THE EFFECT OF RATOON STUNTING DISEASE ON THE EXPRESSION OF SMUT SYMPTOMS

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Abstract

A short review is presented of the literature reporting that hot water treatment controls smut, and also that smut develops significantly in the ratoons of previously hot water treated canes. Data from four trials are given on which observations are made about the influence ratoon stunting disease (RSD) infection has on the expression of smut symptoms. It is concluded that the bacterium causing RSD suppresses smut incidence; however, the mechanism of this suppression is not explained.

Introduction

It has been widely reported that the standard long hot water treatment (50,5°C for 2h) used for the control of ratoon stunting disease (RSD), and other combinations of time and temperature, also control smut (Anon[1, 2]; Byther and Steiner[4, 5]; El Nour[6]; James[7, 8]; Joshi[11]; Shaikh and Ranadive[12]; Srinivasan[13]; Steiner and Byther[14]; and Thomson[15]). However, observations in Rhodesia (James[9]) and Mocambique (Thompson[16]), on the development of smut in canes that have been previously hot water treated (HWT), have revealed higher incidences of disease in first and subsequent ratoon crops of smut susceptible varieties compared to non-HWT canes of the same varieties. Consequently, hot water treatment of seedcane for the establishment of RSD-free nurseries has been discontinued in Rhodesia, where smut is endemic. The major commercial variety in Rhodesia is NCo 376, which is very susceptible to smut.

To try and elucidate this problem the epidemiology of smut was examined in three trials conducted primarily to determine the role RSD plays in yield decline in Rhodesia. A fourth trial gives results from an experiment initiated to discover whether there is any interaction between smut and ratoon stunting disease.

Experimental

RSD experiments

Experiments 1 and 2

These were conducted to observe RSD symptom development on four susceptible varieties after inoculation with juice from suspect cane; however, in addition, data on sugarcane smut epidemiology were recorded.

Materials and methods

Three-budded setts of CB 36-14; N 50-211; NCo 310; and NCo 376 (Experiment 1), and Co 1001; CP 48-103; M 31-45; and NCo 310 (Experiment 2) were inoculated using the pressure cup technique (Bell[3]). For the other treatment whole sticks of the four varieties in both experiments were immersed in water at 50,5°C for 2h. The varieties were then planted and allowed to grow for eight months when all plots were put under water stress (irrigation equivalent to 50% Class A pan evaporation) until harvest at twelve months. In addition to the parameters observed for examining the effects of RSD, the numbers of smut whips which developed up to and including harvest were recorded. Experiment 1 was continued for a plant and three ratoon crops, and Experiment 2 for a plant and two ratoon crops.

Experiment 3

This was conducted to investigate the development of RSD in four varieties under two different irrigation levels. As in experiments 1 and 2, smut incidence data were also recorded.

Materials and methods

The seedcane of each of the four varieties used—CP 29-116; NCo 310; NCo 376; and Q 28—was supplied either from a hot water treated or RSD infected nursery. After the first two irrigations following the planting of three-budded setts, a 50% of Class A pan evaporation irrigation was applied to one half of the trial until harvest. The other half received full irrigation (Pan × 1).

This experiment is currently in progress and the data are presented for the plant and first ratoon crops.

RSD and smut experiment

Experiment 4

This experiment is currently in progress and was planned to investigate the effects of RSD on the expression of smut symptoms.

Materials and methods

The seedcane of CP 29-116, NCo 310 and NCo 376 was supplied from two sources:

(i) a nursery in which the plant cane had been initially hot water treated, and
(ii) a nursery in which the plant cane had been initially RSD inoculated.

Immediately prior to planting, half the three-budded cane setts from both sources were dipped in a smut spore inoculum (10^6 spores per ml water) for five minutes. The other half was not so treated. The following data were recorded:

(*a*) weekly growth measurements,
(*b*) fortnightly tiller populations, and
(*c*) the number of smut whips which developed up to and including the time of harvest.

Results

There was no smut in the plant crop of HWT cane, and the disease incidence was very low in the RSD infected plots of Experiment 1. However, smut incidence increased markedly in first and subsequent ratoons, and there was significantly more smut in the previously HWT cane in all three ratoons. It is interesting to note the decline in overall smut incidence from second to third ratoon — a feature in other smut trials commented on by James[10] (Table 1). An examination of the data for percentage stalks affected by RSD and the smut whip populations up to and including the harvest of first ratoon crops shows an inverse correlation between the two disease infection levels (Table 2).

TABLE 1

Smut whips 100/ha (across varieties) — Experiment 1

Crop	Treatment	
	HWT	RSD inoculation
P	0	0,4
1R	44,2	21,1
2R	185,6	96,5
3R	100,0	43,2

TABLE 2
Relationship between RSD and smut incidences in first ratoon (across varieties) — Experiment 1

Treatment	Disease incidence: RSD percentage	Disease incidence: Smut whips/ha
HWT	32,5	4 420
RSD inoculated	76,0	2 110

In the second RSD experiment, where no smut whips were observed in any of the varieties until first ratoon, there was more disease in the previously HWT plots. This difference was highly significant by second ratoon (Table 3).

TABLE 3
Smut whips 100/ha (across varieties) — Experiment 2

Crop	Treatment: HWT	Treatment: RSD inoculation
P	0	0
1R	35,0	30,0
2R	112,4	49,0

In contrast to the previous two trials there was less smut in the HWT plots than RSD inoculated plots during the plant crop. However, by first ratoon more smut developed in the plots originally planted with seedcane from HWT nurseries. Water stress was also shown to increase smut incidence in both plant and first ratoon crops (Tables 4 and 5).

TABLE 4
Smut whips 100/ha: plant crop (across varieties) — Experiment 3

Disease treatments \ Irrigation treatments	Full pan	50%	Mean
Hot water treated	1,8	5,4	3,6
Ratoon stunting disease inoculated	9,0	9,5	9,3
Mean	5,4	7,5	

TABLE 5
Smut whips 100/ha: First ratoon crop (across varieties) — Experiment 3

Disease treatments \ Irrigation treatments	Full pan	50% pan	Mean
Hot water treated	105,6	112,7	109,1
Ratoon stunting disease inoculated	79,8	95,2	87,1
Mean	91,8	103,5	

In the fourth trial, which is currently in progress to investigate the effect of RSD on smut expression, smut infection was shown to depress cumulative growth at all times in plant, first ratoon and second ratoon crops. In contrast, RSD infection did not have the same growth depressing effect in all three crops (Table 6).

Data in Table 7 show that while smut infection significantly depresses tiller populations, RSD infection has the opposite effect.

TABLE 6
Cumulative growth in cms (across varieties) — Experiment 4

Treatments	Time in weeks: 1	2	3	4	5	6	7	8	9	10	11	Mean
PLANT												
With smut	7,9	16,7	31,5	43,6	58,9	76,8	97,5	113,4	124,2	142,6	161,5	79,5
Without smut	8,2	18,1	34,2	47,2	64,1	81,6	103,5	121,5	132,5	150,1	169,6	84,6
With RSD	8,5	18,3	33,9	45,9	61,4	78,8	99,8	116,4	127,4	144,5	163,0	81,6
Without RSD	7,6	16,5	31,9	44,9	61,6	79,6	101,2	118,5	129,3	148,2	168,1	82,5
FIRST RATOON												
With smut	5,9	14,4	26,6	35,5	48,3	48,7	73,0	88,4	102,0	116,4	128,8	62,5
Without smut	6,7	16,0	29,3	39,6	53,2	64,1	77,9	92,9	110,1	125,3	138,5	68,5
With RSD	6,0	14,4	26,8	36,3	49,4	60,2	74,2	89,9	105,5	120,4	131,8	65,0
Without RSD	6,5	15,9	29,2	38,8	52,1	62,7	76,8	91,4	106,6	121,2	135,4	67,0
SECOND RATOON												
With smut	7,7	19,6	32,1	43,4	53,2	55,0	79,3	92,0	106,2	122,0	136,5	67,9
Without smut	8,0	20,3	33,8	46,2	56,5	68,1	83,4	97,2	111,1	128,1	143,2	72,4
With RSD	8,2	20,6	33,6	45,6	54,9	66,7	81,5	95,3	109,2	125,3	139,9	71,0
Without RSD	7,6	19,3	32,3	44,0	54,8	66,4	81,2	93,9	108,1	124,8	139,7	70,2

TABLE 7
Fortnightly tiller counts 1 000/ha in the plant crop (across varieties): Smut and RSD treatments — Experiment 4

Fortnights	Smut treatments: With smut	Smut treatments: Without smut	RSD treatments: With RSD	RSD treatments: Without RSD	SE $\bar{x}$
1	28,8	35,2	35,9	28,2	± 1,2
2	49,3	61,7	62,4	48,6	± 3,0
3	116,7	134,4	139,2	111,9	± 3,9
4	148,5	166,5	164,8	150,2	± 4,8
5	164,7	191,9	187,4	169,3	± 6,5
6	160,6	165,3	168,4	157,5	± 4,8

TABLE 8

Fortnightly tiller counts 1 000/ha in the plant crop (across varieties): Smut and RSD treatments — Experiment 4

Fortnights	Smut treatments						RSD treatments						P
	CP 29-116		NCo 310		NCo 376		CP 29-116		NCo 310		NCo 376		
	With smut	Without smut	With smut	Without smut	With smut	Without smut	With RSD	Without RSD	With RSD	Without RSD	With RSD	Without RSD	0,05
1	31,5	34,2	24,8	32,9	30,3	38,5	41,2	24,5	30,4	27,4	36,1	32,7	6,3
2	58,2	71,8	35,7	51,0	53,8	62,4	74,7	55,3	49,3	37,5	52,9	63,3	15,3
3	123,8	120,7	95,5	126,5	130,9	156,1	144,1	100,3	118,1	103,8	155,5	131,5	20,3
4	152,2	162,9	132,6	164,6	160,7	171,9	169,1	146,1	151,7	145,5	173,6	159,0	24,6
5	155,2	166,8	162,4	204,6	176,6	204,4	168,7	153,2	192,1	175,0	201,3	179,7	33,7
6	156,6	141,5	142,2	165,5	182,9	188,9	160,2	137,9	158,5	149,2	186,5	185,3	24,8

Considering the varieties separately, smut infection was shown to depress tiller populations in NCo 310 and NCo 376, while the disease had no significant effect on tiller populations in CP 29-116. However, RSD would appear to increase tiller populations in CP 29-116, especially in the first six weeks from initial emergence through the soil surface. RSD did not have the same effect on either NCo 310 or NCo 376 (Table 8). There were no similar differences of significance in tiller populations with either smut or RSD treatments in first or second ratoons.

Though there was an overall increase in smut incidence from plant through second ratoon crops, the plots originally planted with smut infected seedcane maintained a significantly higher smut incidence over the three crops (Table 9). However, an examination of the smut whip population data in the plots originally planted with RSD infected seedcane shows that, while there was significantly more smut in the non-HWT (*vis-à-vis* RSD infected) plots during the plant crop, this situation was reversed in subsequent ratoon crops. There was significantly more smut in the RSD-free plots during first and second ratoons (Table 10).

TABLE 9

Smut whips 100/ha (across varieties with RSD treatments)—Experiment 4

	Crop	Smut treatments		SE $\bar{x}$
		With smut	Without smut	
P	Whips 100/ha-Log_{10} . .	1,5124	0,3647	± 0,0510
	Whips 100/ha-transformed	32,5	2,3	—
1R	Whips 100/ha-Log_{10} . .	2,3772	1,8305	± 0,0267
	Whips 100/ha-transformed	238,3	67,7	—
2R	Whips 100/ha-Log_{10} . .	2,1207	1,8618	± 0,0831
	Whips 100/ha-transformed	132,0	72,7	—

TABLE 10

Smut whips 100/ha (across varieties and smut treatments)—Experiment 4

	Crop	RSD treatments		SE $\bar{x}$
		With RSD	Without RSD	
P	Whips 100/ha-Log_{10} . .	1,0170	0,8602	± 0,0510
	Whips 100/ha-transformed	10,4	7,3	—
1R	Whips 100/ha-Log_{10} . .	2,0316	2,1761	± 0,0267
	Whips 100/ha-transformed	107,5	150,0	—
2R	Whips 100/ha-Log_{10} . .	1,8886	2,0939	± 0,0300
	Whips 100/ha-transformed	77,3	124,2	—

Discussion

The subsequent increase in smut incidence in the ratoons of canes that had previously been hot water treated, has resulted in the abandoning of the two commercial hot water treatment plants in the Rhodesian sugar industry. Heat treatment certainly controls smut infection within seedcane; however, should varieties so "cleaned" be re-exposed to infection or planted in areas where smut is endemic, then they become rapidly re-infected.

The fact that thermotherapy "softens" the buds rendering them more prone to physical damage and secondary infections does not entirely explain this increase in smut incidence following heat treatment. If it did so then disease incidence would be higher in the plant crop of hot water treated cane than in cane not so treated.

When it was first observed that smut incidence was higher in the first and subsequent ratoons of hot water treated canes than non-hot water treated canes, it was postulated that this was the result of RSD depressing growth and tillering rates. It was therefore thought that the hot water treatment of smut susceptible varieties, such as NCo 376, resulted in a greater amount of material available for infection at any given period of time. However, the data in Tables 6, 7 and 8 show this assumption to be erroneous. Under conditions of optimum irrigation, as obtained in the Rhodesian lowveld, RSD has no depressing effect on growth or tillering rates; while, conversely, smut infection has.

The data presented above therefore indicate that there is a possible interaction between the bacterium causing RSD and *Ustilago scitaminea* Sydow. In canes infected with both diseases there is a suppression of smut symptom expression by the causal agent of RSD. The mechanism of this suppression is yet to be elucidated.

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