SOME EFFECTS OF HOT WATER TREATMENT

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Abstract

The role of ratoon stunting disease in causing yield losses under fully irrigated conditions in the lowveld is as yet undefined. Hot water treatment at 50,5°C for 2 hr was shown to adversely affect germination and reduce stalk population in certain varieties. The optimum age for hot water treatment of NCo 310 and NCo 376 seedcane was found to be 11-12 months. Exposure of hot water treated cane subsequent to treatment had no detrimental effect if the period did not exceed two days. No unsatisfactory stands resulted from planting hot water treated cane during a mild winter. Latent infections of culmicolous smut were controlled by thermotherapy.

Introduction

Though ratoon stunting disease (R.S.D.) has previously been recorded in NCo 376 at Chirundu (Whiteside and Herd[7]) the effects of this disease were not obvious in the Rhodesian lowveld until 1968. As a result of reduced irrigation applied over the 1967-68 season, poor uneven growth was seen to occur in many fields both on Hippo Valley Estates Ltd., and Triangle Ltd. Consequently a preliminary survey was carried out to determine the incidence of R.S.D. The results from this survey showed that R.S.D. occurs throughout the lowveld; however, the symptoms observed on longitudinally splitting the sampled canes were somewhat atypical, in that there was usually only one discoloured bundle (at the most two) per stalk in the nodes of affected canes. To confirm that the symptoms recorded in the survey were caused by the R.S.D. pathogen the following inoculation experiments were initiated.

Experimental

Inoculation experiments

Experiment 1

Materials and methods

Three-budded setts of four R.S.D. susceptible varieties — CB 36-14, CP 43-47, Pindar and Q 58 — were subjected to one of the following treatments.

(a) Hot water treatment (H.W.T.) at 50,5°C for 2 hr.
(b) No H.W.T.
(c) H.W.T., then inoculated with juice expressed from canes suspected of having R.S.D.
(d) No H.W.T., but inoculated with suspect juice.

The cane setts were inoculated using the pressure cup technique (Bell[1]). The experiment, which was a 4^2 factorial design (two replications) with single line plots 6,7 m long containing 10 setts planted end to end, was cut at 16 months.

Results

H.W.T. significantly reduced the stalk population ($P<0,01$) when compared with the no H.W.T. plots; and the inoculation of setts with suspect juice also reduced the stalk population at 16 months — No H.W.T. > No H.W.T. + inoculated ($P<0,05$). H.W.T. adversely affected the germination of both Pindar and Q 58, and reduced their stalk populations. (Table I).

TABLE I

Mean stalk population at 16 months in 1 000's per ha. — Expt. 1

Variety	Treatments				Mean	L.S.D.	
	H.W.T.	No H.W.T.	H.W.T. + Inoc.	No H.W.T. + Inoc.		5%	1%
CB 36-14	113,4	146,6	112,4	116,4	122,2	22,9	31,7
CP 43-47	81,7	160,9	100,5	129,7	118,2		
PINDAR	34,2	91,6	—	59,4	46,3		
Q 58	1,0	91,6	—	76,2	42,2		
Mean	57,5	122,7	53,2	95,4			
L.S.D.	5%=22,9		1%=31,7				

C. of V.%=26,2
L.S.D. table 5%=45,9
„ „ 1%=63,4

TABLE II

Percentage infection at 16 months — Expt. 1

	H.W.T.	No H.W.T.
Inoc.	50,8	39,5
Not Inoc.	40,2	39,2

CB 36-14 had a higher R.S.D. incidence than CP 43-47 (50,6% vs. 34,3%); however, there were no statistical differences between treatments (Table II).

Neither inoculation nor H.W.T. had a significant effect on the growth in height of CB 36-14 and CP 43-47.

Comments

Both Pindar and Q 58 were adversely affected by H.W.T. Though the inoculation of setts receiving no H.W.T. reduced the eventual stalk population when compared to non-inoculated non hot water treated canes, closer examination of the data for CB 36-14 and CP 43-47 reveals that this was most likely caused by the secondary invasions of other pathogens rather than the inoculation with R.S.D.

Experiment 2

Materials and methods

Three-budded can setts were pressure inoculated with suspect juice for the one treatment, and for the other treatment whole sticks of the four varieties were hot water treated at 50,5°C for 2 hr. The varieties were then planted in a split plot design — whole plots in 4 × 3 randomised blocks, sub-plots in two randomised blocks. The nett plot size was 74,4 m². The cane was allowed to grow for eight months when all plots were put under water stress (50% Class 'A' pan).

Monthly counts of the number of tillers in one line of every plot were taken for the first five months, and weekly growth measurements were also recorded for 16 weeks. After eight months, fortnightly cane samples were taken randomly from the guard rows in order to assess the development of visible internal symptoms of R.S.D. A final sample was taken also from the nett plots just prior to harvest at 12 months.

TABLE III

Final percentage score of visible internal R.S.D. symptoms — Expt. 2

Variety	Treatment	
	H.W.T.	Inoc.
CB 36-14	13,9	95,8
N 50-211	9,7	58,3
NCo 310	18,1	65,3
NCo 376	11,1	51,4
Mean	13,2	67,7

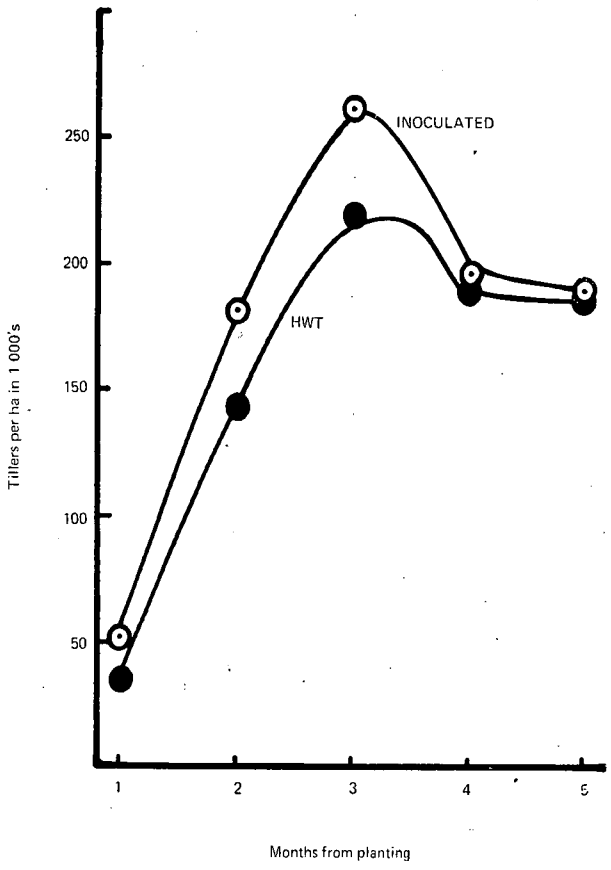

FIGURE 1: Monthly tiller counts in 1 000's per ha.

Results

Hot water treated cane produced fewer stalks per ha. in the first five months of growth than non hot water treated cane. Such differences were significant in the first and third months — $P<0,05$ (Figure 1). There were no significant differences between treatments in growth increment over 16 weeks, though varieties differed widely.

In all varieties there were far higher percentages R.S.D. infections in the inoculated treatments — 67,7% on average — than in the hot water treatments 13,2% on average (Table III). The incidence

TABLE IV

Comparison of treatments (across varieties) — Expt. 2

Harvest data	Treatments		C. of V.%	L.S.D.	
	H.W.T.	Inoc.		5%	1%
Stalk count 1 000's per ha	118,8	120,0	7,9	8,1	12,1
Tonnes cane per ha	108,4	112,4	13,2	17,2	25,1
Purity %	84,6	86,3	2,0	1,2	1,7
Sucrose %	13,80	14,40	4,4	0,48	0,70
Fibre %	12,0	12,3	6,6	0,8	1,2
Brix %	16,3	16,6	3,2	0,5	0,7
E.R.S. % C.*1	11,76	12,44	5,7	0,54	0,79
T.E.R.S.H.*2	12,83	13,88	14,4	2,06	3,00

*1 Estimated recoverable sugar per cent cane = S — 0,451 (B — S) —0,77 F where S= Sucrose % Cane, B= Brix and F= Fibre by direct analysis.

*2 Tonnes estimated recoverable sugar per hactare.

of R.S.D. symptoms was particularly high in CB 36-14.

Though H.W.T. had no significant effect on cane yield, it caused a reduction in juice purity ($P<0,01$) sucrose per cent cane and E.R.S. % C. (both $P<0,05$). H.W.T. appeared to reduce T.E.R.S.H.; however, the difference observed was not significant (Table IV).

There was a marked (though non significant) reduction in sugar yield per ha in CB 36-14, while NCo 310 showed no difference between treatments (Table V).

TABLE V

T.E.R.S.H. data — Expt. 2

Variety	Treatment	
	H.W.T.	Inoc.
CB 36-14	11,58	13,30
N 50-211	10,01	11,33
NCo 310	16,26	16,17
NCo 376	13,46	14,69
C of V%=14,4	L.S.D.	
	5%=3,36	1%=4,68

Comments

H.W.T. caused significant reductions in sucrose, juice purity and E.R.S. % C., and did not produce any yield increases in the plant crop of the four varieties tested, though the trial was stressed (50% of the normal irrigation applied during the last four months of growth). This lack of response to H.W.T. may be attributed to the early set back in growth caused by the thermotherapeutic treatment (Figure 1). Furthermore, the climatic conditions for growth in the lowveld may be such that the morphological effects of R.S.D. are not expressed in the plant crop. However, it is expected that the advantages of H.W.T. will become evident during subsequent ratoons. The trial is therefore being continued, again with water stress imposed.

The relationships of H.W.T. effects and seedcane age, exposure subsequent to thermotherapy, winter planting, and smut incidence

Because certain difficulties and queries arose from the handling of seedcane in the field, subsequent to

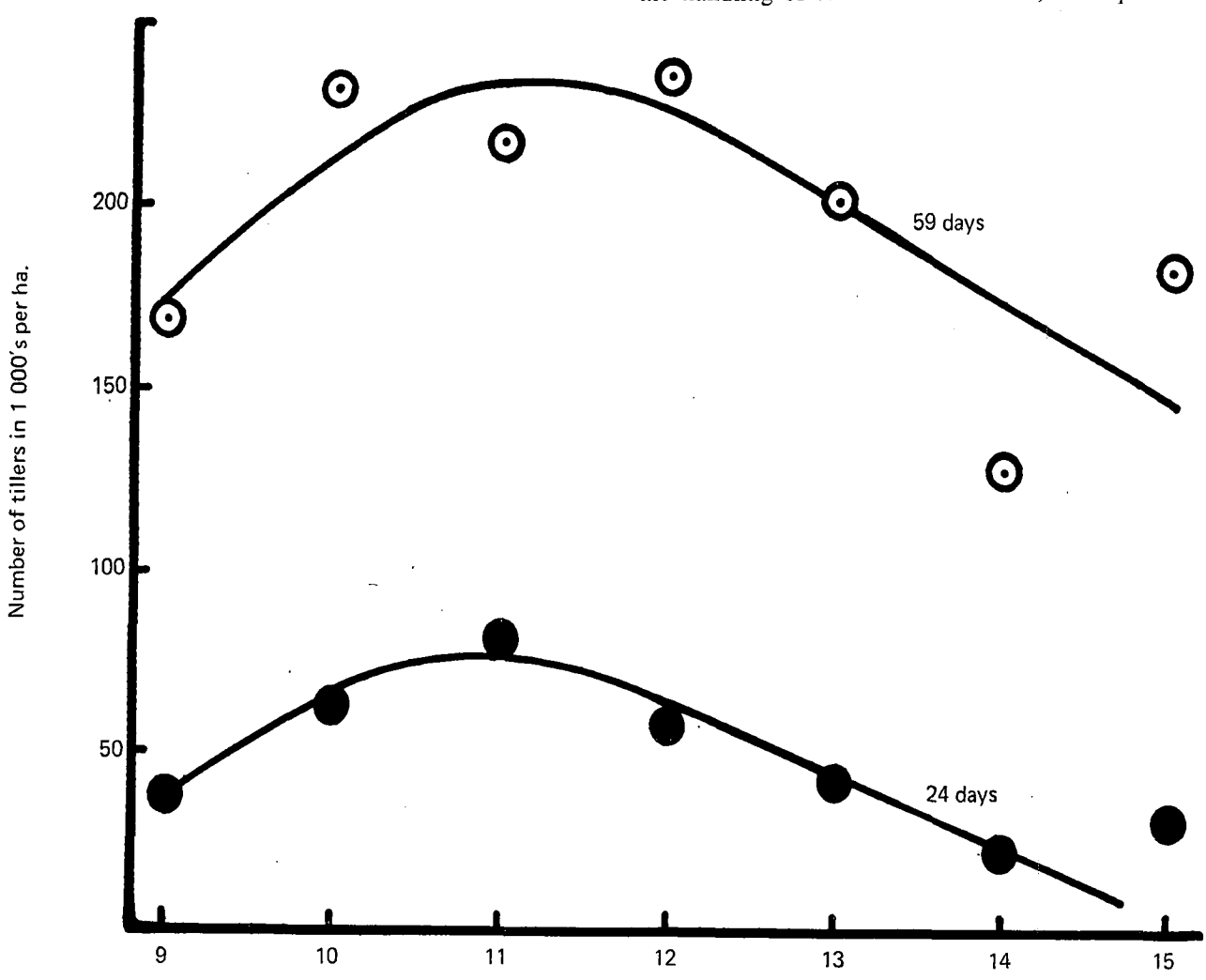

FIGURE 2: *Number of tillers in 1 000's per ha. Expt. 3.* (Mean of both varieties.)

TABLE VI

Treatment data (across varieties) — Expt. 3

	Age of seedcane in months								L.S.D.	
Harvest data	9	10	11	12	13	14	15	C of V%	5%	1%
Tonnes cane per ha	141,8	157,5	165,2	172,1	141,9	120,9	154,6	8,4	15,0	20,3
T.E.R.S.H.	12,15	16,21	17,67	16,57	13,08	11,34	12,99	17,4	2,95	3,99

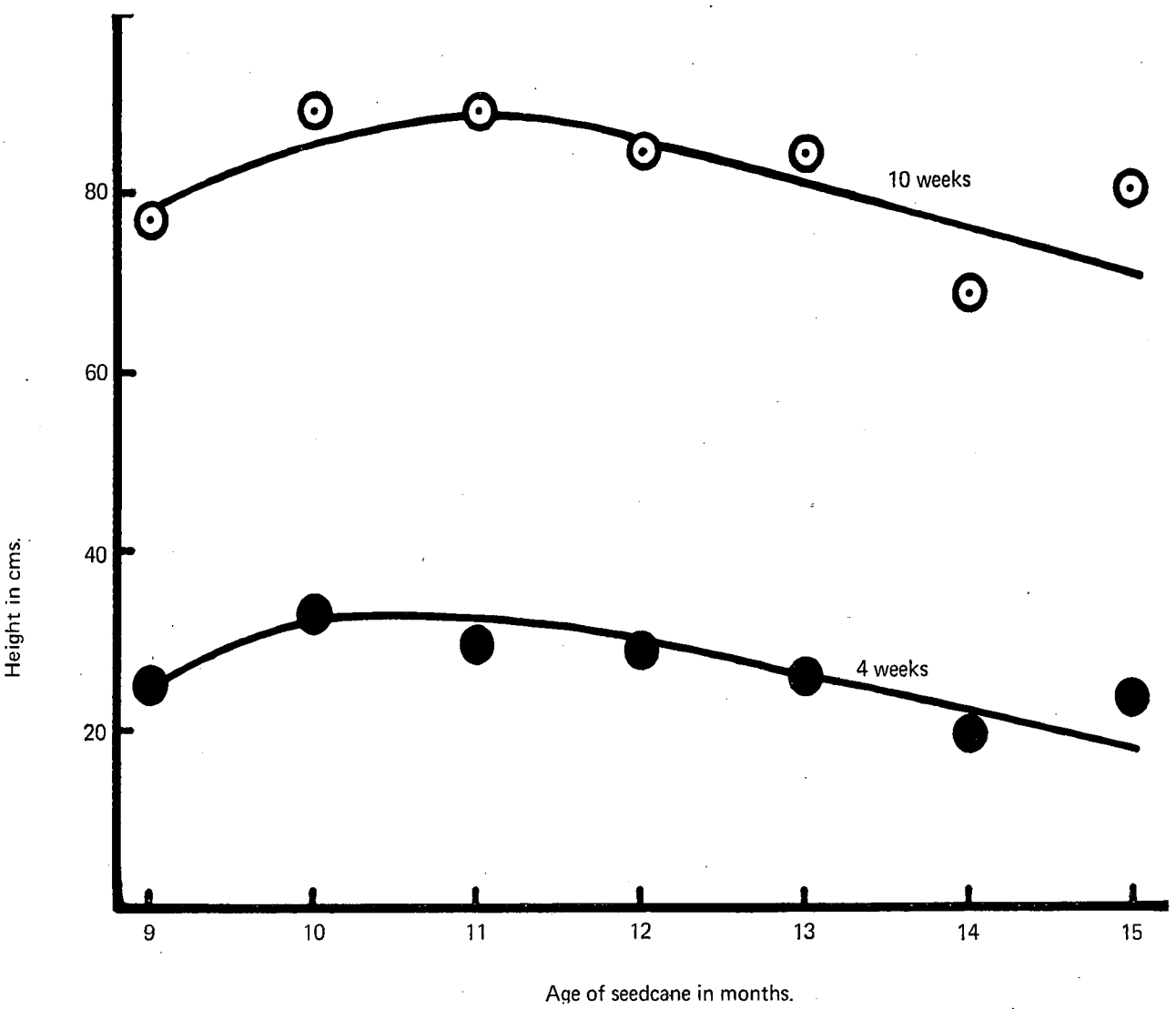

FIGURE 3: Increase in height from initial. Expt. 3. (Mean of both varieties.)

H.W.T., the following series of experiments was initiated.

Experiment 3

Effect of H.W.T. on growth and subsequent yield of seedcane of increasing age

Materials and methods

Seedcane of NCo 310 and NCo 376 was hot water treated at 50,5°C for 2 hr; seven ages of cane were treated: (a) 9, (b) 10, (c) 11, (d) 12, (e) 13, (f) 14 and (g) 15 months old.

The seedcane was double-planted as whole sticks in a split-plot design — ages of seedcane being the main plots and varieties the sub-plots. Main plot size was 46,5 m^2 and sub plots 22,8 m^2 (i.e. single rows 15,2 m long). Weekly recordings of growth increment from initial, and a monthly count of the number of tillers per plot were made.

Results

Twenty-four days from planting the data showed that seedcane age at time of H.W.T. affected the tiller population — 11 month > 10 month ($P<0,01$). This effect persisted until 59 days from planting. At

this time the 14 month old seedcane produced significantly less tillers than the other ages of cane — 14 month < 9 month — P<0,01 (Figure 2).

The point of inflection of the curves in Figures 2 and 3 as well as the maxima for both tonnes cane and tonnes sugar per ha in Table VI occurred between 11 and 12 months.

Comments

It can be concluded that the optimum age for H.W.T. of both NCo 310 and NCo 376 seedcane is between 11 and 12 months.

Experiment 4

Effect of H.W.T. on growth and eventual yield of seedcane which has been exposed to ambient temperatures for varying lengths of time in the field subsequent to thermotherapy.

Materials and methods

Nine month old seedcane of NCo 310 and NCo 376 was hot water treated at 50,5°C for 2 hr. The cane then received the following exposure treatments prior to planting: (a) 0 days, (b) 1 day, (c) 2 days and (d) 4 days. After H.W.T. the cane was stacked under trash in the field: the ambient maximum shade temperatures during the exposure period were 28,0-35,6°C. The seedcane was then double-planted as whole sticks in single row plots 15,2 m long. Weekly recordings of growth increment from initial, and a monthly count of the number of tillers per plot were made.

TABLE VII

Number of tillers in 1 000's per ha, and increase in height from initial after 2 months (Means of two varieties) — Expt. 4

	Treatment in days				C of V%	L.S.D.	
	0	1	2	4		5%	1%
Tillers/ha in 1 000's	168,7	163,3	156,5	106,4	16,0	29,4	40,8
Increase in ht. (cm)	58,2	58,2	55,1	47,4	17,1	11,5	16,0

Results

The length of exposure of seedcane subsequent to H.W.T. affected the tiller population, with the four day exposure producing the least tillers — 2 day > 4 day treatment (P<0,01). There was also a marked (though non significant) growth depression by the four day exposure treatment (Table VII).

At harvest the four day exposure treatment significantly depressed both juice purity and E.R.S. % C. when compared to the other exposure treatments — P<0,05 (Table VIII). There was also a non-significant trend towards lower cane yield with the four day exposure treatment.

Comments

Leaving hot water treated cane stacked in the field would appear to have little detrimental effect on cane yield at harvest in either NCo 310 or NCo 376 unless the exposure period is over two days.

Experiment 5

Effect of H.W.T. on germination and growth of seedcane planted during the winter months

Materials and methods

One year old seedcane of NCo 310 was hot water treated at 50,5°C for two hr, and then double-planted as whole sticks. The centre row of five was planted with non hot water treated canes — double-planted as three budded setts. Cane was planted in the lowveld winter months, namely: May, June, July and August. Weekly counts of the number of tillers and weekly recordings of growth increment from initial in both hot water treated and non hot water treated lines were made.

Results

Planting hot water treated cane during June, July and August would appear to be detrimental to the initial growth — as measured in the increase in tiller population — when compared to non hot water treated cane (Figure 4).

However, no similar effect on growth is indicated in Figure 5.

Comments

The winter temperatures were particularly mild during 1970, thus resulting in little if any inhibition of growth of hot water treated as compared to untreated cane.

Experiment 6

Effect of H.W.T. on the development of smut

Materials and methods

Seedcane of NCo 310 and NCo 376 was collected from fields with an extremely high smut incidence. Half the seedcane for each variety was hot water treated, whilst the other half was left untreated. After H.W.T. the canes were planted in four randomised single line plots, 12,2 m long — 12 replications. Weekly inspections for smut whips were carried out, and any whips which developed were carefully removed from infected stools making sure no cross-infection occurred. Seventeen weeks after planting, the routine smut inspections were discontinued because of lodging in the experimental plots.

When the cane was harvested at 12 months, the total number of smut whips was calculated for each plot — those recorded in the first 17 weeks plus the numbers recorded at harvest.

In Experiment 2, as well as assessment for the development of R.S.D. symptoms being made, weekly counts of the number of smut whips which developed were made for the first five months of the experiment.

Results

In Tables IX and X the data show that smut developed in the non hot water treated plots only. However, at harvest, smut was recorded from all plots in Experiment 6 (Table XI). This was because the smut-free rows of hot water treated cane were

TABLE VIII

Treatment data (across varieties) — Expt. 4

Harvest data	Treatment in days				C of V%	L.S.D.	
	0	1	2	4		5%	1%
Stalk population 1 000's per ha.	131,8	146,3	150,0	126,1	26,8	45,9	63,7
Tonnes cane per ha	119,6	146,2	140,6	105,8	31,4	49,8	69,2
Purity %	81,9	82,1	84,0	76,5	5,6	5,6	7,7
Sucrose %	10,35	10,64	11,27	9,19	14,3	1,83	2,54
Brix %	12,6	12,9	13,4	11,9	8,8	1,4	1,9
Fibre %	10,6	10,3	11,2	10,2	8,0	1,1	1,5
E.R.S. % C.	8,50	8,82	9,44	7,20	17,0	1,79	2,48
T.E.R.S.H.	10,22	13,53	13,64	8,41	38,9	5,51	7,64

TABLE IX

Smut whips per hectare—Expt. 2

Variety	Treatment	
	H.W.T.	No H.W.T.
CB 36-14	0	0
N 50-211	0	119
NCo 310	0	72
NCo 376	0	25

TABLE X

Smut whips per hectare (data from first 17 week plant crop) — Expt. 6

Variety	Treatment	
	H.W.T.	No H.W.T.
NCo 310	0	573
NCo 376	0	0

TABLE XI

Smut whips per ha — up to and including harvest — Expt. 6

Variety	Treatment		C of V%	L.S.D.		
	H.W.T.	No H.W.T.		5%	1%	0,1%
NCo 310	968	2 365	99,9	894	1 205	1 597
NCo 376	215	753				

under infection pressure from the non hot water treated cane, and from surrounding fields. H.W.T. very significantly reduced the number of smut whips per ha in NCo 310 ($P<0,01$); however, though there was a difference between the two treatments in NCo 376, this was not significant.

Comments

The data from these two experiments show that thermotherapy can be used for smut control in seedcane.

Discussion and conclusions

Under fully irrigated conditions in Swaziland, R.S.D. has been estimated to cause yield losses of up to 28% in NCo 310 and 43% in NCo 376 (Durandt[2]). It is therefore imperative that the role of the ratoon stunting virus in bringing about yield losses under the similar agronomic conditions obtaining in the Rhodesian lowveld be evaluated. From the results of two inoculation experiments reported here it can be concluded that R.S.D. has little if any effect on growth and yield in the plant crop, even when water stress is imposed. However, the effects of virus infection are expected to become increasingly marked in subsequent ratoons.

The inhibitary effects of H.W.T. on initial growth of certain varieties need to be elucidated, as it is pointless having the cure to a disease more severe than the disease itself.

Under lowveld conditions the optimum age for H.W.T. of seedcane is between 11 and 12 months; however, such cane must be from unlodged fields for reasons of efficiency. Obviously the straighter the seedcane for thermotherapy the greater will be the output in a given unit of time, when the whole stick is hot water treated.

Hot water treated NCo 310 and NCo 376 can be stacked in the field for up to two days without any detrimental effect. This observation is important if large plant programmes of hot water treated cane are envisaged.

As planting hot water treated cane during the winter months in Queensland, Australia, has been found to result in an unsatisfactory stand (Rehbein[5]), the risks of planting seedcane after H.W.T. during the lowveld winter (May-August) must be defined. The data in Experiment 5 show that planting hot water treated cane during a mild winter, such as 1970 was, has no detrimental effects.

An interesting side effect of H.W.T. is the fact that it controls smut. Joshi[4] reported that the treatment of setts at 52°C for 18 minutes controlled culmicolous smut in the susceptible variety Co 213, and Thomson[6] has said that there was an indication

latent infections of the same disease are controlled by the standard H.W.T. for R.S.D. — a conclusion confirmed by James[3].

Acknowledgements

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REFERENCES

1. Bell, A. F., 1935. Two inoculation methods. Proc. Inter. Soc. Sug. Cane Tech. 5th Cong. 199.
2. Durandt, H. K., 1970. Sugarcane crop hygiene scheme. Proc. A.G.M., S. Afr. Sug. Ind. Agronomists Assoc.
3. James, G. L., 1971. Hot water treatment and smut. Sugarcane Pathologists newsletter 6, 11.
4. Joshi, N. C., 1954. Effect of hot water treatment of setts for the control of red rot and smut disease of sugarcane. Indian Sugar, N.S., 4. (Abstr. R.A.H. 35: 44).
5. Rehbein, C. A., 1970. Approach Autumn hot water treatment with caution. Cane Growers Quart. Bull. 33, 4, 115.
6. Thomson, G. M., 1970. Smut disease and hot water treatment. Sugarcane Pathologists Newsletter 5, 48.
7. Whiteside, J. O., and Herd, G. W., 1966. List of diseases of economic plants in Rhodesia. Tech. Bull. No. 5. 28 pp. publ. Rhodesia Agr. J.

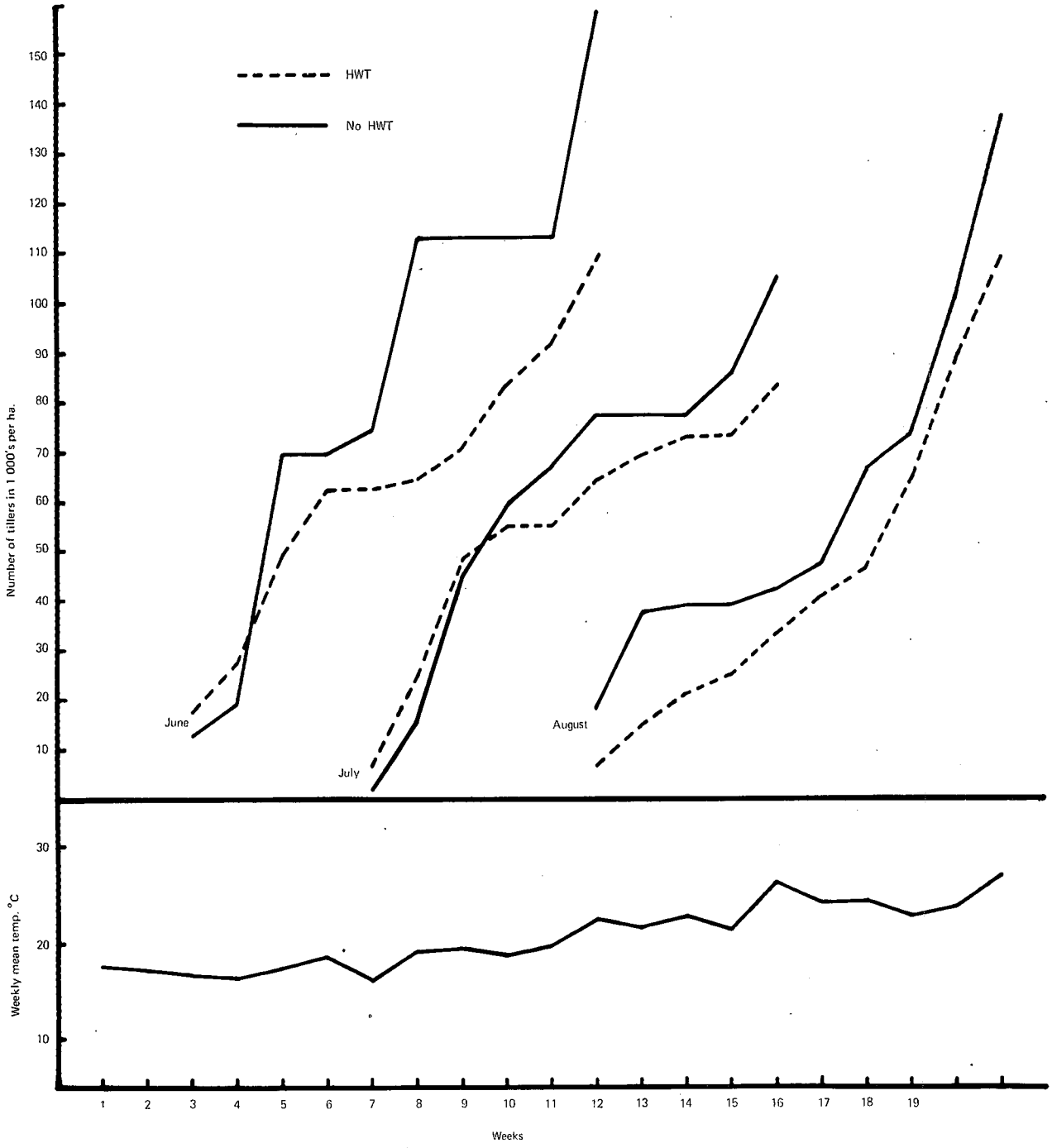

FIGURE 4: Number of tillers in 1 000's per ha — over 10 weeks, June, July and August.

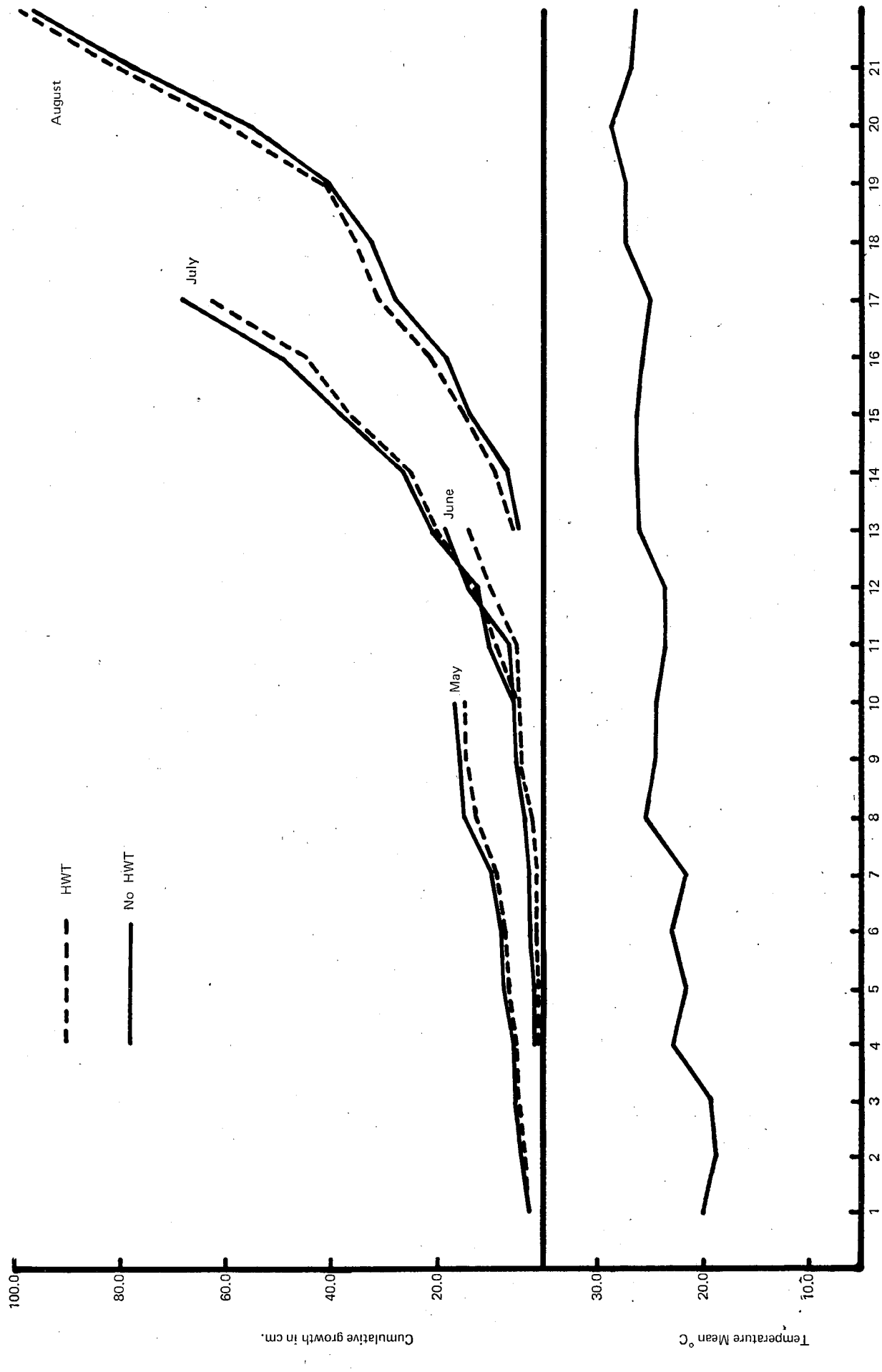

FIGURE 5: Cumulative growth from initial.

Discussion

Dr. Dick: We do not plant fields with hot water treated cane, but we use it to plant nursery beds and we use sterilised instruments for harvesting it.

Dr. James: This is the case in Rhodesia; only fields set aside for future seedcane supply are planted with hot water treated cane. However, I have heard that some commercial fields in this country are being planted direct with treated cane.

Dr. Cleasby: Should not the recommendation in Rhodesia be to plant from treated can and so sure smut disease?

Dr. James: Hot water treatment is being considered as a method of controlling smut; but it is extremely difficult to keep the cane free of the disease when the germinating can is exposed to a high inoculum pressure of smut spores from neighbouring fields. Unless the highly infected fields are eradicated then hot water treatment will be ineffective in controlling smut.

Mr. Thomson: Our experience is that CB 36-14 is more susceptible to RSD than other varieties, and is certainly also likely to suffer germination damage due to heat treatment.

We have done ratoon stunting trials and compared diseased and healthy plots, using inoculated cane and heat treated cane. Results were inconsistent so we now use prior planting of seed beds of healthy and RSD cane to avoid the effect of heat treatment on the healthy plots. This shows, particularly with a variety like CB 36-14, a large decrease of yield due to RSD even in the plant cane crop.

We have carried out smut disease observation trials on N 55/805 using sticks bearing whips and treated these in hot water at 50,5°C for two hours. This effectively suppressed the production of whips. This should now be carried on to the ratoon stage.

Dr. Cleasby (in the chair): It appears in Swaziland that there has been yield reduction due to RSD, and yet in Rhodesia, with similar conditions of irrigation and climate, no reduction has been found in the plant cane crop.

Mr. Schalkwyk: At Ubombo Ranches we plant nurseries from hot water treated cane, and then use the seed for commercial planting. The decrease in yield may well be due to poor germination, which we found particularly in NCo 376. Tiller counts were much lower in the hot water treated experiment from the first month, indicating poor germination.

Mr. Gilfillan: At Tongaat we found that heat treatment just before winter seriously affected germination, and, like Mr. van Schalkwyk, we found NCo 376 very susceptible to damage.

Mr. Pearson: At UVS some years ago, when Co 331 was planted in February, we got a total crop failure. This year we have also had poor results after heat treating in February.