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# EFFECT OF ABIOTIC DEFENSE INDUCERS ON MANAGEMENT OF SUGARY DISEASE OF SORGHUM CAUSED BY *SPHACELIA SORGHI*

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**ABSTRACT**

Sorghum (*Sorghum bicolor*), a vital cereal crop, is notably impacted by the devastating sugary disease, particularly in hybrid seed production. This disease, caused by the pathogen *Sphacelia sorghi*, can lead to considerable reductions in yield. The current study aimed to assess the efficacy of various abiotic defense inducers, including Salicylic Acid (SA), Chitosan, Benzothiadiazole (BTH), Acibenzolar-S-Methyl, and Jasmonic Acid, in mitigating sugary disease under field conditions. These inducers were administered as foliar sprays, and disease severity was carefully tracked throughout different stages of plant growth. The findings demonstrated that Salicylic Acid and Chitosan were the most effective, resulting in a marked reduction in disease severity and a significant increase in grain yield. Conversely, Jasmonic Acid, Acibenzolar-S-Methyl, and BTH exhibited comparatively moderate to low efficacy in disease suppression. This research underscores the potential of utilizing abiotic defense inducers as a sustainable strategy for managing sugary disease in sorghum, providing an environmentally friendly alternative to conventional chemical fungicides.

**Keywords**: Sorghum, Sugary Disease, *Sphacelia sorghi*, Abiotic Defense Inducers, Salicylic acid, Chitosan

## Introduction

Sorghum (*Sorghum bicolor* (L.) Pers.) is a major cereal crop that serves as a source of food, fodder, livestock feed, fiber, broomcorn, fuel, feedstock for biofuel production, alcoholic beverages, and building materials in many regions of the world, and is ranked among the top five cereal crops globally (Hariprasanna and Patil, 2015; Ananda *et al*., 2020). According to the 3rd advance estimates, Government of India for 2022-23, sorghum production estimate was 3.99 million tonnes as compared to previous year's production of 4.15 million tonnes. Sorghum is well-known for its strong resistance and wide adaptability to multiple biotic and abiotic stresses (Zhang *et al*., 2019). However, sorghum production is often hampered by various diseases, one of which is the sugary disease of sorghum. Sugary disease of sorghum, caused by the fungus *Sphacelia Sorghi*, is a threat to sorghum production and causes significant yield loss worldwide. According to Kazungu *et al.*, (2023), sugary disease of sorghum is identified as one of the most detrimental diseases affecting sorghum crop. Contaminated with honeydew, the grain exhibits diminished feed intake and poses a toxicity risk when consumed by livestock (Parh *et al*., 2008).

Chemical fungicides tend to persist on crops for extended periods, raising concerns about residual contamination (Goswami *et al*., 2018). Unlike traditional chemical fungicides that directly target pathogens, plant defense elicitors enhance the plant's intrinsic immune system by triggering systemic acquired resistance (SAR). This mechanism primes the plant to recognize and respond more effectively to future infections, reinforcing its ability to combat potential pathogens and offer a more sustainable and eco-friendly approach to disease control (Bektas and Eulgem, 2015; Wang *et al*., 2015). Chemical inducers have been developed and used as plant defense inducers in practical crop protection (Noutoshi *et al*., 2012). Benzothiadiazole (BTH), also referred to as acibenzolar-S-methyl, is a synthetic chemical that has been used for protection against diseases in various agronomically important crops, such as rice, wheat, potato, and tomato (Shimono *et al.*, 2007). ASM (Acibenzolar-S-Methyl) has recently been shown to reduce Fusarium head blight (*Fusarium graminaearum sensu stricto*) in wheat. Application at anthesis gave the most significant control of disease and reductions in seed infection (Shude *et al.*, 2022). Chitosan was a viable alternative or supplement to copper formulations and provided good control of downy mildew even under high disease pressure (Romanazzi *et al.*, 2021).

These elicitors stimulate the plant's innate defense mechanisms without directly harming microorganisms, making them less likely to disturb the surrounding microbial communities compared to conventional fungicides. This non-toxic nature positions plant defense elicitors as a more favorable option for both environmental and agricultural systems, promoting biodiversity while effectively managing plant diseases by activating this defense pathway, elicitors offer a sustainable approach to disease management, equipping plants with long-lasting resistance and reducing the dependency on external chemical treatments (Graham *et al.*, 2016; Kunwar *et al.*, 2017). This research focuses on examining the impact of various defense inducers on reducing the severity of sugary disease in sorghum and how these inducers are effect in mitigating sugary disease in field condition, thereby contributing to sustainable disease management strategies for sorghum cultivation.

## Materials and Methods

The present field experiments were carried out during *kharif* seasons in 2021-22, at Livestock Research Centre, G.B. Pant University of Agriculture and Technology (GBPUAT), Pantnagar, Udham Singh Nagar, Uttarakhand with the objective to study Effect of Abiotic Defense Inducers on Management of Sugary Disease of Sorghum caused *Sphacelia sorghi*. The experiment was laid in randomized block design (RBD) with six treatment Salicylic Acid (SA), Chitosan, Benzothiadiazole (BTH), Acibenzolar-S-Methyl, Jasmonic Acid along with a check each replicated three times. Sorghum cultivar PC-4 (susceptible to sugary disease) were sown in three rows of 6m length with a sub plot of 2 × 2m$^2$. The sowing was done with a spacing dimension of 45 × 15 cm. Seed was sown @ 15 Kg/ha at a depth of 3-4 cm. The defense inducers were applied as foliar sprays at a rate of 0.01% (100 ppm), whereas the control plot was sprayed with distilled water only. Applications of the inducer were carried out three times, with each treatment applied at seven-day intervals, starting after the initiation of floret development. Observations on disease severity were recorded for all panicles before and after the application

**Table 1:** Ergot severity score and disease reactions.

| Score | Infection (%) | Disease Reaction |
|---|---|---|
| 1 | No infection | Highly resistant (HR) |
| 2 | 1–10% infection | Resistant (R) |
| 3 | 11–25% infection | Moderately resistant (MR) |
| 4 | 26–50% infection | Susceptible (S) |
| 5 | >50% infection | Highly susceptible (HS) |

of inducers, using a 1-5 rating scale (Table 1) based on visual scoring as described by Musabyimana *et al.*, (1995). Further, these scales were converted into severity (Per cent disease index) using formula given by Wheeler (1969) and the collected data were subjected to analysis of variance using statistical software, and the means were compared using (test) at a significance level of 5%. To quantify the disease progression in spikelets for each replication, the Area Under the Disease Progress Curve (AUDPC) was determined following the method described by Wilcoxson *et al.*, (1975). This approach allows for an accurate assessment of disease development over time by integrating disease severity across multiple observations. AUDPC serves as a robust measure of cumulative disease intensity, providing valuable insights into the temporal dynamics of disease spread within the experimental treatments.

Per cent Disease Index will be recorded using the following formula (Wheeler, 1969):

$$\text{Percent disease index} = \frac{\text{Sum of Individual ratings}}{\text{Total units assessed} \times \text{Maximum grade}} \times 100$$

$$\text{Percent disease control} = \frac{\text{Disease severity in control - Disease severity in treatment}}{\text{Disease severity in control}} \times 100$$

$$AUDPC = \sum_{i=1}^{n-1} \frac{y_i - y_{i+1}}{2} \times (t_{i+1} - t_i)$$

Where, $y_i$ represents the disease assessment at the $i^{th}$ observation, which may be quantified as a percentage, proportion, ordinal score. $t_i$ corresponds to the time at $i^{th}$ observation, measured in days, hours etc. The total number of observations is denoted by n. These parameters allow to assess disease progression over time by providing a systematic approach to analyze the dynamics of disease incidence across multiple observations.

## Result and Discussion

### Disease Severity

The study, as presented in Table 2, aimed to assess the effects of various abiotic defense inducers on the severity of sugary disease in sorghum caused by *Sphacelia sorghi*. Where, Salicylic acid demonstrated

**Table 2:** Field efficacy of abiotic inducers in the management of sugary disease in sorghum.

| S. No. | Treatment | Disease Severity (%) | | | | Average disease severity (%) | PDC | AUDPC | Grain yield (Q/ha) |
|---|---|---|---|---|---|---|---|---|---|
| | | Before spray | After Ist spray | After IInd Spray | After IIIrd Spray | | | | |
| 1. | Salicylic Acid (SA) | 09.73 | 13.44 | 14.47 | 15.89 | 13.38 | 67.83 | 66.60 | 16.98 |
| 2. | Acibenzolar-s methyl | 17.02 | 19.98 | 22.62 | 26.35 | 21.49 | 48.34 | 109.11 | 12.88 |
| 3. | Jasmonic acid | 14.05 | 16.56 | 19.93 | 21.22 | 17.94 | 56.87 | 91.83 | 15.78 |
| 4. | Chitosan | 11.16 | 14.09 | 15.09 | 19.01 | 14.83 | 64.26 | 73.82 | 16.12 |
| 5. | Benzothiadiazole (BTH) | 19.18 | 24.87 | 26.24 | 29.67 | 24.99 | 39.87 | 127.41 | 12.07 |
| 6. | Control | 18.98 | 29.98 | 38.98 | 47.98 | 41.60 | 0 | 211.75 | 71.0 |
| CD @ 5% | | 0.735 | 1.034 | 1.400 | 1.617 | 0.761 | - | - | 0.504 |
| SEm± | | 0.230 | 0.324 | 0.439 | 0.507 | 0.238 | - | - | 0.158 |

as the most effective inducer for control of sugary disease. Disease severity increased slightly from 9.73% before spraying to 15.89% after the third spray, yielding an average severity of 13.38%. This treatment resulted in the highest percentage of disease control (PDC) at 67.83% which suggests that SA significantly reduced disease progression compared to the control. Chitosan was also effective, though slightly less than SA as it demonstrated disease severity rising from 11.16% to 19.01%. The average disease severity of 14.83% and PDC of 64.26% indicates that Chitosan performed slightly less effective than SA. However, its impact was still substantial in mitigating the disease, making it a valuable defense inducer. Jasmonic Acid showed an increase in disease severity, with values progressing from 14.05% to 21.22%. Its average disease severity of 17.94% and a PDC of 56.87% indicate moderate control of the disease. Acibenzolar-S-Methyl exhibited less control over disease development. Disease severity increased from 17.02% to 26.35%, with an average disease severity of 21.49%. The PDC was 48.34%. Benzothiadiazole resulted in a marked increase in disease severity from 19.18% to 29.67%, and its average severity was 24.99% with a PDC of 39.87%, BTH showed the least efficient among the tested inducers in controlling sugary disease. In the untreated control, disease severity escalated significantly from 18.98% to 47.98%, resulting in an average severity of 41.60%. As expected, the control exhibited the highest disease progression, confirming the efficacy of the defense inducers in mitigating the disease to varying degrees.

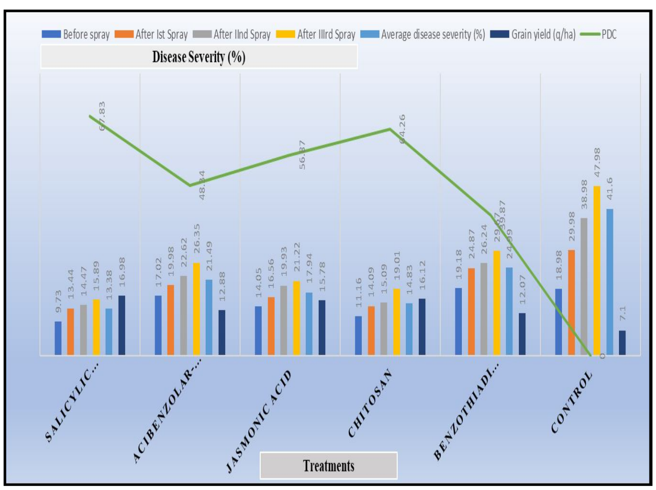


**Fig. 1:** Variation in Disease Control (%) Across Different Treatments.

### Area Under Disease Progress Curve (AUDPC)

The AUDPC values were calculated and tabulated in Table 2 to provide a cumulative measure of disease severity over time. Salicylic acid had the lowest AUDPC value of 66.60, reflecting its superior ability to reduce disease progression. Chitosan and Jasmonic acid treatments followed with AUDPC values of 73.82 and 91.83, respectively, indicating moderate disease progression over time. Acibenzolar-S-Methyl and Benzothiadiazole treatments had higher AUDPC values of 109.11 and 127.41, respectively, suggesting that these inducers were less effective in limiting disease development. The control plot had the highest AUDPC value of 211.75, clearly demonstrating the rapid and unchecked progression of sugary disease in the absence of any inducer.

### Grain Yield

Grain yield was also affected by the different treatments. The highest yield was recorded in plots treated

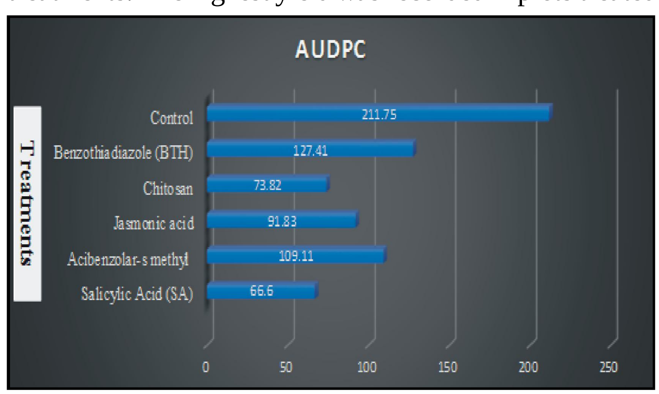


**Fig. 2:** Area under disease progress curve over various treatments.

with Salicylic Acid (16.98 q/ha), followed by Chitosan (16.12 q/ha). Jasmonic Acid treatments yielded 15.78 q/ha, and Acibenzolar-S-Methyl yielded 12.88 q/ha. The lowest yield was observed in Benzothiadiazole-treated plots (12.07 q/ha) and the control (7.10 q/ha). These results suggest a clear correlation between reduced disease severity and higher grain yield, particularly in treatments with Salicylic Acid and Chitosan.

The results of the study demonstrate the effectiveness of various abiotic defense inducers in managing Sugary Disease of sorghum. Where, Salicylic Acid (SA) was found the most effective treatment, significantly reducing disease severity, and providing the highest PDC. These findings align with previous research by Bektas and Eulgem (2015), which reported the role of SA in enhancing systemic acquired resistance (SAR) in plants, enabling them to combat pathogens more effectively.

Chitosan, another potent elicitor, showed comparable results, supporting its well-documented role in activating plant defense pathways (Wang *et al*., 2015). Both SA and Chitosan work by priming the plant's immune system, allowing for a more rapid and robust response to pathogen attacks.

The moderate performance of BTH, Acibenzolar-S-Methyl, and Jasmonic acid suggests that while these inducers are effective, they may require higher concentrations or more frequent applications or combination of two inducers to achieve results comparable to SA or Chitosan. Their ability to activate different components of the plant defense mechanism, such as SAR and induced systemic resistance (ISR), provides a broad-spectrum approach to disease management as also suggested by (Warabieda *et al.,* 2015; Wang *et al.,* 2021).

The control plots, with the highest disease severity, clearly demonstrate the negative impact of sugary disease on sorghum when no defense measures are employed. These findings emphasize the importance of using abiotic inducers as part of an integrated disease management strategy.

## Conclusion

Salicylic Acid emerged as the most effective abiotic defense inducer, as evidenced by its significant reduction in disease severity, high PDC, and superior grain yield. Chitosan also performed well, showing similar patterns of disease control and yield enhancement. Jasmonic Acid provided moderate disease control, while Acibenzolar-S-Methyl and Benzothiadiazole were less effective in reducing disease severity and increasing yield. The control treatment confirmed the substantial impact of sugary disease on sorghum yield and highlighted the importance of deploying effective abiotic defense inducers for sustainable disease management. The results underscore the potential of Salicylic Acid and Chitosan as viable strategies for mitigating sugary disease in sorghum, contributing to improved plant health and productivity. Thus, it can be said that the use of abiotic defense inducers, proved to be an effective strategy for reducing the severity of sugary disease in sorghum. These inducers enhance the plant's natural defense mechanisms, providing a sustainable and environmentally friendly alternative to traditional chemical fungicides. Further research is recommended to explore the long-term effects of these inducers and to optimize application protocols for broader adoption in plant disease management.

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## Authors' contribution:

Saurabh Dubey: Led the conceptualization, design, material preparation, and data collection for this research as part of his Ph.D. thesis: Y. Singh: served as the major advisor, providing invaluable guidance and support, including help with securing funding: Sapna: Contributed to the study through critical review and editing of the manuscript.

## Conflict of interest:

The authors declare no conflict of interest.

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