International Journal of Forestry and Crop Improvement
December, 2011 | Volume 2 | Issue 2 | 199-204

Research Article

Influence of climatic parameters and management strategies on sugarcane smut disease

S. SUNDRAVADANA, T. RAGAVAN, A. THIRUMURUGAN, K. SATHIYA AND E. SHAH

Abstract : The present investigation was conducted to study the influence of climatic parameters and management strategies on sugarcane smut disease. Culmicolus smut (*Sporisorium scitamineum* Meike), the sett borne pathogen causes considerable loss to sugarcane productivity. Due to high intensity of temperature, sett and soil borne teliospore heavily infect sugarcane bud. Also, due to high rainfall, smut spores were whipped off and its survival declined. Further as a management strategy the sett and soil borne smut pathogen was significantly reduced by sett treated with triademifon (0.1%), had shown radical reduction in smut incidence (6.9 %) followed by propiconazole (8.2%) as against control (30.8%). The toxicant entered into the host plant through its systemic action and subsequently penetrates the pathogen in sufficient quantity. In turn, it was inhibited the entry of *S. scitamineum* in the sugarcane buds and further controls the establishment of the disease. The sett treatment with systemic fungicide, triademifon (0.1%) was found to be the best in terms of controlling the smut disease and leads to getting higher yield, quality and sugar yield, respectively of, 108.8 t/ha, 13.1 per cent and 14.1 followed by *T. harzianum* (0.4%) 106.4 t/ha, 12.5 per cent and 13.7 as against control which recorded, respectively, 69.0 t/ha, 10.8 per cent and 7.2.

Key Words : Weather factors, Smut, Fungicide, Biocontrol

How to cite this Article: Sundravadana, S., Ragavan, T., Thirumurugan, A., Sathiya, K. and Shah, E. (2011). Influence of climatic parameters and management strategies on sugarcane smut disease, *Internat. J. Forestry & Crop Improv.,* **2** (2) : 199-204.

Article Chronical : **Received :** *20.10.2011;* **Revised :** *17.11.2011;* **Accepted :** *30.11.2011*

INTRODUCTION

In India, sugarcane has become a crop of commercial importance and grown in all the states of India except the hilly regions. Currently, it is cultivated in an area of 5.15 million ha with an average productivity of 69 t/ha with the total production of 355.4 million tonnes of sugarcane and 28.3 million tonnes of sugar. In Tamil Nadu, it is cultivated in an area of 3.35 lakh ha with an average productivity of 105 t/ha accounting the total production of 357.07 lakh tonnes of sugarcane and 25.40 lakh tonnes of sugar. Of the total area cultivated, 52.70 per cent is planted and 47.30 per cent is under ratoon.

Sugarcane smut (*Sporisorium scitamineum*), (Piepenbring *et al*., 2002) the sett borne pathogen causes considerable loss to sugarcane productivity (Rott *et al.*, 2000). Smut established quickly and remaining the most economically important fungal disease of the crop. Yield losses may be 39-56 per cent in planted crop and 52-73 per cent in ratoon crop (Briceno *et al.,* 2005; Braithwaite *et al.,* 2008). The smut is prevalent in all sugarcane growing countries of the world.

Weather plays an important role in crop growth as well as development of smut disease. The high temperature in the sugarcane growing area of Zimbabwe and conducive to the development of the smut and the disease is endemic (Zvoutete, 2008). Although, controlling of the smut disease with fungicides have been found to be ineffective (Agnihotri and Sinha,1996; Wada *et al.,* 1999; Vijaya, 2000) due to the

MEMBERS OF RESEARCH FORUM

Author of the Correspondence :
S. SUNDRAVADANA, Department of Plant Pathology, Sugarcane Research Station (T.N.A.U.), Melalathur, VELLORE (T.N.) INDIA
Email : sundravadana@gmail.com

Address of the Coopted Authors :
T. RAGAVAN, A. THIRUMURUGAN, K. SATHIYAAND E.SHAH, Department of Plant Pathology, Sugarcane Research Station (T.N.A.U.), Melalathur, VELLORE (T.N.) INDIA

formidable rind of setts, fibrous nature of nodes, presence of water in setts besides deep seated buds in stubbles (ratoon) do not allow the fungicides to reach to site of infection to the desired concentration sufficient to manage the pathogen. The most eco-friendly means to contain the pathogen is through the use of resistant varieties/genotypes, botanicals / botanical derivatives and bioagent(s). Sinha and Singh (1983) reported that culture filtrate of *Fusarium* sp. completely inhibited the germination of teliospores of *S. scitamineum*. Fungal bioagents, like *Trichoderma*, *Aspergilus flavus*, *A. niger, Penicillium* spp. etc., have been found antagonistic to *S. scitamineum* by various workers (RamJiLal *et al.,* 2009). However, the information on use of bioagent(s) for the management of the disease under field conditions is entirely lacking.

Keeping all in view, the experiment was designed to evaluate the reaction of sugarcane clones to the smut disease and to determine the impact of the weather factors and mitigation approach on smut diseases.

EXPERIMENTAL METHODS

Smut inoculum and inoculation:

The acute smut whips were collected from the sugarcane fields. The teliospores suspension was prepared and which containing about 5 x 10^6 telispores per ml. The dipping method was employed for artificial inoculation. The single budded sugarcane setts used for the planting were dipped in a smut spores suspension for 30 min. The respective setts were incubated for 12 h in polyether sacks and then planted in the field (Ferreira *et al.,* 1980).

Field experiment I:

Field experiment was conducted at Sugarcane Research Station, Melalathur, with an objective to screen the new sugarcane clones for the smut tolerance and to study the influence of weather parameters on the occurrence of smut in sugarcane.

For the experiment, thirteen new sugarcane clones which are in the pipeline were selected for the screening purpose. In addition, for assessing the comparative performance two released sugarcane varieties which are resistant and susceptible to smut incidence were also taken for the study. The experiment was laid out in randomised block design and replicated thrice. The planting of sugarcane clones were done during the early season of the experimental years. The planting was done in the ridges and furrows method of cultivation using single budded setts. The recommended packages for the sugarcane crop were strictly followed to maintain the uniform stand of the crop.

Recording smut incidence:

The trial was closely monitored for appearance of first smut whips and recorded monthly intervals until the trial was completed. Smut description, rating and infection were done as explained by Rao *et al.* (1996).

Reaction		% age of reaction
Resistant	R	0 - 5%
Moderately resistant	MR	5.1 - 15%
Moderately susceptible	MS	15.1 - 30%
Susceptible	S	Above 30%

Weather data collection:

Temperature and rainfall data for three growing season during the study period were obtained from a weather station at the Sugarcane Research Station, Melalathur and used for the study.

Field experiment II:

Field experiment was conducted at Sugarcane Research Station, Melalathur, with an objective to find out the effect of fungicides and bio control agents on smut incidence and yield parameters.

The experiment was conducted with the following treatments: T_1-Diseased check, T_2-Healthy check (Untreated), T_3-Sett treatment with triademifon (0.1%), T_4-Sett treatment with propiconazole (0.1%), T_5-Sett treatment with carbendazim (0.1%), T_6-Sett treatment with *Trichoderma viride* talc (0.8%), T_7-Sett treatment with *Trichoderma harzianum* talc (0.4%), T_8-Sett treatment with *Psuedomonas fluorescens* talc (0.4%)

In this study, plant setts were dip-inoculated in smut spore suspension (appox. 10^6 teliospore /ml) for 30 min and incubated overnight to ensure smut infection in the buds. Smut infected setts were subsequently treated with fungicides and bioagents for 4 hrs before planting and planted out in field trial. The sugarcane variety COG 95076 was taken for the field experimentation. All the treatments were replicated thrice in a Randomized Block Design (RBD).

Statistical analysis:

The analysis of the information was done based on the percentage of infected strains of the last observation and these were processed using the statistical parametric analysis for randomized blocks.

EXPERIMENTAL RESULTS AND ANALYSIS

The results obtained from the present study as well as relevant discussion have been summarized under following

heads :

Smut reaction:

Owing to its vegetative mode of propagation sugarcane is prone to infect by systemic pathogens. Among, smut disease caused by *S. scitamineum* is a dreadful disease of sugarcane and is endemic in most of the tropical regions. The most eco-friendly means to contain the pathogen is through the use of resistant varieties/genotypes, botanicals / botanical derivatives and bioagent (s). In the present investigation, thirteen sugarcane promising pipeline clones were evaluated for their resistance against whip smut pathogen under field conditions by creating the disease artificially. Based on this it was concluded that, out of thirteen promising lines two were found resistant, seven moderately resistant, three moderately susceptible and one had susceptible reaction against the disease (Table 1 and 2).

The resistance/ susceptibility of the variety were determined by bud morphological characters. In the most resistant varieties the germspore adapted sub apical position in the bud whereas the susceptible varieties the position was apical. The position was considered to be associated with the tendency of the bud to sprout which makes it more vulnerable to the entry of promycelium and hence more prone to infection. Hence, bud scales acted as morphological barrier and restricted smut pathogens. Source of resistant against whip smut is available in sugarcane clones and it can be further manipulated through breeding program for evolution of new high yielding sugarcane varieties (Sabalpara and Vaisknav, 2002; Begum *et al*., 2007).

Weather factors on smut incidence:

Rainfall and temperature are two important factors in smut epidemiology.

Rainfall:

Rainfall distribution and its frequency is one of the important climatic parameter affecting the severity of outbreak in smut disease. The correlation studies between rainfall and smut incidence revealed that the smut incidence was negatively correlated with the distribution of rainfall. Since Tamil Nadu is a state receiving North East Monsoon season rainfall and its onset was coinciding with the month of September, it was observed that the smut incidence was 16.51 per cent with the rainfall occurrence of 237.1 mm (Fig 1). The smut incidence sharply declined from 28.16 per cent due to heavy rain. The smut disease incidence was less and mother spores were whipped off by the raindrops. Spore concentrations recorded above the crop were 5–8 times lower than those inside and showed only one seasonal peak occurring after the cessation of high intensity rainfall. Smut whips in relation to the crop canopy and environmental factors possibly including winter temperature and rainfall during infection periods (Hoy and Grisham, 1988; Ahire *et al.,* 2010). Based on the Bhuiyan *et al.* (2009) investigate the survival of the smut fungus teliospores can only survive for a few months at high soil moisture level (>10%) or when buried in soil. However, teliospores of the smut fungus have

Tablet 1: Evaluation of sugarcane clones to smut (%) incidence

Sr. No.	Clones	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Cumulative Smut %
1.	G.95701	0.00	0.50	0.00	1.50	0.53	0.27	1.03	0.33	1.13	1.57	6.86
2.	G.95702	0.00	0.00	0.60	1.90	0.47	1.57	1.07	1.00	1.26	2.13	10.00
3.	G.95716	0.27	1.40	0.00	3.53	1.53	0.00	3.07	2.40	2.10	2.80	17.10
4.	G.95768	0.00	0.00	2.37	1.00	1.00	1.20	1.83	0.60	1.00	1.10	10.10
5.	G.95717	0.33	2.00	0.83	1.87	1.87	1.20	1.67	0.83	1.06	0.93	12.59
6.	G.95741	0.00	0.33	0.00	0.00	0.00	0.00	0.93	1.07	0.60	0.00	2.93
7.	G.95749	0.00	0.57	0.00	0.47	1.53	1.33	2.33	2.33	1.40	0.73	10.69
8.	G.95769	0.80	1.20	1.60	0.33	0.33	1.13	2.93	1.43	1.73	1.13	12.61
9.	G.95770	0.00	0.63	0.80	0.00	0.63	1.56	2.13	1.83	2.16	1.30	11.04
10.	G.95775	0.00	3.68	4.63	1.87	2.37	1.23	3.57	3.77	3.37	4.27	28.76
11.	G.95784	2.07	2.67	1.20	0.77	1.50	1.23	1.10	3.83	2.13	2.33	18.83
12.	G.95785	0.00	1.46	4.00	0.27	0.27	1.10	3.03	1.50	2.80	0.90	15.33
13.	G.95790	0.00	0.93	0.00	0.00	0.00	1.00	0.73	1.23	1.20	0.00	5.09
14.	Co.6806	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15.	Co.740	3.03	5.13	12.13	3.00	3.93	2.37	5.57	5.97	4.50	4.10	49.73
	Cumulative smut %	6.5	20.5	28.16	16.51	15.96	15.19	30.99	28.12	26.44	23.29	

potentially greater longevities when maintained in dry environments.

Temperature:

The prevalence of dry climate and raise in the temperature ranges resulted with the development of smut incidence in sugarcane. This study revealed that the first whip smut appeared during month of June with raise in day temperature, coinciding tillering phase of the crop. With the emergence of whips resulting from the primary infection, airborne inoculum increased sharply inside the crop between June and August. A second and larger peak in whip production was appeared after October with the second flush of rainfall due to secondary infection.

Maximum smut incidence ranged from 6.5 to 30.99 per cent was observed when the temperature ranged from 25°C to 40°C (Fig. 1). Smut incidence observed from June to March, but the smut incidence varied due to intensity of temperature. These experiments demonstrate that temperature has a substantial effect smut disease. Bhuiyan *et al.* (2009) revealed that the optimum temperature for smut spore germination was around 30°C. Below 20°C or above 35°C spore germination slowed down or stopped completely. This result is in conformity with the earlier findings that the high incidence of smut due to presence of optimum temperature increase smut spores germination, gives rise to a promycelium and subsequently it may give rise to infection hyphae which are capable of infecting sugarcane bud. Also,

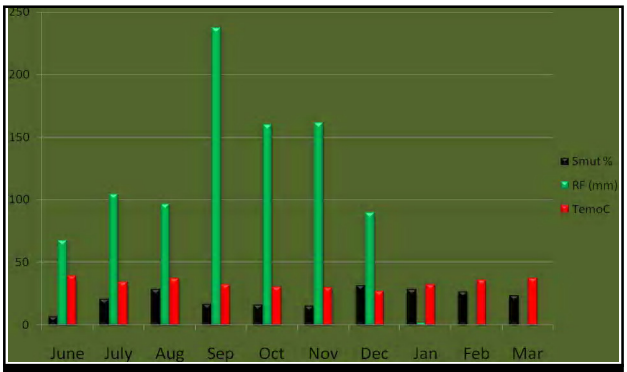

Fig. 1 : Influence of weather parameters on sugarcane smut incidence (%)

the temperature has an enhanced effect on the release and dispersal of smut spores in the air (Ahire and Kadam, 2008). High temperature dry weather and shortage of water leading to high incidence smut (Nzioki *et al.,* 2010).

Management strategy of smut disease:

It is an immense need to develop a cohesive approach to managing Sugarcane smut disease. Sugarcane smut has required significant changes to normal sugar industry operations. In responding to those changes, there is need to adopt to new management strategies for ramifications of this disease.

Table 2 : Reaction of different sugarcane promising lines to whip smut disease

Sr. No.	Reaction	No. of lines	Cultivars / lines
1.	Resistant 0 - 5%	3	G.95741, G.95790, Co.6806 (check)
2.	Moderately resistant 5.1 - 15%	7	G.95701, G.95702, G.95768, G.95717, G.95749, G.95769, G.95770
3.	Moderately susceptible 15.1 - 30%	3	G.95716, G.95784, G.95785
4.	Susceptible above 30%	2	G.95775, Co.740 (Check)

Table 3: Effect of fungicides and biocontrol agents on the sugarcane smut incidence

Treatments details	Smut incidence (%)	Cane yield (t/ha)	CCS %	Sugar yield
T_1- Diseased check	32.8	69.0	10.8	7.2
T_2-Healthy check (Untreated)	0.0	93.7	11.3	10.9
T_3-Triademifon (0.1%) *	6.9	108.8	13.1	14.1
T_4-Propiconazole (0.1%)*	8.2	104.1	11.3	12.5
T_5 - Carbendazim (0.1%)*	13.2	95.4	11.4	11.6
T_6 - *T. viride* talc (0.8%)*	16.7	105.4	11.5	13.2
T_7 -*T. harzianum* talc (0.4%)*	10.8	106.4	12.5	13.7
T_8 - *P. fluorescens* talc (0.4%)*	12.6	102.3	12.6	12.6
C.D. (P=0.05)	4.2	8.6	0.6	1.2

Sett treatment*

Smut incidence:

The present study showed that, sett treatment with triademifon (0.1%) had shown radical reduction in smut incidence (6.9 %) followed by propiconazole (8.2%) as against control (30.8%). Hence, sett dip with triademifon (0.1%) or propiconazole (0.1%) was recommended for as an effective management of sett transmitted sugarcane smut.

Yield and quality parameters:

Among the management practices tried, sett dipping with triademifon (0.1%) was significantly superior in controlling the smut pathogen and found to be the best in terms of getting higher yield, quality and sugar yield, respectively of, 108.8 t/ha, 13.1 per cent and 14.1 followed by *T. harzianum* (0.4%) 106.4 t/ha, 12.5 per cent and 13.7 as against control which recorded, respectively, 69.0 t/ha, 10.8 per cent and 7.2.

These two fungicides, though systemic in action, had different toxic effects on *S. scitamineum*. This can be explained with the reason advocated by Miller (1969) that in one type of systemic effect, the toxicant must enter the host plant and subsequently penetrate the pathogen in sufficient quantity in order to be fungicidal or at least fungistatic.

Conclusion:

It can be concluded that the intensity of sugarcane smut incidence highly influenced by the weather factors. The prevalence of optimum temperature during the crop stage of germination to tillering, increased the sett and soil borne teliospores germination subsequently it may give rise to infection hyphae which are capable of infecting sugarcane bud. Also, the temperature has an enhanced effect on the release and dispersal of smut spores in the air. In addition to this, smut spores were whipped off and survival of the smut fungus decline due to high rainfall during grand growth stage to maturity of sugarcane. Sett treatment with fungicide and biocontrol agent inhibited the entry of the *S. scitamineum* through sugarcane bud and further establishment of smut disease and its spread. Among the mitigation strategies, the sett treatment with fungicides *viz.*, triademifon (0.1%), propiconazole (0.1%), and biocontrol agent *T. harzianum* (0.4%) significantly reduced the smut incidence as well as improved the sugarcane yield, quality (CCS%) and sugar yield.

REFERENCES

Agnihotri, V.P. and Sinha, O.K. (1996). Culmicolous smut of sugarcane. In: *Disease scenario in crop plants*. Vol.II (Eds. V.P. Agnihotri, Om Prakash, Ram Kishun, A.K. Mishra), Intern. Books and Periodicals Supply Sewrvice, Delhi, pp. 137-149.

Ahire, P.P., Kadam, V.B. and Patel, S.I. (2010). Atmospheric concentration and seasonal variation in the smut spores at Nashik, Maharashtra, India. *Plant Archives*, **10** (2): 963-964.

Begum, F., Talukdar, M.I. and Iqbal, M. (2007). Performance of various promising lines for resistance to sugarcane smut (*Ustilago scitaminea* Sydow). *Pak. Sugar J.,* **22**(6): 16-18.

Bhuiyan, S.A., Croft, B.J. and Cox, M.C. (2009). Survival of sugarcane smut teliospores under south east Queensland conditions. In: Proceedings of the 2009 Conference of the Australian Society of Sugar Cane Technologists held at Ballina, New South Wales, Australia, 5-8 May. 135-144.

Braithwaite, K.S., Bakkeren, G., Croft, B.J. and Brumbley, S.M. (2008). Genetic variation in a worldwide collection of the sugarcane smut fungus *Ustilago scitaminea. Proc. Aust. Soc. Sugar Cane Technol*., **26**: 24-35.

Briceno, B., De Sousa, O., Vieira and Rea, R. (2005). Reaction of twenty sugarcane clones to smut disease *Ustilago scitaminea* Sydow. *Rev. Fac. Agron. (LUZ)*, **22** : 399-406.

Ferreira, S.A. and Comstock, J.C. (1989). In: *Diseases of sugarcane. Major diseases.*

Hoy, J.W. and Grisham, M.P.(1988). Spread and increase of smut disease in Louisiana. *Phytopathology,* **78**: 1371-1376.

Miller, L.P. (1969). Mechanisms for reaching the site of action. In: Dewayne, T.(Ed.), Fungicides—An advanced treatise, chemistry & physiology, Vol.III. Academic Press, New York, pp.1–59.

Nzioki, H.S., Jamoza, J.E., Olweny, C.O. and Rono, J.K. (2010). Characterization of physiologic races of sugarcanesmut (*Ustilago scitaminea*) in Kenya. *African J. Microbiol. Res.*, **4** (16): 1694-1697.

Pipenbring, M., Stoll. M. and Oberwinkler, F. (2002). The generic position of *Ustilago maydis, Ustilago scitaminea* and *Ustilago esculanta* (Ustilaginales). *Mycol. Progress,* **1** : 71-80.

Ram Ji Lal , Sinha, O.K., Sanjay Bhatnagar, Sunita Lal and Awasthi, S.K. (2009). Biological control of sugarcane smut (*Sporisorium scitamineum*) through botanicals and *Trichoderma viride. Sugar Tech.*, **11**(4): 381-386.

Rao, G.P., Triphathi, D.N.P., Upadhaya, U.C., Singh, R.D.R. and Singh, R.R. (1996). CoSe-91423 and CoSe-93232; New Promising Red Rot and Smut Resistant Sugarcane Varieties for Eastern Utterpardesh. *Indian Sugar J.,* **12**: 261-263.

Rott, P., Bailey, A., Comstock, J.C., Croft, B.J. and Sauntally, A.S. (2000). A guide to sugarcane diseases. CIRAD and ISSCT. 339 pp.

Sabalpara, A.N. and Vishnav,M.U. (2002). Screening of sugarcane clone/ varieties for resistance to smut caused by *Ustilago scitaminea* Syd. *Indian Sugar J.,* **12**(7): 507-509.

Vijaya, M. (2000). Chemical control of sett-borne infection of smut of sugarcane. *J. Mycol. & Pl. Pathol.,* **30**: 128-129.

Wada, A.C., Agboire, S., Abo, M.E., Obakin, F.O. and Okusanya, B.A. (1999). Incidence, severity and distribution of sugarcane diseases in Nigeria I.Southern Guinea Savannah Zone. *Discovery Innovat.,* **1** : 33–39.

Zvoutete, P. (2008). Fluctuation in the smut in responce to changes in disease management strategies in the ZIMBABUE sugar industry. *Proc. S. Afr. Sug. Tecnol. Ass.*, **81**:381- 387.

****