



## Hot Water Treatment Enhanced Rapid Germination of Cane Setts and Reduced the Incidence of Pineapple Disease [*Ceratocystis paradoxa* (Dade) Moreau.] Significantly

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### ABSTRACT

Hot water, at 42 °C and 52 °C, as separate therapeutic and prophylactic treatments, were evaluated for the management of pineapple disease of sugarcane. *Ceratocystis paradoxa*, the causal organism of pineapple disease was isolated from infected sugarcane, while the test crop was DTS 44-33 sugarcane variety. Therapeutic hot water treatment of setts was achieved by infecting cane setts with 10<sup>7</sup> spore suspension of *C. paradoxa* for 72 hrs before immersion in hot water for 30 minutes. Prophylactic treatment, cane setts were submerged in hot water before infection with *C. paradoxa*. Infected setts without hot water treatment forms the control, while the standard check was made up of setts treated with Mancozeb fungicide before infection with the pathogen. The results showed that significant ( $p < 0.05$ ) differences in percentage germination, the incidence of pineapple diseases, growth and yield parameters. Cane sett subjected to 52 °C prophylactic hot water treatment had the highest percentage germination (88.15%), the lowest incidence of pineapple diseases (8.30%) and the highest fresh weight (140.67 tons/ha). The therapeutic treatment at the same temperature gave significantly lower values for these parameters. Prophylactic hot water treatment may be recommended for the management of pineapple disease of sugar cane.

**Keywords:** Hot water, therapeutic and prophylactic treatment, pineapple diseases, *Ceratocystis paradoxa*, sugarcane

### 1. Introduction

Sugarcane, *Saccharum officinarum* L, is a perennial monocot plant that belongs to the Poaceae family. It is cultivated primarily for the sucrose it stores in its stem and the crop is credited with the production of 60 – 70% of global sugar needs (Sulaiman *et al.*, 2015). Sugarcane has immense medicinal, industrial, agricultural and pharmaceutical importance (Neves and Chaddab 2012; Dotaniya *et al.*, 2016). The use of sugarcane in power generation, production of ethanol and biofuel has also been reported (Khatiwada *et al.*, 2012; Giri *et al.*, 2013; Baz *et al.*, 2017).

Sugarcane sett rot (SSR) or pineapple disease of sugarcane (PDS) is one of the major limitations to the cultivation of the crop. This disease is caused by a soil-borne fungus, *Ceratocystis paradoxa*. It is an Ascomycetous fungus in the family *Ceratocystidaceae* and is found in the topsoil up to 25 cm depth (Wickramasinghe *et al.*, 2015). The pathogen is widely distributed in many sugarcane growing regions of the world (Mbenoun *et al.*, 2017). Infection occurs mostly in sett canes and sometimes in standing canes with wounds or cuts. The inoculum of the pathogen can remain dormant in the soil for several years (Nasution *et al.*, 2019). Soil to soil dispersal occurs through run-off, from rain/irrigation water in cane fields, and crop residue. Pineapple disease is more common in waterlogged or dry soil where germination of sett is delayed. Infection usually starts from open wounds such as cut ends, splits

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or cracks, and small openings created by burrowing insects. The pathogen reproduces sexually and asexually, leading to rapid multiplication within the central tissues of infected setts. Few days after infection, the parenchyma tissue turns pale red, appearing like, and often misdiagnosed as, sugarcane red rot disease. The red colour gradually turns dark brown/black as the pathogen sporulates (Wickramasinghe *et al.*, 2015). Metabolic activities from the pathogen lead to the production of ethyl acetate, with the accompanying characteristic smell of an over-ripe pineapple (Rahman *et al.*, 2019). This probably gave rise to the name “pineapple disease”.

Resistant strains of sugarcane to PDS are not readily available, especially to sugarcane farmers in rural communities. Consequently, farmers rely on the application of synthetic chemicals, as fungicide deep for cane setts, before planting. Sole reliance on synthetic chemicals for plant diseases management has several associated hazards. Modern plant diseases management, therefore, focuses more on the use of safer alternatives that are environment-friendly. Regulated heat is one such alternative. It has been reported to kill seed-borne pathogens/inoculum of several crops (Lu *et al.*, 2009; Damayanti *et al.*, 2010). Additionally, the regulated use of hot water is known to speed up the germination of cane setts, (Anwar *et al.*, 2010, Sharma and Tamta 2015). This study evaluated hot water at two temperatures of 42 °C and 52 °C and 30 minutes duration of treatment. The aim is to provide a safe and cost-effective management option for sugarcane farmers, especially in the developing world, against pineapple disease. The approach has low technological input and can be adopted by both small and large-scale producers of sugarcane.

### 1.1 Objectives of the study

The objectives of the study are

- I. Determine the impact of hot water treatments at 42 °C and 52 °C on sett germination
- II. Evaluate hot water, prophylactically and therapeutically, for its inhibitory effects on *C. paradoxa* infection of cane setts
- III. Determine the effects of hot water treatments on the growth and yield of sugarcane

## 2. Materials and methods

### 2.1 Preparation of growth medium and isolation of *C. paradoxa*

Potato dextrose agar (PDA) the medium of isolation, was prepared following the manufacturer’s recommendation. *Ceratocystis paradoxa* was isolated from infected sugarcane collected from the sugarcane field of the Department of Crop, Soil and Pest Management (CSP), Federal University of Technology, Akure (FUTA). The cane was transferred to the laboratory of CSP and washed in running tap water to remove dirt and soil particles. Longitudinal splitting of the canes was done to expose the parenchyma tissue (Figure 1). Small segments (about 3 mm x 5 mm) were obtained from the regions of active infection.



**Fig. 1:** Longitudinal section of a sugarcane stem infected with *C. paradoxa*

The segments were surface sterilised in 70% alcohol, rinsed in 3 changes of sterile distilled water and dried with sterile blotting papers. Segments were inoculated on PDA medium at 2 – 3 segments per Petri-plate. Incubation was carried out at room temperature (27 °C ± 2 °C), followed by subculturing after 24 hours, to obtain pure cultures of *C. paradoxa*. Initial identification of the isolated fungus was

through visual observation of its colony characteristics, and microscopic observation of its mycelia and reproductive structure. The isolate was transferred to the pathology section of the International Institute of Tropical Agriculture (IITA) Ibadan, Nigeria for confirmation.

A Pathogenicity test was carried out on healthy cane setts to confirm the virulence of the isolate.

## 2.2. Collection of sugarcane and preparation of *C. paradoxa* inoculum

The DTS 44-33 sugarcane variety was collected from the National Cereal Research Institute (NCRI) Badeggi, Niger State, Nigeria. The choice of the cultivar was because it is high yielding, tolerant to drought and resistant to whip smut disease. Spores were harvested from a one-week-old culture of *C. paradoxa*. Harvested spores was made into suspensions and concentrated to  $10^7$  spores/ml using a haemocytometer slide.

## 2.3. Cutting, hot water treatment and planting of cane setts

Cane setts from DTS 44-33 were cut uniformly, such that each had three nodes. They were then divided into six groups, representing the treatments evaluated, of 60 cane setts each.

**Treatment 1.** Therapeutic application of hot water at 42 °C (HT42T). Cane setts were sprayed with  $10^7$  spores/ml suspension of *C. paradoxa*, with special attention on the cut ends. Sprayed setts were kept in polythene bags (Figure 2a) for 72 hrs, to generate warmth and moisture required for infection, before transferring to hot water at 42 °C in a 160 liter plastic container (Figure 2b and 2c) for 30 minutes.

**Treatment 2.** Therapeutic application of hot water at 52 °C (HT52T). The procedure described in treatment 1 was repeated but the water was 52 °C.

**Treatment 3.** Prophylactic application of hot water at 42 °C (HT42P). Cane setts were kept in hot water at 42 °C for 30 minutes. They were then transferred to polythene bags, after cooling, for 72 hours. Thereafter, spraying with  $10^7$  spores/ml of *C. paradoxa* was done.

**Treatment 4.** Prophylactic application of hot water at 52 °C (HT52P). Cane setts were treated as described in treatment 3, but the temperature of the water was 52 °C.

**Treatment 5.** Standard check (SDCHK). Cane setts were subjected to Mancozeb fungicide deep at the manufacturers recommended rate. Treated setts were then kept in a polythene bag for 72 hrs before infection with *C. paradoxa*.

**Treatment 6.** Control (CONTR). Cane setts were sprayed with  $10^7$  spore suspensions of *C. paradoxa*, kept in polythene bags for 72 hours and spraying with sterile distilled water.

Planting was done 24 hours after the application of the last treatment in all the experimental units.



Fig. 2: (a). Treated sugarcane setts in polythene bags (b and c). Sugarcane setts in hot water.

## 2.4. Site selection, field layout and planting of cane setts

The study was conducted at the teaching and research farm (TRF) of FUTA, located in the rain forest agro-ecology of Nigeria, longitude 5°06' E to 5°38' E and between latitude 7°07'N to 7°37'N), between October 2018 and September 2019. A site measuring 30 m x 15 m (450 m<sup>2</sup>) on ploughed and harrowed land was marked out. The experimental design was a randomized complete block (RCBD), consequently, the land was divided into 18 equal plots, measuring 4 m x 4 m (16 m<sup>2</sup>) and three replicates consisting of 6 plots each. Plots and replicates were separated by 1 m spacing, while the boundaries were 0.5 m. The 6 treatments evaluated were allocated randomly to plots. Each plot had 4 rows of 5 setts (20 setts). The setts were laid horizontally and spaced out evenly in shallow grooves of 3 cm depth.

The spacing between rows was 1 m. Weeding, fertilizer application and irrigation were done as required. Harvesting was done 12 months after planting (MAP).

## 2.5 Data collection and statistical analysis

### I. Setts germination

The number of sprouted setts were counted and recorded from the 3<sup>rd</sup> - 5<sup>th</sup> week after planting (WAP). The values obtained were converted to percentage cane germination using equation 1.

$$pg = \frac{np-ng}{np} \times 100 \dots\dots\dots(1)$$

Where;

*pg* = percentage germination

*np* = number of cane setts planted

*ng* = number of germinated cane setts

### II. Incidence of sugarcane sett rot disease

Dead seedlings and ungerminated setts were dug out and examined for infection by *C. paradoxa* at 7 WAP. The number of infected setts was counted and recorded. The values obtained for each treatment was converted to a percentage using equation 2.

$$isr = \frac{x-y}{z} \times 100 \dots\dots\dots(2)$$

Where;

*isr* = incidence of sugarcane sett rot diseases

*x* = total number of dead seedlings and un-germinated setts

*y* = total number of dead seedlings un-germinated setts due to factors other than SSR

*z* = total number of planted setts.

### III. Settling establishment

The number of canes that survived in each treatment at 10 WAP was counted and recorded. The values obtained were converted to percentage crop establishment with equation 3

$$pse = \frac{x}{y} \times 100 \dots\dots\dots(3)$$

Where;

*pse* = percentage settling establishment

*x* = total number of stands at 10 WAP

*y* = total number of germinated setts.

### IV. Number of leaves

A maximum of 10, out of the established stands per plot, were marked randomly and tagged at 4 MAP. Data for the number of leaves and other growth parameters were obtained from the tagged stands. Only completely opened leaves were counted. Counting was done once a month, starting from the 7<sup>th</sup> - 10<sup>th</sup> MAP.

### V. Tiller formation

The number of stock/stools, tillers, were counted manually, through visual observation, once a month, starting from the 7<sup>th</sup> - 10<sup>th</sup> MAP.

### VI. Stem girth

The diameter of each cane was measured with a digital vernier calliper at the second node above the ground once a month, starting from the 7<sup>th</sup> - 10<sup>th</sup> MAP. The girth of each cane was then determined with the formula  $\pi d$ . Where  $\pi = 3.14$ , and *d* = diameter of cane.

**VII. Sucrose quality**

The sucrose quality was determined with a portable hand-held refractometer. A small quantity of cane juice was withdrawn from the third node above the ground. A drop of the juice was placed on the screen of the refractometer. The value was read-off and recorded. Data were collected from the same node on the same cane stands in each plot from the 8<sup>th</sup> - 10<sup>th</sup> MAP.

**VII. Cane yield quality**

**a. Millable canes**

The number of canes with at least three matured nodes were counted as millable at 12 MAP. Percentage millable cane was obtained using equation 4

$$pmc = \frac{mc}{ss} \times 100 \dots\dots\dots(4)$$

Where;

*pmc* = percentage millable cane

*mc* = number of millable canes

*ss* = number of stock/stools

**b. Cane fresh weight**

All the cane stands in each plot were harvested, by cutting the stem just above the soil surface, and weighing with the aid of a 50 kg capacity Dial Spring scale, SP Model. The values obtained were extrapolated to kg ha<sup>-1</sup>.

**Statistical analysis**

All data collected were subjected to analysis of variance (ANOVA) with MINITAB software, version 17. Means were separated with Tukey’s test at 5% level of probability.

**3. Results**

**3.1. Effect of hot water treatments on cane germination (%)**

The general trend was an increasing germination percentage with the increasing number of weeks, starting from the 3<sup>rd</sup> to the 5<sup>th</sup> WAP, for all treatments (Table 1). At 3 WAP, HT42P had 64.62% germination. The value was the highest, but it was not significantly different (*p* < 0.05) from 63.04% which was recorded for HT52P. The lowest value of 1.21% germination was recorded for HT52T. By the 4<sup>th</sup> and 5<sup>th</sup> WAP, HT42P gave 81.25% and 87.88% germination respectively, while 78.13% and 88.15% were recorded for HT52P during the same period. No statistical difference was observed between the two treatments at 5 WAP (Table 1). HT52T consistently gave the poorest percentage sett germination.

**Table 1:** Effect of hot water treatments on sett germination (%)

Treatments	Germination/ weeks after planting		
	3	4	5
HT42T	11.28d	14.64e	21.17d
HT42P	64.62a	81.25a	87.88a
HT52T	1.21e	6.32f	6.32e
HT52P	63.04a	78.13b	88.15a
SDCHK	34.77b	59.65c	69.74b
CONTR	16.31c	26.36d	36.24c

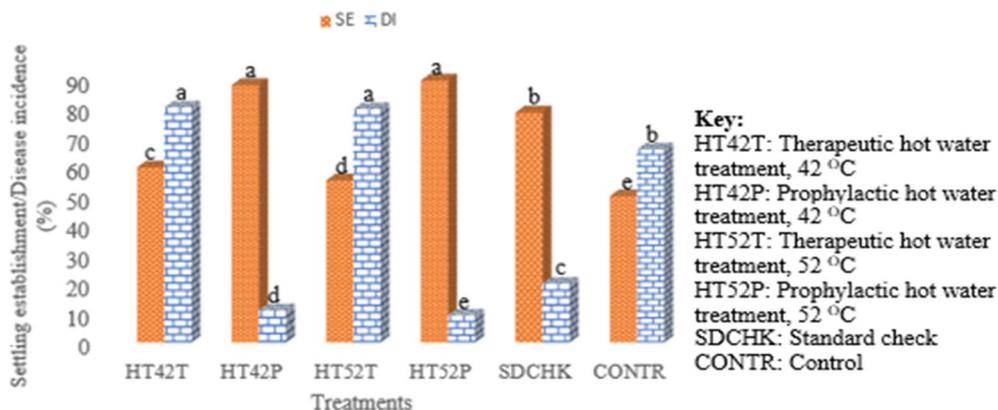
Note. Means in the same column followed by the same alphabets are not significantly different (*p* < 0.05) based on Tukey’s test.

**Key:**

Therapeutic application of hot water at 42 °C (HT42T). Therapeutic application of hot water at 52 °C (HT52T). Prophylactic application of hot water at 42 °C (HT42P). Prophylactic application of hot water at 52 °C (HT52P). Standard check (SDCHK). Control (CONTR).

### 3.2. Effect of hot water treatments on settling establishment (%)

Data for crop establishment was collected at 10 WAP. The values obtained were not significantly ( $p < 0.05$ ) different for HT42P and HT52P, 88.22% and 89.85% respectively. Both values were significantly higher than the other treatments (Figure 3). A Significantly lowest settling establishment was recorded in CONTR, 55.17%, it was followed closely by HT52T, 55.53%, but the two values were statistically different (Figure 3).



**Fig. 3:** Effect of hot water treatments on settling establishment and the incidence of pineapple disease on setts and settlings.

**Note:** Bars with the same pattern and alphabets are not significantly different ( $p < 0.05$ ) based on Tukey's test.

### 3.3. Effect of hot water treatments on the incidence of pineapple disease on setts and settlings (%)

The incidence of sett rot disease was low in setts treated prophylactically with hot water but very high in therapeutically treated ones. The highest incidence, 80.46%, was obtained from HT42T. Next was 79.93% obtained from HT52T. The two values were, however, similar statistically (Figure 3). Significantly lowest disease incidence of 9.23% was obtained from HT52P, while HT42P recorded 11.01%.

### 3.4. Effect of hot water treatments on leaf production

The general trend observed was that leaf numbers increased steadily with the increasing age of canes, but there was no definite correlation among treatments and leaf numbers (Table 2). The highest number of leaves, 13.90, was produced by HT52P at 7 MAP. It was significantly ( $p < 0.05$ ) higher than the other treatments. HT42P and HT52T produced 13.29 and 12.89 leaves respectively and were not significantly ( $p < 0.05$ ) different. At 10 MAP, HT52P, HT42P and SDCHK produced 23.37, 23.23 and 23.11 leaves respectively. All the values did not differ statistically (Table 2). The least number of leaves, 20.03, was produced by HT42T at 10MAP.

**Table 2:** Effect of hot water treatments on leaf production

Treatments	Leaf production/Months after planting			
	7	8	9	10
HT42T	12.16c	15.83a	17.29c	20.03b
HT42P	13.29b	16.14a	21.27a	23.23a
HT52T	12.89b	15.42a	17.72c	20.26b
HT52P	13.90a	15.94a	20.51b	23.37a
SDCHK	12.99b	15.97a	21.17a	23.11a
CONTR	12.09c	14.05b	20.09b	20.23b

**Note.** Means in the same column followed by the same alphabets are not significantly different ( $p < 0.05$ ) based on Tukey's test.

**Key:**

Therapeutic application of hot water at 42 °C (HT42T). Therapeutic application of hot water at 52 °C (HT52T). Prophylactic application of hot water at 42 °C (HT42P). Prophylactic application of hot water at 52 °C (HT52P). Standard check (SDCHK). Control (CONTR).

### 3.5. Effect of hot water treatments on tillering

Tillering progressed steadily as the canes increased in age. An average of 1 to 3 tillers, depending on treatment, was produced per month. The highest number of tillers at 7 MAP was 11.84. It was produced by SDCHK but was not significantly different from CONTR (11.50), HT42T (11.46) and HT52T (11.13) (Table 3). The tillers produced by SDCHK at 10 MAP was 18.55. It was the highest and was significantly ( $p < 0.05$ ) different from the other treatments. HT42T was next, it produced 17.67, followed by HT52T, 17.12. The two treatments were not significant statistically at 10 WAP. The least number of tillers, 14.10, was produced by HT42P in the same period. It was statistically similar to 14.42 produced by HT52P (Table 3).

**Table 3:** Effect of hot water treatments on the tillering of sugarcane

Treatments	Number of tillers/Months after planting			
	7	8	9	10
HT42T	11.46ab	12.58a	14.63b	17.67b
HT42P	10.74b	11.29b	13.12c	14.10d
HT52T	11.13ab	12.44a	14.41b	17.12b
HT52P	10.64b	12.57a	13.32c	14.42d
SDCHK	11.84a	12.25a	16.72a	18.55a
CONTR	11.50ab	12.45a	14.37b	16.11c

Note. Means in the same column followed by the same alphabets are not significantly different ( $p < 0.05$ ) based on Tukey's test.

**Key:**

Therapeutic application of hot water at 42 °C (HT42T). Therapeutic application of hot water at 52 °C (HT52T). Prophylactic application of hot water at 42 °C (HT42P). Prophylactic application of hot water at 52 °C (HT52P). Standard check (SDCHK). Control (CONTR).

### 3.6. Effect of hot water treatments on stem girth (cm)

Stem girth increased slowly across all the treatments from 7 to 10 MAP. Therapeutically heat-treated canes had significantly lower values of stem girth in comparison to prophylactically treated ones from the 7<sup>th</sup> to 9<sup>th</sup> MAP. SDCHK had the highest value, 6.28 cm, at 7 MAP, but this was not significantly ( $p < 0.05$ ) different from the values obtained for CONTR, HT42P and HT52P (Table 4). A similar trend was observed at 8 and 9 MAP, with SDCHK having the highest values of 6.33 cm and 6.43 cm respectively, it was however similar statistically to HT42P, HT52P and CONTR at both periods (Table 4).

**Table 4:** Effect of hot water treatments on the stem girth of sugarcane (cm)

Treatments	Stem girth/Months after planting			
	7	8	9	10
HT42T	5.43b	5.64b	5.80b	6.18c
HT42P	6.09a	6.15a	6.20ab	6.27c
HT52T	5.46b	5.64b	5.83b	6.16c
HT52P	6.16a	6.21a	6.32a	6.38abc
SDCHK	6.28a	6.33a	6.43a	6.57a
CONTR	6.27a	6.28a	6.42a	6.49ab

Note. Means in the same column followed by the same alphabets are not significantly different ( $p < 0.05$ ) based on Tukey's test.

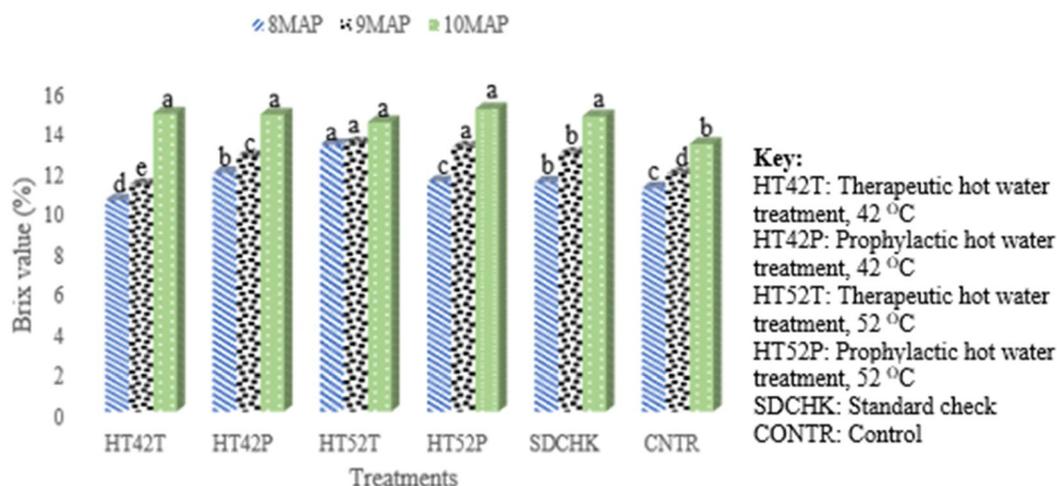
**Key:**

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### 3.7. Effect of hot water treatments on sucrose quality (%)

Sucrose quality was not impacted negatively by the treatments evaluated and the concentration increased steadily in all the treatments from 8 – 10 MAP. At 8 MAP, the highest sucrose value, 13.19%,

was obtained from HT52T. This value increased to 13.19 at 9 MAP. But was not significantly different from HT52P. At the 10<sup>th</sup> MAP, Brix values in all treatments, except CNTR were statistically similar (Figure 4).

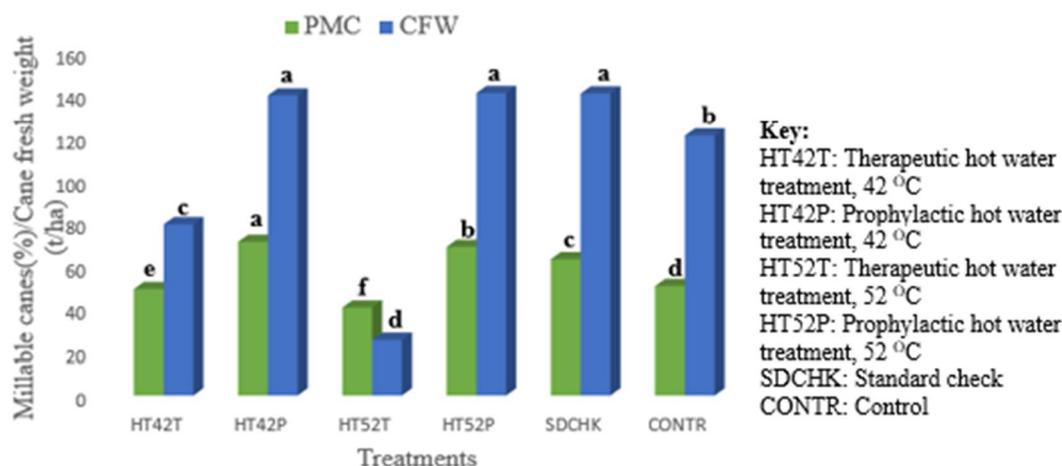


**Fig. 4:** Effect of treatments on Brix (sucrose quality) of sugarcane  
 Note: Bars with the same pattern and alphabets are not significantly different ( $p < 0.05$ ) based on Tukey's test.

### 3.8. Effect of hot water treatments on yield

#### I. Percentage millability of canes

The percentages of canes that were matured for milling differed significantly ( $p < 0.05$ ) among the treatments at harvest. The highest and statistically significant percentage of 71.18%, was obtained from HT42P. HT52P was next with 68.85%. It was statistically better than SDCHK that had 63.13%. The least value of 40.63% was obtained from HT52T (Figure 5).



**Fig. 5:** Effect of hot water treatments on sugarcane yield  
 Note: Bars with the same pattern and alphabets are not significantly different ( $p < 0.05$ ) based on Tukey's test.

#### II. Cane fresh weight (tons/ha)

Cane fresh weight also differed significantly ( $p < 0.05$ ) among treatments. HT52P, SDCHK and HT42P produced cane fresh weights of 140.67, 140.49 and 139.59 t/ha<sup>-1</sup> respectively. They were not significantly different. A significantly lowest value of 25.63 t/ha<sup>-1</sup> was obtained from HT52T (Figure 5).

#### 4. Discussion

Germination was rapid, while the overall percentage of sett germination was high in cane setts subjected to prophylactic hot water treatment. These findings agree with results from previous work on the effect of regulated heat on the germination of sugarcane setts (Damayanti *et al.*, 2010; Sharma *et al.*, 2015; Wonda *et al.*, 2015). The mechanism of action of regulated heat in speeding up cane sett germination has been explained to be through the breaking of dormancy associated with the individual cane buds and the neutralisation of apical dominance through the denaturation of indole acetic acid IAA (Damayanti *et al.*, 2010; Sharma *et al.*, 2015). Indole acetic acid, at high concentration, has been reported to inhibit seed germination in weeds (Busangiam *et al.*, 2021). The incidence of sett rot disease was above 70% in canes setts treated therapeutically with hot water. This may be an indication that hot water treatment of cane setts already infected with *C. paradoxa* holds little or no benefit. Furthermore, research findings have shown that *C. paradoxa* produces ethyl acetate on infected cane setts and that a 48-hour infection period can lead to the production of a sufficient quantity of ethyl acetate to inhibit sett germination completely (Talukder *et al.*, 2007; Borges *et al.*, 2019). Consequently, germination failure will still result even if infecting *C. paradoxa* was killed by hot water. The germination percentage in setts treated with Mancozeb fungicide was less than 70%, while diseases incidence was above 20%. This may not be unconnected with the short half-life of the fungicide, especially when it makes contact with water (Lopez-Fernandez *et al.*, 2017). This may have prevented maximum efficacy against the pathogen. Additionally, Vijaya *et al.* (2007) reported on the poor inhibitory effect, 31.22%, of Mancozeb on the mycelial growth of *C. paradoxa in-vitro*. Settling establishment was low in treatments with a high incidence of sett rot disease, owing to the death of setts and settlings. This observation is not out of place. A similar trend was reported by Wickramasinghe *et al.* (2015). Leaf production and sucrose quality were very similar in all treatments, especially at the maturity phase of the canes. This is understandable, sett rot disease was absent on standing canes at maturity in all the treatments. It has also been reported that sugarcane tend to accumulate more sucrose as they maturity (Awadalla 2016). Cane setts subjected to therapeutic heat treatment produced sugarcane stands with more tillers compared to those that were subjected to prophylactic treatment. This was probably due to the fewer stands of canes in the former. Reports from previous works support this view (Chattha *et al.*, 2007; Ayele *et al.*, 2014). A high population of cane stands brings about competition which ultimately reduces tillering. It is worthy of note, however, that the tillers produced by therapeutically treated canes had small sizes and appeared weedy. This may have accounted for the smaller girth recorded in these treatments, as against those of prophylactic treatments. The number of millable canes was more and the overall yield was higher in sugarcane plots treated prophylactically with hot water. A similar finding has been reported earlier by Raskar and Bhoi (2003). Cane subjected to HT42P gave the highest percentage of millable canes, while HT52P had the highest fresh weight.

#### 5. Conclusion

Results from this study showed that the therapeutic application of hot water at 42 °C and 52 °C for 30 minutes was not effective in managing sugarcane sett rot diseases. The prophylactic application was however very promising. Prophylactically treated setts had rapid germination, helping them to escape/tolerate infection by *C. paradoxa*. Prophylactic hot water treatment of cane setts at 42 °C and 52 °C may be recommended as physical/organic management strategy for sugarcane sett rot diseases.

#### Declarations

##### Author's contributions

AMA: Plan of work, design of experiment, data collection, manuscript preparation and follow up on manuscript publication. OTH: Data analysis, manuscript preparation and revision. OOA: Data analysis, manuscript preparation and revision.

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