cumbersome, amenable for large scale application under farmer's field conditions and possible to adopt this technology for treating planting materials of major vegetatively propagated crops other than sugarcane. The new device has opened new vistas towards effective management of major fungal diseases and healthy nursery programmes in sugarcane.

Keywords: Sugarcane, fungal diseases, sett treatment device, delivery methods, agro-inputs.

INTRODUCTION

Sugarcane is a major industrial crop of the country grown in about 5.0 million hectares in both tropical and subtropical regions. The crop productivity is affected by a number of biotic and abiotic stresses in the field. Effective management of a stress is associated with cropping pattern and operability of a management practice. As sugarcane is propagated through vegetative cuttings (setts), seed canes serves as a source for infection of most of the pathogens persists and this results in disease development to an epidemic proportion/ situation. Besides, the pathogens causing red rot and wilt diseases survive in the soil and infect planting material immediately after planting. Hence sett treatment plays an important role in protecting the crop from sett and soil-borne inoculum of fungal pathogens during their initial growth period.

Earlier studies of Malathi *et al.* (2002a) showed that soaking sugarcane setts in 0.25% Thiophanate Methyl for more than 18h before planting was found to be effective in controlling red rot infection from soil-borne inoculum than merely soaking for 1 h period at elevated doses. Also increased efficacy was demonstrated by combining fungicide with biocontrol agent (Malathi *et al.* 2002b). Recent studies with new systemic fungicides also confirmed the advantage of overnight sett treatment than treatment for few hours (Malathi *et al.*, 2011). These studies clearly proved that increased duration of fungicide treatment is required for effective diffusion of the fungicidal compound into the setts. However none of the fungicides could be used in the field due to practical difficulties in handling voluminous planting material unlike other seeds. Hence use of effective fungicides/biocontrol agents/inducers could not be recommended for the farmers and application methods like spray/soil drench and dipping the setts for short time were recommended.

Considering the limitations of each method, modified fungicide treatments through low pressure diffusion technique involving less fungicide consumption with short duration of treatment was evolved with a lab prototype and encouraging results were obtained at ICAR-SBI, Coimbatore. Further the prototype was validated for sett treatment under many situations mainly for

disease management and growth promotion with fungicides and microbes. The efficacy of mechanized means of sett treatment with selected systemic fungicides was found to be far superior as compared to conventional overnight soaking for managing red rot in sugarcane (Malathi *et al.*, 2016). Besides the prototype has been validated for the delivery of different microbes *viz.*, *Pseudomonas fluorescens*, the biocontrol agent and biofertilizer microbes (*Azospirillum, Glucanoacetobacter* and *Phosphobacterium*) to study their efficacy and growth promoting attributes. During the evaluation for various inputs, the results on tissue bioassay, pot culture and field experiments indicated that the uptake and efficacy of fungicides/microbes was found to be similar for both the methods of treatment in terms of disease control and growth promotion. This novel mechanized sett treatment technology has been filed as a patent (3323/CHE/2011- Malathi *et al.*, 2011) as 'Rapid treatment for planting materials of sugarcane and other vegetatively propagated crops" and it was published in 'The patent office Journal 21/06/2013'.

Based on the encouraging results obtained with the lab prototype, new units of different sizes have been fabricated under the DST-IDP programme on 'Development of mechanised system for effective sett/ bud treatment of sugarcane' in collaboration with CIAE-RS, Coimbatore. The units were specifically validated for the management of fungal diseases with fungicides/ microbes and for raising healthy nursery with various inputs supporting sugarcane cultivation. For disease management, along with sett treatment, other delivery methods *viz.*, soil application, spray and delivery of fungicides through micro-irrigation systems, microbes and their combinations were evaluated against red rot, smut and wilt the major fungal diseases affecting sugarcane production and productivity in the country. The studies have shown that the mechanized treatment increased the uptake of fungicides in the setts in a shorter time to effectively arrest sett / soil borne inocula of major fungal diseases in the field. Also this device was found amenable to deliver various other agro inputs recommended for healthy seed nursery programme in sugarcane.

MATERIALS AND METHODS

Mechanized means of sett treatment

Two/three budded sugarcane setts were treated with fungicides using STD for field experiments on disease management, while for healthy nursery programme, delivery of different kinds of inputs *viz.*, agrochemicals and microbes (fungicides, insecticides, inducers, micro and macro nutrients, growth hormones, chemicals for abiotic stress tolerance, biocontrol agents, growth promoting bacteria / biofertilizers) were treated in different concentrations and

combinations. The principle involved in STD is vacuum infiltration by creating a negative pressure followed by absorption of the chemicals inside the setts. This method of sett treatment was performed at prescribed vacuum level and duration (15-30 min) in the newly fabricated large size units of different shapes *viz.*, square and cylindrical types (Fig. 1a & b) as standardized earlier in the prototype (Malathi *et al.*, 2016).

Disease management trials

Disease management trials were conducted at the institute and factory fields for the management of three major fungal diseases *viz.*, red rot, smut and wilt with different fungicides. For red rot management, thiophanate methyl (Roko 70WP) as sett treatment in sett treatment device (STD) at 1000 ppm level alone or in combination with delivery of fungicide or *Pseudomonas fluorescens* through micro-irrigation systems at 90 DAP. Red rot susceptible variety CoC 671 was used in the institute trials conducted at Coimbatore and a popular variety CoV 09356 grown in Cauvery command area and susceptible to red rot was used in the trials conducted at the factory areas of M/s Ambiga Sugars, Kottur, Thanjavur Dt, Tamil Nadu for two seasons during 2014-16. Efficacy of treatments was assessed by artificial inoculation of *C. falcatum* inoculum multiplied on sorghum grains. At the time of planting, pathogen inoculum was applied over the setts @ 100 g/10' row. The treatments were replicated four times in a randomized block design. Observations were recorded on germination, disease incidence and plant survival at periodical intervals and finally the number of millable stalks and yield/plot were recorded at the time of harvest.

For smut management, 100% infected canes were used as planting material at the institute trials, Coimbatore and factory trials at Kottur. Treatments were given as sett treatment with propiconazole (Tilt 20 EC) at 100 ppm as sett treatment using STD individually or in combination with its delivery through micro-irrigation or as foliar spray at 100-200 ppm level. For wilt management, carbendazim (Bavistin 50 WP) at 1000 ppm was given as sett treatment using STD and soil drenching with the same fungicide around infected clumps. Besides *Trichoderma* multiplied in farm yard mature was applied at the time of planting.

Healthy nursery programme

Since mechanized treatment is amenable to deliver more than one input simultaneously, it was compared with conventional soaking in the trials conducted at M/s Ponni Sugars, Oodathurai, Namakkal Dt for improving settlings quality with super lime to mitigate drought in the popular variety

Co 86032. The different inputs include fungicide – carbendazim (1000 ppm) insecticide – Fipronil (50 ppm), super lime (2.5%), urea (0.25%), ferrous sulphate (0.25%) and zinc sulphate (0.25%) at their recommended doses as mentioned and at reduced concentrations by 1/8 and 1/4th levels. The inputs were treated individually at their recommended doses and for combinations they were delivered at lower concentrations. The vacuum level inside the treatment chamber varied in case of combinations as higher concentration was found to cause deleterious effect on germination. Optimizations for the input concentrations and vacuum level were performed in different sets of experiments.

RESULTS

Validation of mechanized system for varietal response under field conditions

Red rot and smut management field trials were laid out at the institute field with the varieties CoC 671 susceptible to red rot, Co 97009 and Co 96007 susceptible to smut. The fungicides *viz.*, thiophanate methyl and triadimefon at 1000 ppm were treated for red rot and smut, respectively. Observations on plant survival indicated that, sett treatment with newly fabricated unit and overnight treatment with the fungicides were found to be similar for red rot and smut management irrespective of varieties. Similar results were observed when the varieties CoA 92081 and CoV 09356, susceptible to smut and red rot, respectively were treated with fungicides *viz.*, thiophanate methyl and propiconazole by overnight soaking and mechanized treatment in the field trials conducted at Sri Ambika Sugars factory areas, Kottur. Based on the results, separate trials were laid out with different treatments involving various delivery methods for the management of red rot, smut and wilt under field conditions at the institute and factory areas.

Validation of mechanized system for the management of fungal diseases at SBI, Coimbatore

Wilt management

To validate the efficacy of mechanized treatment for wilt management, two budded setts of 25 different sugarcane varieties from National Hybridization Garden (NHG) were treated with fungicide (Carbendazim 0.1%) during January 2014 and planted in the field. The efficacy of mechanized sett treatment was compared with the conventional overnight soaking of the setts in the fungicide solution. Sugarcane sett treatment with fungicide in the mechanized device revealed that all the 25 varieties recorded good germination as in the

conventional soaking method. The results indicated that the device can be used for fungicide treatment across the varieties. Subsequently, during 2014-15, about 611 clones maintained in NHG were subjected to mechanized treatment with the newly fabricated unit with large size. Along with the sett treatment *Trichoderma* in FYM formulation @ 1 kg/10' row was applied to protect the setts from soil-borne inoculum of wilt. Besides soil drenching was carried out to manage secondary spread of the disease.

Evaluation of mechanized means of sett treatment for red rot and smut management under factory areas

Red rot management

Results of the field trial for red rot management in CoV 09356 laid out at factory areas in Tuhili during 2014-15 indicated that the sett treatment was able to protect the setts from soil borne inoculum of red rot and significantly improved the plant survival. Further, cane yield was improved by 1.4 and 1.2 fold increase in sett treatment + soil drenching with fungicide (thiophanate methyl – 1000ppm) and sett treatment + soil drenching with *P. fluorescens* respectively, while it doubled in sett treatment alone as compared to inoculated control treatment and yield improvement was only 35% in uninoculated control plots (Fig. 2a & b). The efficacy of fungicide delivery was again confirmed in the 2015-16 trial in the factory area (Fig. 3).

Smut management

In smut management trial laid out during 2014-15 with cent percent smut-affected seed cane, the fungicide propiconazole 100 ppm was delivered through different methods. Results of the trial indicated that the treated plots showed increased yield with reduced smut incidence. Among the different treatments, combination of sett treatment and fungicidal (propiconazole – 100 ppm) application through drip was found to be superior and the yield improvement was 1.4 fold, while the increase was 0.81 by sett treatment + spray and 0.36 by sett treatment alone (Fig. 4a & b). The results were also confirmed in 2015-16 trial in the same factory area (Fig. 5a & b).

Mechanized sett treatment for healthy nursery programme

Results showed that the mechanized treatment with a mixture of 0.5% super lime, 0.5% urea and 0.1% carbendazim was highly effective in producing first quality settlings as compared to 2.5% concentration of super lime and urea in the conventional practices (Fig. 6). The mechanized treatment with the inputs revealed that it reduced chemical requirement, effective impregnation of setts with the inputs and production of more number of high quality settlings.

Similarly doses of micro nutrients for individual and combined applications with insecticide through sett treatment device were standardized. Our results revealed that the dose of the chemicals was reduced by 1/10th from conventional dipping and it was further reduced for combined application. From the results, it was confirmed that production of first quality settlings was significantly high at the recommended doses of fungicide, insecticide and nutrients and also at stipulated vacuum level (Fig. 7). Depending on the unit, the vacuum level varied from 200-350 Hg/ mm, which had to be validated without affecting the germination. Finally the combination of inputs standardized include Carbendazim - 0.5 to 1.0 g/l; Fipronil (Regent 5SC) - 0.5 to 1.0 ml/l; Urea – 0.5 g/l of commercial grade $ZnSO_4$ and $FeSO_4$.

DISCUSSION

Various plant pathogens including fungi, bacteria, phytoplasma and viruses cause diseases of sugarcane. Among them red rot, smut, wilt and sett rot are the important fungal diseases (Viswanathan and Rao, 2011). Exploiting disease resistance is the major strategy employed in sugarcane to manage these fungal diseases in the field. Planting disease free material is another major strategy employed to prevent disease introduction through planting materials. While for managing certain diseases, sett treatment, soil application and spraying of fungicides/ biocontrol agents are being recommended. Among all these methods, importance is given for sett treatment as planting material serves as source of primary inoculum for major stalk diseases caused by fungal agents (Viswanathan, 2012). Apart from this, sett treatment provides various advantageous like less chemical requirement and thereby reducing the soil contamination, protection of planting materials before the disease incidence results in reduced loss and finally reduced cost and lobour. However, in endemic situations, more than one delivery method can be followed to reduce inoculum pressure, if handled propoerly by combining more than one chemical and combination of chemicals and microbes. Hence present study was undertaken to validate and demonstrate the efficacy of sett treatment device (STD) with chemicals/ microbes for initial protection and along other delivery methods for the management of major sugarcane fungal diseases using fungicides and microbes.

For the past two decades, a wide range of fungicides have been evaluated under in vitro (Imtiag *et al.* 2007, Subhani *et al.* 2008) and in vivo (Chand *et al.*, 1974; Lewin *et al.*, 1976; Agnihorti 1990) conditions for the effective management of red rot along with resistant source. Usually the fungicides are applied as sett treatment (Rao and Satyanarayana, 1995) and rarely as stool spray (Pliansinchai, 1999) to protect from the soil borne/secondary

inoculum. Spraying along with sett treatment was also tried for the effective management of red rot (Yang and Seaberg, 1974; Yang and Braud, 1977; Malathi *et al.*, 2002a). Sett treatment for limited duration or stool spray failed to control diseases at earlier crop stages. Partial chemical control of the disease under field conditions might be due to impervious nature of the rind, limited uptake of fungicide under limited duration of treatment and inability of the fungicide to reach the site of infection in the tissue (Agnihorti, 1983; Rao and Sathyanarayana, 1995). However studies of Malathi *et al.* (2002a) showed that the fungicides applied before infection reduced the red rot incidence and improved both germination of setts and plant survival. Soaking of sugarcane setts in a 0.25% suspension of fungicides for 24h before planting was found to be more effective in controlling debris-borne infection than soaking for 1 h period at elevated doses. Subsequently Malathi *et al.* (2002b) found increased efficacy of the fungicide by combining with biocontrol agents. Further studies with new systemic fungicides also confirmed the effect of overnight sett treatment (Malathi *et al.*, 2012). Recently Malathi *et al.* (2016) standardized and demonstrated the mechanized means of sett treatment as effective means of delivering fungicides for the management of primary source of red rot inoculum. The present investigation with bigger units of STD confirmed the previous results obtained using a prototype.

Earlier studies of Comstock *et al.* (1983) revealed Vangaurd® and Bayleton® treatments inhibited smut development from systemically infected seed pieces. Further it is a recommended practice to subject the planting setts to a hot water treatment @ 52°C for 30 min combined with a chemotherapy using 0.1% Triademephon (Mameghmay, 1984). Wada *et al.* (1999) suggested effective strategies for the management of sugarcane smut, viz. pre-plant heat therapy of planting setts; pre-plant fungicidal dips of planting setts and screening of sugarcane clones for identification of resistant varieties. The need for continuing tests of different fungicides with varying modes of action for smut control has been discussed by Wada (2003). Our finding from different field trials revealed the efficacy of different delivery methods for effective management of sugarcane smut. The treatments were found to completely eliminate the sett-borne infections of smut.

Although systemic fungicides are being recommended for sett treatment, they are able to take care of sett borne inoculum, while they are not effective in eradicating soil borne inoculum. It has been found that the amount of systemic fungicide absorbed by the setts steeped for 24h was only fungitoxic and not fungicidal to the wilt pathogens (Agnihotri and Rao, 2002). Hence it is advantageous to use biocontrol agents as soil application to improve soil

health and reduce the inoculum pressure of wilt pathogen. The potential of *Trichoderma* spp. to suppress diseases caused by *Fusarium* spp. has been evaluated on other crops such as wheat, sorghum, asparagus and maize. Earlier Viswanathan *et al.* (2012) conducted detailed field trials in the wilt endemic locations in Gujarat and Andhra Pradesh with pressmud formulations of *Trichoderma* and found effective suppression of the disease. In relation to present investigation, Zakria *et al.* (2008) from Japan tried a vacuum infiltration technique for the effective delivery of endophytes in the internodal tissue of sugarcane stalks and they proved the establishment of endophytes in the stalks. While the present invention involves use of a sugarcane planting material *viz.*, bud chips, single/two/three budded setts particularly the sugarcane stalk tissue with buds for treatment and their effect on protection of setts from any biotic stress, further growth and development of canes.

Our detailed studies optimized effective delivery of fungicides in single bud or two budded setts/bud chips utilizing mechanized-vacuum infiltration approach and the treatment has resulted in more effective diffusion of the chemical into sugarcane setts/buds due to reduced pressure created in the treatment chamber. The newly devised sett treatment device is portable and simple to operate. Recycling of chemicals resulted in huge savings in chemical used for pre-treatment, thus making the system environmental friendly. Field trials conducted at Institute and red rot and smut endemic locations revealed that delivery of fungicides Thiophanate methyl, Propiconazole and Carbendazim through the new device efficiently protected the crop from red rot, smut and wilt, respectively. In addition, delivery of different agrochemicals for sugarcane multiplication nurseries (bud-chip or single bud) can be effectively delivered through the device. Our studies concluded that the mechanized sett treatment device increased the fungicide uptake and this resulted in extended protection of sugarcane crop against red rot and smut in the respective susceptible varieties. To take care of disease build-up during grand growth phase, delivery of Thiophanate methyl and liquid formulation of *Pseudomonas* through sub surface irrigation system effectively reduced red rot under endemic locations. Similarly subsequent application of Propiconazole through microirrigation system has effectively managed smut in plant and ratoon crops. These new opportunities have created alternate strategies to effectively manage red rot and smut diseases in sugarcane. Further by treating the planting material with different inputs through simple, rapid and cost effective method, the industry will be able to produce good quality settlings with improved germination, growth promotion and tolerance to abiotic stresses. It is expected that sugar industry may adopt this new approach to manage sugarcane diseases effectively and to produce healthy seedlings to sustain sugarcane productivity.

ACKNOWLEDGEMENTS

The authors are grateful to Dr. Bakshi Ram, Director, ICAR-Sugarcane Breeding Institute, Coimbatore for encouragement and support. They also profusely thank the factory authorities of M/s Ambiga Sugars, Kottur, M/s Ponni Sugars, Oodathurai and M/S Sakthi Sugars unit-4, Poondurai Semur for the facilities provided to conduct the field trials.

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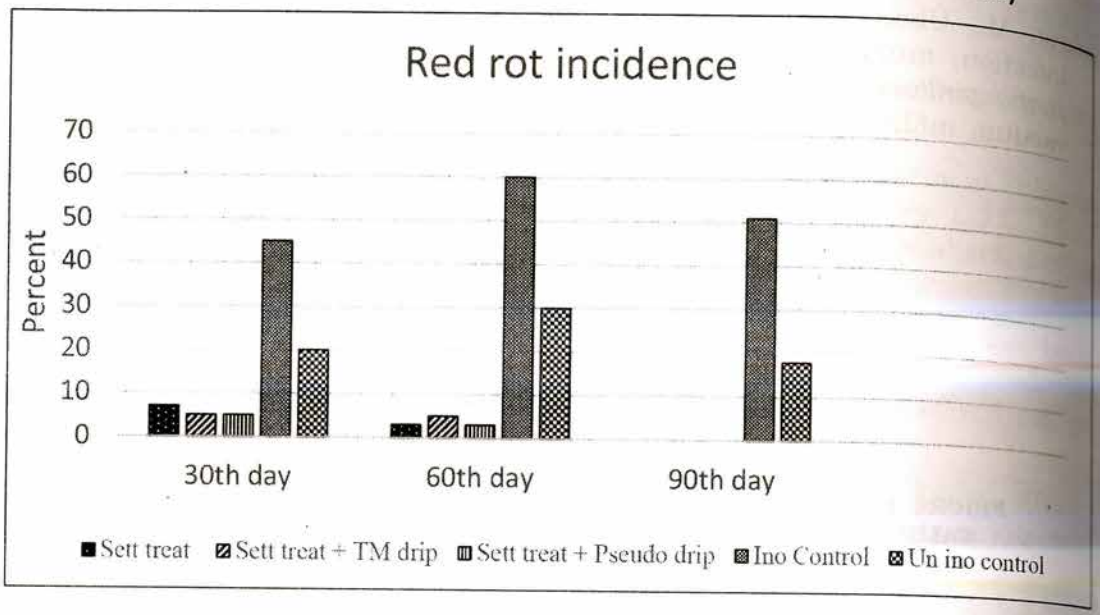
FIGURE 1 – TWO TYPES OF SETT TREATMENT DEVICES USED TO VALIDATE DISEASE MANAGEMENT UNDER FIELD CONDITIONS

FIGURE 2A & 2B – VALIDATION OF SETT TREATMENT DEVICE AND DELIVERY METHODS FOR RED ROT MANAGEMENT WITH THIOPHANATE METHYL (TPM) AND PSEUDOMONAS FLOURESCENS (PF) IN THE CV COV 09356 (2014-15)



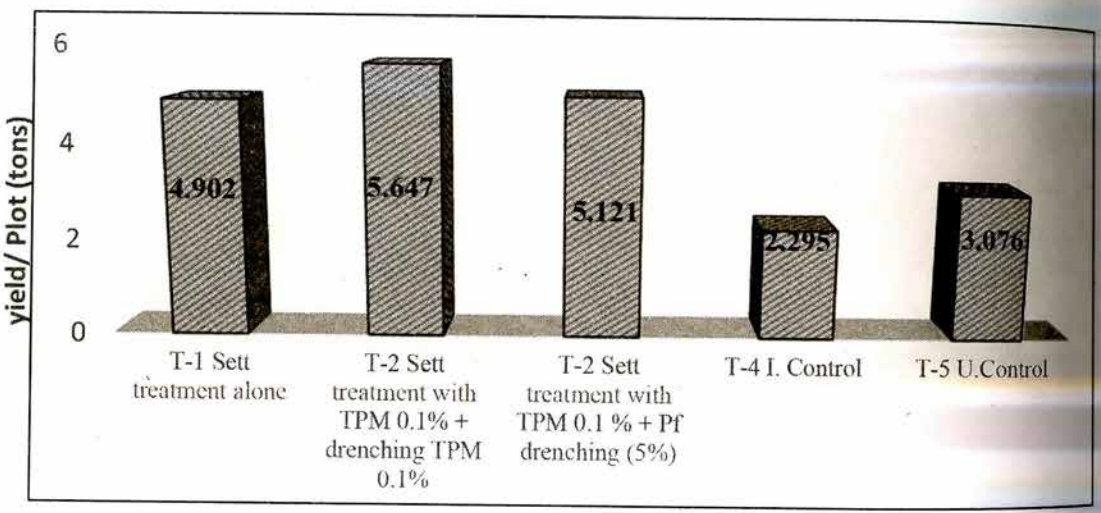
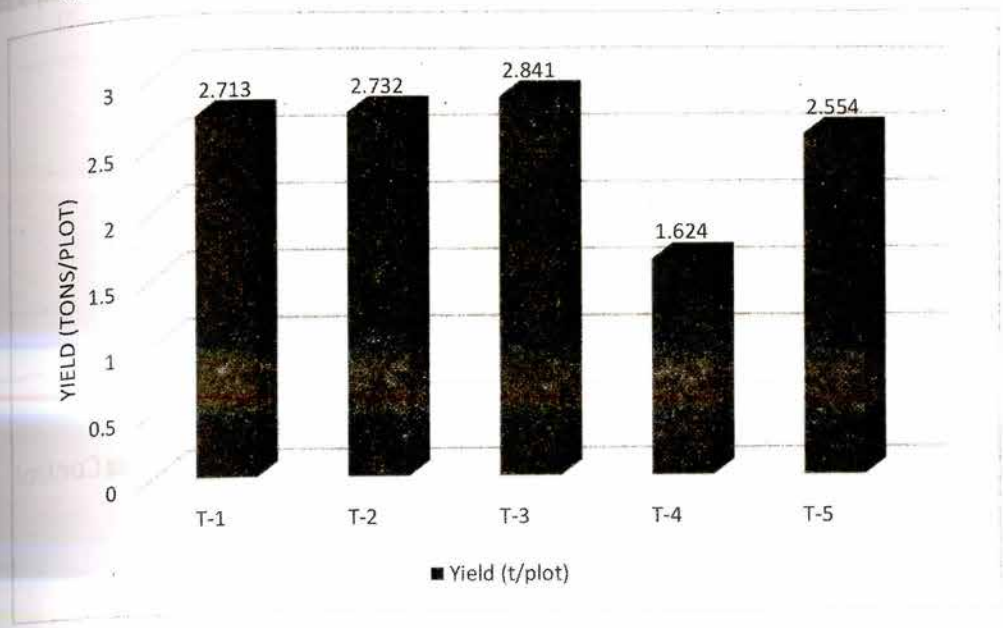


FIGURE 3 – EFFICACY OF MECHANIZED SETT TREATMENT AND OTHER DELIVERY METHODS WITH THIOPHANATE METHYL ON CANE YIELD (2015-16)



T1. Mechanized sett treatment with TPM (0.1%)

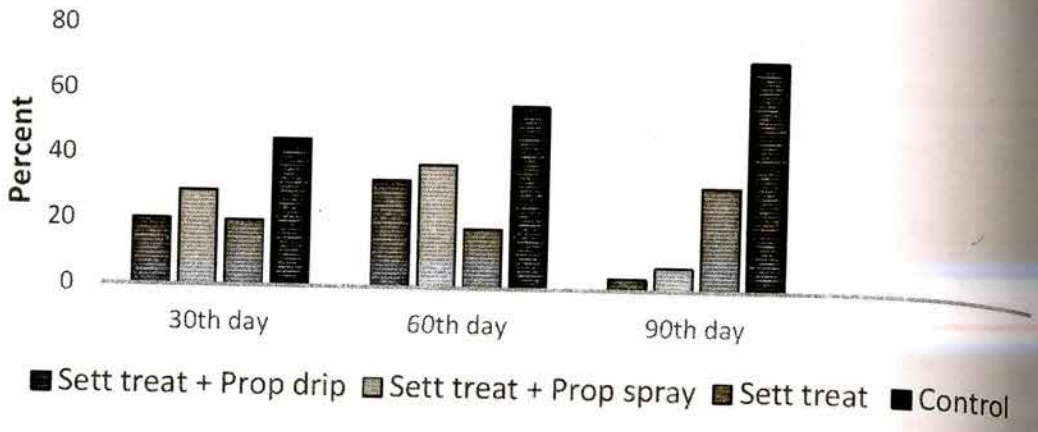
T2. Mechanized sett treatment + spray with TPM (0.1%)

T3. Mechanized sett treatment + soil drenching with TPM (0.1%)

T4. Inoculated control

T5. Uninoculated control

FIGURE 4A & B – EFFICACY OF MECHANIZED SETT TREATMENT AND OTHER DIFFERENT DELIVERY METHODS WITH PROPICONAZOLE FOR SMUT MANAGEMENT IN THE FIELD TRIAL (2014-15)



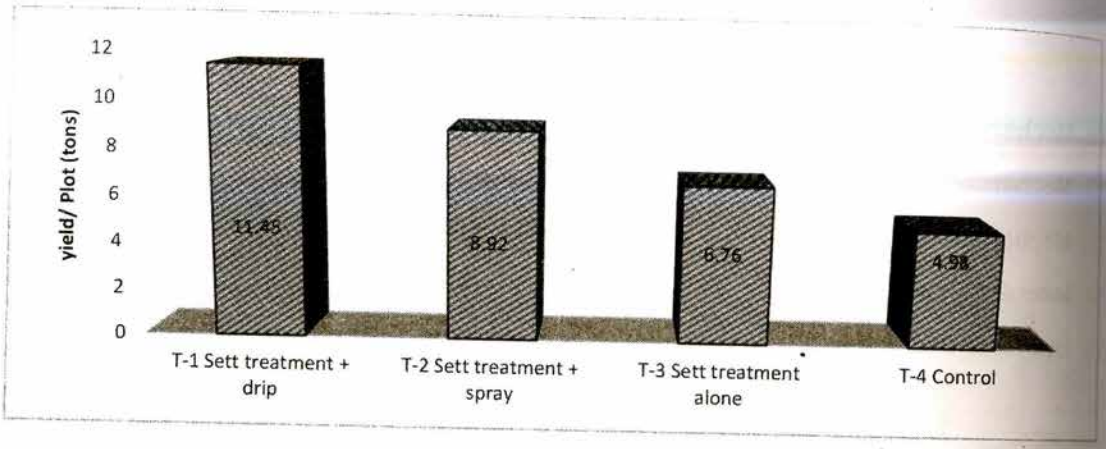
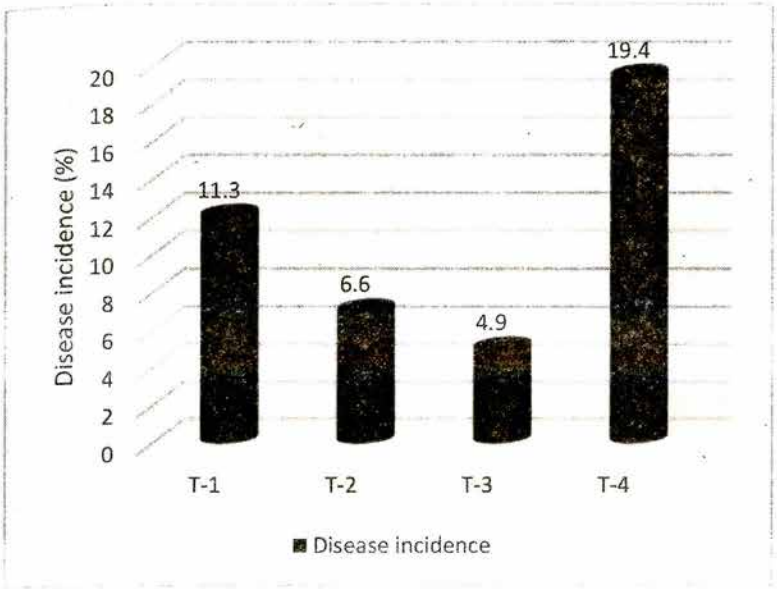
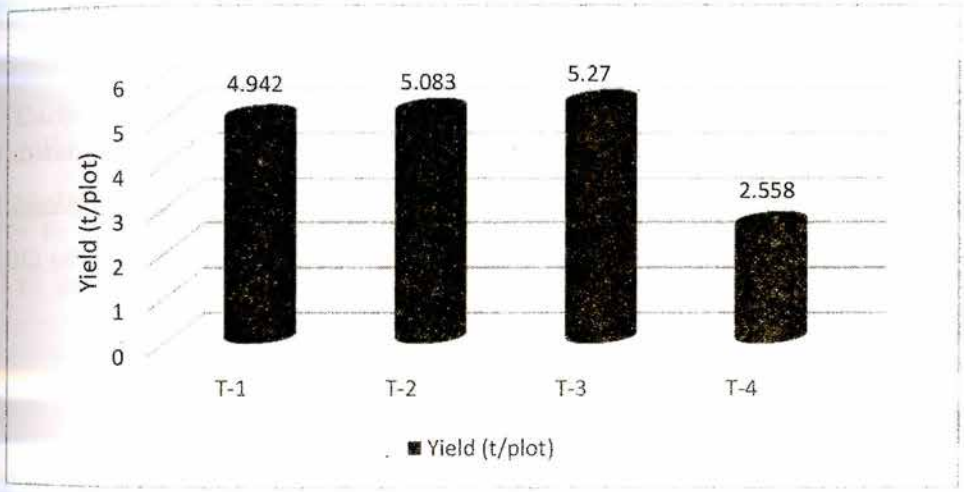


FIGURE 5A & B – EFFICACY OF MECHANIZED SETT TREATMENT AND SPRAY WITH PROPICONAZOLE ON PLANT SURVIVAL AND DISEASE INCIDENCE IN THE FIELD TRIAL (2015-16





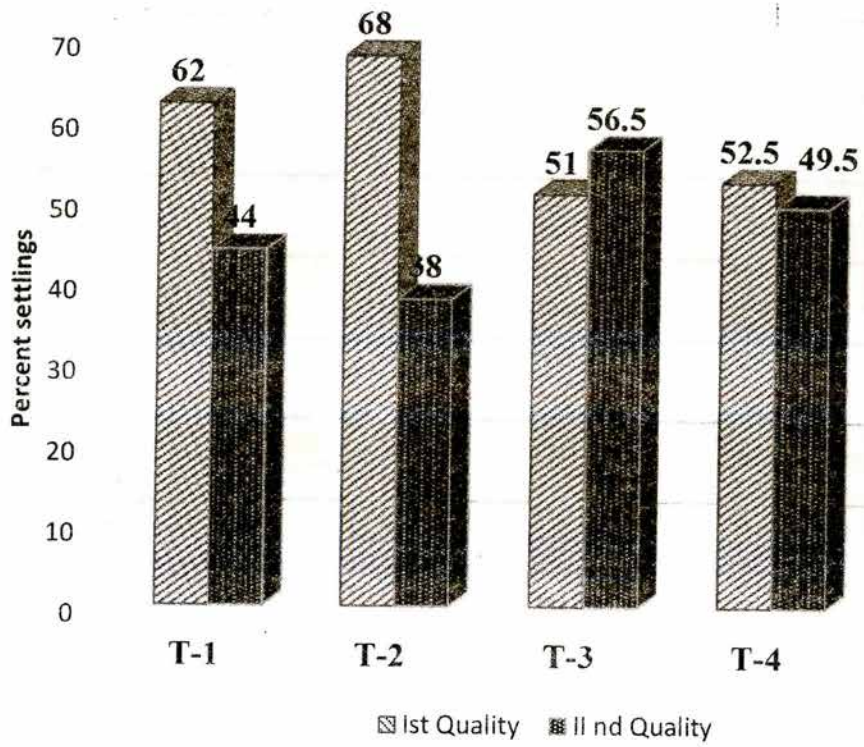
T1 - Mechanized sett treatment with Propiconazole -100 ppm

T2 - Mechanized sett treatment + spray 100 ppm

T3 - Mechanized sett treatment + Spray 200 ppm

T4 - Infected control

FIGURE 6 – VALIDATION OF SETT TREATMENT DEVICE FOR THE DELIVERY OF DIFFERENT INPUTS UNDER HEALTHY NURSERY PROGRAMME (PONNI SUGARS)



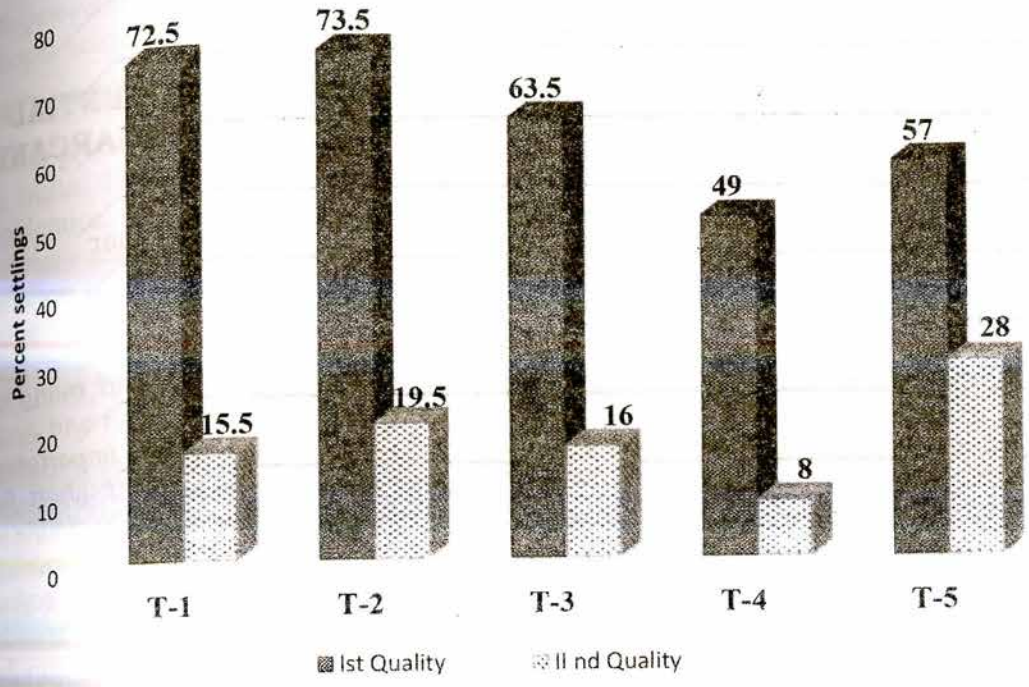
T1 – Sett treatment with Super lime (0.25%) + Urea (0.25%) + Carbendazim (0.1%)

T2 – Sett treatment with Super lime (0.50%) + Urea (0.50%) + Carbendazim (0.1%)

T3 – Indigenous soaking with Super lime (0.50%) (30 min)+ Urea (0.50%) (30 min)+ Carbendazim (0.1%) (30 min)

T4 – control

FIGURE 7 – VALIDATION OF SETT TREATMENT DEVICE FOR THE DELIVERY OF DIFFERENT INPUTS UNDER HEALTHY NURSERY PROGRAMME (SAKTHI SUGARS)



T1 – Carbendazim – 0.05% + Fipronil – 0.05 % + Urea – 0.05 % + $ZnSO_4$ - 0.05% + Fe SO_4 - 0.05% - Commercial grade – 200 Hg/mM

T2 – Carbendazim – 0.05% + Fipronil – 0.05 % + Urea – 0.05 % + $ZnSO_4$ - 0.05% + Fe SO_4 - 0.05% - Commercial grade. – 250 Hg/mM

T3 – T1 at 300 Hg/mM; T4 – T1 at 400 Hg/mM; T5 - Control