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Full Length Research

Epidemiology of *Ustilago scitaminea* (Syd.): II. Teliospore Viability and Longevity in Wet and Dry Soils

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Greenhouse experiments were conducted at the Sugarcane Research Centre, Guneid (Lat. 15oN, long. 33oE and approximately 400 m above sea level) between March and September of seasons 2007/2008 and 2009/2010, respectively. The objectives of the study were to determine the viability and longevity of Ustilago scitaminea (Syd.) teliospores in dry and wet soil environments. Results showed that under both dry and wet soil environments viability and longevity of U. scitaminea (Syd.) teliospores remained effective up to the last tested sowing date interval of 64 days. Spore viability and longevity under the two soil conditions of wet and dry showed that smut teliospores maintained viability that was able to infect and incite the disease at an average of 64.3% and 50% infectivity at 64 days longevity under dry and wet soil conditions, respectively. The highest spore viability was observed in sowing date intervals of 1 and 2 days. And, the lowest were observed in sowing date intervals of 6 (32 days) and 7 (64 days). Sowing date interval 3 (4 days); 4 (8 days) and 5 (16 days) were intermediate.

Keywords: Epidemiology; Ustilago scitaminea (Syd.); teliospore viability; wet; dry; soils

INTRODUCTION

Sugarcane smut disease is incited by the fungus *Ustilago scitaminea* Syd. (Syn. *Sporisorium scitamineum* (Syd.), M. Piepenbring) and, it is a pathogen with a history of serious epidemics worldwide and international spread. The fungal spores are well adapted to long distance dispersal both wind, irrigation water and the planting of infected cane cuttings can perpetuate the disease. The fungus can survive within infected cane plants as long as the plant remains alive; thus, it requires a living plant to produce spores (Croft *et al*. 2000). Therefore, the importation of infected sugarcane seed materials or regional movement of contaminated farm machinery could also spread the disease. Likewise, spores of the fungus can also be carried on the clothing of workers and long distance travelers who, have been, in smut infested sugarcane fields. The spores of *Ustilago scitaminea* (Syd.) have also been reported to survive for long periods. Luthra *et al*. (1938) reported that longevity of smut spores varied from 56 to 1306 days at 5^0C and James (1969) indicated that viability varied between 640 to 1210 days. Alexander and Srinivasan (1964) also found that under atmospheric laboratory conditions germination was reduced to 51% in eight weeks and totally lost in sixteen weeks (112 days). They further stressed that when stored over calcium chloride spores retained viability over a period of 25 months. However, Alexander and Ramakrishnan (1978) in a separate study reported that under completely dry laboratory conditions spores of *U. scitaminea* retained viability for a period of up to ten years. Thus, signaling the potential risk this pathogen can pose to sugarcane plantations especially in arid and semi-arid dry areas, where, humidity essential for its germination and subsequent death in the absence of a host is very low.

Elsewhere, other reports indicated that spores can survive for 2-3 months in moist soil but for longer periods in dry soil or other dry environments (Leu, 1968). Spore germination was reported to be favored by high temperatures and low relative humidity conditions, which appears, to be ideal for maximum infections in the field (Gul, 1989). However, smut spores have also been

reported to lose viability very rapidly when stored under high humidity conditions or in wet soils (Luthra *et al*., 1938). The reasons for this rapid viability loss under field conditions have not however, been clearly understood nor elucidated. Therefore, a nursery trial (barrel experiments) were thus, conducted with the objective to determine the longevity of smut spores in wet and dry soils under the conditions of the Sudan central clay plains.

MATERIALS AND METHODS

Nursery experiments were conducted at Sugarcane Research Centre, Guneid (Lat. 15^{o}N, long. 33^{o}E and approximately 400 m above sea level) between March and September of seasons 2008/09 and 2009/10 respectively.

Experimental materials, soil and planting materials

Eighty four halved empty barrels (drums) with holes made at base to ease drainage were prepared and all were filled with river soil (silt) mixed with sand in the ratio of approximately 2:1 (2 parts silt and 1 part sand). 20 fresh smut whips collected from cane variety NCO 376 were then added to 56 of the 84 drums. No smut whips were added to the remaining 28 drums (controls). 28 drums from the 56 with whips were then kept wet at field capacity by irrigating every three or four days and the other 28 kept completely dry.

Preparation of sugarcane seed setts and planting

Twenty four single eyed (budded) sugarcane seed setts were prepared from the smut sensitive cane variety NCO376, and given a long hot water treatment regime (HWT) at 50^{0} C for 2hrs., and were then planted as double setts in three hills per each drum at the following 7 sowing date intervals (SDI) in days of: - 1, 2, 4, 8, 16, 32, and 64 days. Each SDI was replicated three times.

Evaluation of viability/longevity

The time period in days from planting to first symptom expression of smut (DSE) was recorded for each SDI; and percentage smut infection (%SI) determined. Also, the time period in days to no whip appearance within the time period of the trials will be determined to indicate loss of viability of the spores either in the wet or dry soil conditions. The DSE and %SI indexes were subjected to analysis by the complete linkage cluster algorithm and resultant tree maps interpreted for viability/ longevity respectively.

RESULTS AND DISCUSSION

Results for the days to symptom expression (DSE) and percentages of smut infection on stool basis (SI) for the seven SDI's tested; in both the dry and wet soil environments is shown in Table 1. Accordingly, DSE and percentage infections (SI) were found to be between 54 to 109.3 days; 50 to 100% for dry soils and 61 to 95.5 days; 25 to 100% for the wet soil environments; and means of DSE 86.8; SI 64% for dry and DSE 77.5; SI: 50% for wet soils respectively. No infection was observed in the control plots as expected. However, in SDI 6 (32 days) and 7(64 days) a 50% infection at DSE 180 and SI 25% infection at DSE 104 were recorded. This was rather unusual but since SDI 1(1 day) to 5(16 days) all recorded 0 infections and 0 DSE this implies that the infection in SDI 6 and7 was not a result of contaminated planting material but rather a clear case of an accidental late infection in the standing cane by air borne smut teliospores from outside the experimental area or '*allo'* infection since its DSE of 180 days was comparatively high. From the mean DSE and SI of 86.8 and 64.3 for dry soil; 77.5 and 50.0 for wet soils we can conclude that from SDI 1(1 day longevity) to SDI 7 (64 days longevity) spores showed some degradation in viability but still remained viable to cause at least 64.3% and 50% infection under the dry and wet soil conditions respectively. This result is supported by the findings of Hoy and Geaghan (1992) who reported that spore germination percentages after 23 wk of storage under desiccation ranged from 17 to 55% indicating some loss of viability with time. Workers elsewhere showed that *Ustilago scitaminea* (Syd.) spores lost viability within 90 days under wet soil environments and longer periods in dry soil conditions (Leu, 1968); Alexander and Ramakrishnan, 1978). Also, James (1969) indicated that viability varied between 640 to 1210 days but did not specify the conditions of storage or treatment therein. Meanwhile, Luthra *et al*. (1938) also reported that longevity of smut spores varied from 56 to 1306 days under controlled storage conditions at 5^{0}C; and, Alexander and Ramakrishnan (1978) also indicated that spores can remain viable for up to 10 years in laboratory desiccators. Our experiments did not proceed much beyond two months and lasted at 64 days. However, our results agree and compared favorably to the 60 to 90 days' time period stipulated by Leu, (1968).

Elsewhere, Hoy and Geaghan (1992) found that only few viable spores (1%) could be detected after 4 wk in contact soils saturated with water, and none were detected after a 6 wk period (42 days). They further stressed that under three moisture levels, in non-sterile soils the number of viable spores decreased rapidly after 1–4 wk (28 days). And viable spore numbers decreased most rapidly in the wettest soil; but, the spore

Table 1: Mean percentages of smut infection on clump basis for the various sowing date intervals and different soil conditions.

SDI (Days)	Dry soil		Wet soil		Control	
	DSE	PSI	DSE	PSI	DSE	PSI
SDI 1 (01)	99.3	100	93.3	100	0	0
SDI 2 (02)	118.0	50	95.5	50	0	0
SDI 3 (04)	109.3	75	61.0	50	0	0
SDI 4 (08)	93.0	50	98.0	25	0	0
SDI 5 (16)	92.0	75	64.0	50	0	0
SDI 6 (32)	116.0	75	57.5	25	180	50
SDI 7 (64)	54.0	50	72.5	50	104	25
Mean	**86.8**	**64.3**	**77.5**	**50**	**40.6**	**10.7**

SDI= Sowing date interval in days; **DSE**= days to symptom expression; **PSI**= percentage of smut infection on stool basis; Figures in parenthesis are number of days in the respective SDI.

longevity trend was similar for all three moisture levels in each soil (Schlub *et al.* 1985; Hoy *et al.* 1993).

Thereafter, they concluded that, longevity of spores was only limited to 7–9 wk in soils containing moisture and that teliospores of *U. scitaminea* are not long-lived in soils when moisture is present. This tentatively explains the reason why smut infections under subtropical climate conditions is low as soil borne inoculums is low and usually does not persist. Therefore, under such conditions sett borne inoculums is the most important as a source of disease and subsequent spread.

CONCLUSION

In conclusion, the present study has demonstrated that:

1) In both dry and wet soil environments spore viability and longevity remained effective up to the highest tested SDI of 64 days with little degradation or deterioration.

2) The highest spore viability was obtained in SDI 1 (1 day) and SDI 2 (2 days) and the lowest viability in SDI 7 (64 days); SDI's 3(4 days); 4(8 days); 5(16 days); and 6(32 days) were intermediate.

3) Mean spore viability at SDI 7 (64 days) longevity as expressed by the percentage of stool infection SI (%) was higher in dry soils (64.3%) and a lower (50%) under wet soil conditions indicating loss of viability under wet soil environments with time.

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