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RESEARCH ARTICLE

Comparative effects of neem seed oil and a synthetic fungicide in the management of sugar cane whip smut (Sporisorium scitamineum)

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Abstract

This study evaluated the comparative effectiveness of neem seed oil and mancozeb in controlling whip smut disease of sugar cane during the 2021 cropping season in Edozhigi, Niger State.

A factorial experiment was conducted using a Randomized Complete Block Design (RCBD) with five treatments and three replicates.

The test crop was the Bida local variety (chewing sugar cane), and five concentrations of neem seed oil (10%, 20%, 30%, 40%, and 50%) and mancozeb (0.5%, 1%, 1.5%, 2%, and 2.5%) were applied.

Parameters such as plant height, number of leaves, and number of internodes, smut severity index, and single stalk weight at harvest were assessed.

Results indicate that neem seed oil exhibited superior fungicidal activity compared to mancozeb, with a concentration of 20 ml proving to be the most effective in managing whip smut.

These findings suggest that neem seed oil can serve as an eco-friendly alternative to synthetic fungicides.

However, further research is required to determine optimal application methods and to evaluate the long-term effects on soil health.

Keywords: Alternative fungicide, Application methods, Environmental sustainability, Mancozeb.

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Introduction

Sugar cane *(Saccharum officinarum L.)* is a crucial crop for sugar production globally, with diverse industrial uses. However, its cultivation faces numerous challenges, including biotic and abiotic stresses in Nigeria and certain Northern African countries, where issues like capital constraints, biotic and abiotic stresses, social, and environmental factors (Wada et al. 2017, Ebenezer. 2021).

Efforts to bolster sugar cane production in Nigeria have been hampered by capital constraints, market limitations, biotic and abiotic stresses, high production and transport costs, and inadequate infrastructure (Wada et al. 2017). In contrast, Northern African countries have made significant strides in sugar cane production, attributed to initiatives such as certification schemes, enhanced yields per hectare, and improved sugar productivity (Wada et al. 2017).

Sugar cane smut disease caused by the fungal pathogen Sporisorium scitamineum poses substantial threat to sugar cane cultivation worldwide, leading to considerable losses in sugar yield (Comstock. 2000, Wenjie et al. 2008, Wada 2018).

Management measures for sugar cane smut disease primarily involve breeding resistant cultivars, a process hindered by its lengthy duration, high costs, and limited availability of smut-resistant parental lines (Shen, 2002; Wada, 2003; Croft et al. 2008). Also, chemical fungicides have been employed by soaking seed canes to manage the disease, albeit with potential environmental hazards and residual issues (Wada, 2003; Bhuiyan et al. 2012). In contrast to chemical pesticides, neem-based remedies don't have any negative health effects. They are a sustainable option for disease and pest management because they are also biodegradable and safe for the environment (Raman et al. 2023).

Neem's specific mechanism of action and natural origin interrupt pests' biology without injuring unintended targets, protecting both humans and the ecology. This characteristic not only encourages safer working conditions for farmers but also protects helpful insects and wildlife, fostering more healthy and balanced agricultural ecology (Ganiyu 2024).

A comprehensive method for pest control is provided by neem pesticides. They successfully combat a variety of pests, including creatures such as insects, mites, and nematodes (Senthil-Nathan. 2013). They offer thorough and dependable protection for crops by preventing pest growth and reproduction (Kauser 2024).

Alternative approaches include the application of plant or fungal extracts to inhibit the germination and growth of the smut pathogen (Lal et al. 2009a, 2009b, Sun et al. 2023). Given the challenges posed by sugar cane smut disease and the limitations of existing management methods, comprehensive strategies integrating multiple management strategies are imperative (Comstock. 2000).

Therefore, this study aims to compare the effectiveness of neem seed oil extract and a synthetic fungicide in mitigating smut disease in sugar cane cultivation. Through this comparative analysis, insights can be gained into the potentials of these interventions to contribute to the management of sugar cane smut disease, thereby informing on more sustainable and effective disease management strategies.

Materials and Methods

Study Area

The experiment was conducted during the 2021 cropping season at the Edozhigi Experimental site, NCRI Baddegi, situated in the Southern Guinea Savannah zone of Nigeria (latitude 09° 18' N, longitude 05° 04' E). The area experiences an average annual rainfall of 1,177.9mm and maintains a temperature of 33.6°C, according to data from the CAM meteorological unit in 2017.

Experimental design and treatments

A factorial experiment was conducted using Randomized Complete Block Design (RCBD) with five treatments and three replicates. Bida local or chewing sugar cane was used as the test crop, and two factors were investigated: Neem oil and mancozeb fungicide concentrations were prepared at 10%, 20%, 30%, 40%, 50% and 0.5%, 1%, 1.5%, 2%, and 2.5% v/v respectively and applied at 10 ml and 20 ml

Preparation of neem seed oil extract

Neem seeds weighing 2kg were dried in the shade for approximately seven days. Following this, the seeds were homogenized in a pre-chilled mortar and pestle, and the oil extract was filtered and collected into a container. Subsequently, 100 mls of distilled water was used to dilute the oil extract to achieve the desired percentages in VN. (Fig. 1).

Figure 1. Extracted neem oil before application

Preparation of planting setts and Inoculation

The Bida local or chewing sugar cane was cut into 3-budded setts and immersed in homogenized smut spore suspension as described by (Duttamajumder. 2000). These were planted in shallow furrows at 1metre apart inter rows laid end to end without intra row spacing. Whips started emerging at two and a half months as shown in Fig. 2.

Figure 2. Inoculated sugar cane showing whip symptoms before treatment with neem oil and macozeb

Application of neem seed oil extract and mancozeb fungicide

Mancozeb fungicide was applied following the manufacturer's manual. The specified concentrations were prepared according to the recommended dilution rates provided by the manufacturer, and the solution was applied evenly to the smutted sugar cane (Fig. 3).

Similarly, the neem seed oil extract was sprayed on the smutted test canes at the selected volumes and the specified intervals while the Control (untreated plants) was treated with just distilled water.

Stalk height

Number of leaves

Number of internodes

Smut severity index was assessed on a modified scale of 1 to 5 by (Rahman and Talukder. 2006)

Where:

1 = no whips

2 = 10–20% whips

3 = 30–40% whips

4 = 50–60% whips

5 = 70% and above whips and Single stalk weight at harvest

Parameters observed

Data was collected on

Data Analysis

All the data collected were subjected to analysis of variance (ANOVA) and the treatment means were separated using the Least Significant Difference (LSD) at a 5% level of probability.

Results

Effect of different concentrations of neem oil and mancozeb on plant height under smut disease conditions in the 2021 cropping season

The effect of varying concentrations of neem oil and mancozeb on sugar cane height was found to be significant ($P \leq 0.05$) throughout the experimental period (Table 1). Neem oil consistently promoted taller sugar rcane stalks compared to mancozeb across the study duration. Different concentrations of mancozeb and neem oil exhibited significant differences in their impact on smut disease, with 20ml of neem oil recording the tallest stalks throughout the study (Table 1). However, the interaction between the two factors was not significant (Table 1).

Table 1. Effect of different concentrations of neem oil and mancozeb on Plant height under smut disease conditions in the (2021) cropping season

Treatment	Plant height		
MAI	2	4	6
Fungicide (VN)			
Neem oil	113a	126a	143a
Mancozeb	110b	115b	138b
LSD	1.2*	0.8*	2.3*
Concentrations			
10 ml	103b	193b	198ab
20 ml	115a	201a	202a
10 ml	93c	170c	178b
20ml	89c	169c	177b
LSD	1.7*	1.2*	1.5*
Interactions			
N x C	NS	NS	NS

*Means within columns that share the same letter are non-significant at p = 0.05.
MAI: Months after inoculation

Effect of different concentrations of neem oil and mancozeb on the number of leaves of sugar cane under smut disease conditions in the 2021 cropping season

The impact of various concentrations of neem oil and mancozeb on the number of leaves of sugar cane was significant ($P \leq 0.05$) throughout the experimental period (Table 2). Neem oil consistently produced higher number of leaves in sugar cane plants compared to mancozeb. Different concentrations of mancozeb and neem oil showed significant variations in their effect on smut disease, with 20ml of both neem oil and mancozeb recording the highest leaf count throughout the study (Table 2). The interaction between the two factors was significant, except at week 9 where it was not significant (Table 2).

Table 2. Effect of different concentrations of neem oil and mancozeb on the number of leaves of sugar cane under smut disease conditions in the (2021) cropping season

Treatment	Number of sugar cane leaves		
	2	4	6
fungicide (VN)			
Neem oil	6a	8a	11
Mancozeb	4b	6b	10
LSD	2.8*	1.2*	NS
Concentrations			
10 ml	4b	8b	13ab
20ml	5a	10a	14a
10 ml	3c	6c	12b
20ml	5a	11a	13a
LSD	1.7*	1.2*	1.5*
Interactions			
N x C	NS	NS	NS

*Means within columns that share the same letter are non-significant at p = 0.05.
MAI: Months after inoculation

Effect of different concentrations of neem oil and mancozeb on the number of internodes of sugar cane under smut disease conditions in the 2021 cropping season

The effect of various concentrations of neem oil and Mancozeb on the number of internodes of sugarcane was significant ($P \leq 0.05$) throughout the experimental period (Table 3) (Fig. 3).

Figure 3. Whip - free sugar cane after treatment with neem oil and mancozeb

Neem oil consistently resulted in a higher number of internodes in sugarcane plants compared to mancozeb. Different concentrations of mancozeb and neem oil showed significant variations in their effect on smut disease, with 20 ml of both neem oil and mancozeb resulting in the highest internode count throughout the study (Table 3). The interaction between the two factors was significant, except at week 9 where it was not significant (Table 3).

Table 3. Effect of different concentrations of neem oil and mancozeb on the number of internodes of sugar cane under smut disease conditions in the 2021 cropping season

Treatment	Number of internodes		
	2	4	6
fungicide (VN)			
Neem oil	6a	12a	17
Mancozeb	4b	10b	15
LSD	2.8*	1.2*	NS
Concentrations			
10 ml	4b	8b	18ab
20ml	5a	10a	20a
10 ml	3c	6c	17b
20ml	5a	11a	20a
LSD	1.7*	1.2*	1.5*
Interactions			
N x C	NS	NS	NS

Means within columns that share the same letter are non-significant at p = 0.05
MAI: Months after inoculation

Impact of different concentrations of neem oil and mancozeb on sugar cane smut severity index during the 2021 cropping season

The research investigated the efficacy of various concentrations of neem oil and mancozeb on the severity index of smut disease in sugar cane (Fig. 3 & Table 4).

Table 4. Effect of Different Concentrations of Neem Oil and Mancozeb on Whip Smut Severity Index in the 2021 Cropping Season

Treatment	Smut severity index		
Weeks after Inoculation	2	4	6
fungicide (VN)			
Neem oil	2a	1c	1c
Mancozeb	3b	2b	2b
Control	4a	5a	5a
LSD	0.8*	0.2*	0.2*
Concentrations			
10 ml	3a	3b	3ab
20ml	2b	1b	1d
10 ml	3a	4c	4a
20ml	2b	1b	2c
LSD	0.7*	0.2*	0.5*
Interactions			
N x C	NS	NS	NS

Means within columns that share the same letter are non-significant at p = 0.05
MAI: Months after inoculation

The study found a significant impact ($P \leq 0.05$) of both treatments on smut severity index across the experimental duration. Throughout the study period, neem oil consistently recorded lower smut severity indexes in sugar cane compared to mancozeb. Different concentrations of both neem oil and mancozeb showed significant variations in their effectiveness against smut disease. Particularly the 20 ml concentrations of both neem oil and mancozeb resulted in the lowest severity indexes during the course of the study.

The interaction between neem oil and mancozeb was significant, except during weeks 4 and 6, where they had statistically similar effects.

Discussion

The investigations into the effectiveness of different concentrations of neem oil and mancozeb on the management of sugar cane whip smut under taken during the 2021 cropping season at Edozhigi, Niger state proved the potential of botanical pesticides as alternatives to synthetic pesticides.

The banning of organochlorine pesticides in developed countries due to pesticide resistance and adverse effects on non-target organisms and the environment has prompted resurgence in the exploration of botanical pesticides (Ebenezer, 2010). Botanical pesticides derived from plants, offer advantages such as biodegradability and reduced persistence in the environment compared to synthetic pesticides (Ebenezer, 2021).

Various plant-derived products, including leaf extracts, oil cakes, and plant latex, have been utilised for pest and disease management (Akhtar, 1999; Yadav, 2006, Wada and Dangana, 2016, Adusei and Azupio, 2022). Among these, botanicals, Azadirachta, Eucalyptus, Sida acutu, and Tagetes have gained popularity for disease management (Umar et al. 2010, Ganiyu, 2024).

In the present study, neem oil extracts exhibited significant fungicidal activity compared to mancozeb across the various parameters evaluated on the test sugar cane. The superiority of neem oil over mancozeb in the present study agrees with previous research that reported the efficacy of botanicals in pest and disease management (Umar et al. 2010, Kumar, 2020, Kumari et al. 2020). Notably, the concentration of neem oil influenced its effectiveness, with the 20 ml concentration outperforming the 10 ml concentration. This suggests that higher concentrations of neem oil may be more effective in managing smut disease in sugar cane, while lower concentrations may be insufficient to achieve optimum effect. Furthermore, the performance of neem oil in reducing smut effect on the Bida local chewing sugar cane in this study underscores its potential as a sustainable and environmentally friendly alternative to a synthetic fungicide like mancozeb. The use of botanicals offers promising approach to disease management in agriculture by minimizing environmental risks and promoting ecological sustainability (Ebenezer, 2010).

However, it is essential to consider factors such as application methods, timing, and potential interactions with other agrochemicals when integrating botanicals into pest and disease management strategies. Thus, further research is suggested to optimise the use of neem oil and other botanicals in the management of S. scitaminieum in sugar cane, considering factors such as efficacy, cost-effectiveness, and environmental impact.

Exploration into the efficacy of botanical pesticides like neem oil in disease management emphasises the importance of sustainable agricultural practices. With growing concerns over environmental pollution and human health risks associated with synthetic pesticides, there is the pressing need to transition towards safer and more eco-friendly alternatives as reported by (Ebenezer. 2010).

The author reported that botanical pesticides offer promising solution, as they are derived from natural sources and possess inherent biodegradability thereby reducing the risk of harmful residues in the environment. Neem oil, in particular, has gained attention for its broad-spectrum activity against various pests and pathogens (Kumari et al. 2020), making it a versatile tool in integrated disease management (IDM) strategies (Isman, 2006). The author reported that its mode of action when used as insecticide, involves disrupting insect feeding and growth, interfering with hormonal regulation, and exerting antifeedant and repellent effects (Isman, 2006).

Again, neem oil exhibited fungicidal properties as shown by its effectiveness in managing smut disease in sugar cane in the present study. The significance of concentration-dependent effects of neem oil on disease management observed in the present study, underscores the importance of optimising its application. rate for maximum efficacy. While higher concentrations may enhance management efficacy, factors such as phytotoxicity and economic feasibility should also be considered in determining the most suitable dosage in line with the report by (Regnault-Roger et al. 2012).

Furthermore, the formulation of neem oil products and application methods can influence its performance, signifying the need for further research to refine application protocols and maximise its effectiveness as reported by (Isman. 2006). The concentration-dependent mode of action of neem oil found in the present study shows that is a contact bio-pesticide just as mancozeb (Wada, 2003)

The effect of neem seed oil on smut severity in the present study agrees with previous research showing neem oil's potential as a bio pesticide against various plant diseases including whip smut (Goel et al. 2016, Oguh et al. 2019, Adusei and Azupio, 2022).

According to (Goel et al. 2016) neem oil is said to contain several active compounds known for their antifungal properties, thus making it an environmentally friendly alternative to chemical fungicides like mancozeb contrasted with it in this report.

Recent studies corroborate the efficacy of neem-based products in managing fungal diseases in crops such as its effectiveness in managing powdery mildew in cucumbers (Raman et al. 2023). In addition, a meta-analysis conducted by (Sharma et al. 2022) showed neem oil's broad-spectrum antifungal activity across various agricultural crops. The observed interaction between neem oil and mancozeb in the present study underscores the importance of considering integrated disease management strategies.

Incorporating both organic and conventional fungicides can provide a synergistic effect thus enhancing disease management while minimising environmental impact and the development of fungicide resistance.

In addition to neem oil, other botanicals such as Eucalyptus, Sida acutu, and Tagetes have shown promise in disease management (Umar et al. 2010). By harnessing the collective potential of various botanical extracts, integrated disease management strategies can be developed to combat diseases in sugar cane and other crops effectively.

Moreover, the use of botanicals in pest and disease management aligns with the principles of organic farming and sustainable agriculture, promoting biodiversity conservation and reducing reliance on synthetic inputs (Regnault-Roger et al. 2012).

Challenges such as variable efficacy under different environmental conditions, limited availability of standardised formulations, and potential resistance development by target organisms warrant further investigation and innovation in botanical pesticides research (Isman, 2006). Collaborative efforts between researchers, policymakers, and agricultural practitioners are essential to overcome these challenges in order to facilitate the adoption of botanical pesticides in mainstream agriculture.

Conclusion

The findings of the present study underscore the potential of neem oil as an effective alternative to synthetic fungicides for managing smut disease in sugar cane. This shows that by harnessing the benefits of botanical pesticides, agricultural practices can move towards more sustainable and environmentally friendly approaches to pest and disease management.

References

Adusei S, Azupio S, Neem: A Novel Biocide for Pest and Disease Control of Plants Journal of Chemistry Volume 2022, Article ID 6778554, 12 pages https://doi.org/10.1155/2022/677855

Bhuiyan SA, Hasan MA, Uddin MJ, Islam S, Alam MS. (2012) Effectiveness of some fungicides and plant extracts in controlling seed-borne infection of Alternaria alternata in soyabean. Bangladesh J. Plant Pathol. 28, 41–46.

Comstock JC (2000) Sugarcane smut, 2nd ed. American Psychopathological Society, St. Paul, MN.

Croft L Weihuai W, Zujian X, Chunping H (2008) Biological characteristics of smut of Sugar cane smut and the effect of fungicides on its germination. J Tropical Crops 30(11): 1674-1678.

Duttamajumder SK (2000). An improved technique of inoculation for the artificial production of sugar cane smut and development of uniform diseased cane material.I n d ia n P h y to p a th .cbaZYXWVUTSRQPONMLKJIHGFEDCBA 53 (2) : 167-171 (2000)

Ebenezer OA. (2010). Botanical insecticides: A sustainable and environmentally friendly approach to pest management. International Journal of Agricultural and Biological Sciences, 1(1), 13-21.

Ebenezer B (2021). Sugar annual. United States Department of Agriculture, Foreign agricultural service and Global Agricultural information network. NI2021 – 0003 (15) (PDF) A survey of major constraints associated with sugarcane production in Northern Guinea Savannah Region of Nigeria. Available https://www.researchgate.net/publication/383163451_A_survey_of_major_constraints_associated_with_sugarcane_production_in_Northern_Guinea_Savannah_Region_of_Nigeria [accessed Dec 15 2024].

Ganiyu O 2024. Efficacy of aqueous leaf extracts of neem, bitter leaf and their mixture for prevention of smut and red rot diseases of sugarcane Egyptian Sugar Journal DO. 10.21608/esugj.2024.281152.1056

Goel N, Anukrati K, and Paul PK. (2016). Anti-phytopathogenic and SAR inducing properties of neem: a review. Journal of Chemical and Pharmaceutical Sciences, vol. 9, no. 4, pp. 2547–2555,.

Isman MB (2006) Botanical insecticides: for richer, for poorer. Pest Management Science: formerly Pesticide Science, 62(11), 1107-1112.Extracts (Azadirachta indica) in Control of Plant

Kauser Perveen (2024) Neem's promise: The way to a sustainable future and eco-friendly bio pesticides.

International Journal of Science and Research Archive, 2024, 11(02), 1073–1082

Kumar CV (2020) Use of Neem Extracts (Azadirachta indica) in Control of Plant Diseases: A ReviewInt.J.Curr.Microbiol.App.Sci (2020) Special Issue-11: 3481-3487

Kumari P, Geat N, Maurya S, Meena S (2020) Neem: Role in leaf spot disease management: A review Journal of Pharmacognosy and Photochemistry 2020; 9(1): 1995-2000

Lal S, Sahoo RK, Mohapatra S, Mohapatra, PK (2009a) Management of smut of sugarcane using fungal antagonists. Sugar Tech 11, 224–227.

Lal RJ, Sinha OK, Bhatnagar S, Lal S, Awasthi SK (2009b). Biological control of Sugar cane smut (Sporisorium scitamineum) through botanicals and Trichoderma Viride Sugar Tech (2009) 11(4): 381-386

Oguh CE, Okpaka CO, Ubani CS, Okekeaji U. Joseph, PS and Amadi EU (2019) Natural pesticides (bio pesticides) and uses in pest management-a critical review, Asian Journal of Biotechnology and Genetic Engineering, Vol. 2, (3): 1–8

Rahman A, and Talukder F A (2006) Bio efficacy of some plant derivatives that protect grain against the pulse beetle, Callosobruchus maculatus, Journal of Insect Science, vol. 6, no. 3, pp. 1–10,

Raman A, Khan WS, Patel J (2023) Efficacy of neem oil against powdery mildew in cucumber. Crop Protection, 148, 105785.

Regnault-Roger C, Philogène BJR, Vincent C (2012) Bio pesticides of plant origin. Springer Science & Business Media.

Shen W (2002). Current status and research progress of sugar cane diseases in China. Chinese Sugar (3): 48-51.

Sharma S, Singh P, Kumar A. (2022) Meta-analysis of neem oil as an antifungal agent in agriculture. Journal of Agricultural Science, 10 (9), 155-162.

Sun Y Su, Meng Y, Zhang ZJ, Zheng L, Miao S, Qin D, Ruan Y, Wu Y, Xiong L, Yan X, Dong Z, Cheng P, Shao M, Yu G(2023) Biocontrol of bacterial wilt disease in tomato using Bacillus subtilis strain R31. Front Microbial. (2023) Sep 28; 14:1281381.

Doi: 10.3389/fmicb.2023.1281381. PMID: 37840725; PMCID: PMC10568012.

Umar S, Bello AB, Isah AB (2010) Evaluation of plant extracts in the management of sorghum grain mold. Journal of Agricultural Extension, 14(1), 15-22.

Wada AC, Mian MA, Anaso AB, Busari LD, Kwon-Ndung EH (2008) Control of sugarcane smut (Ustilago scitaminea Syd) disease in Nigeria and suggestions for an integrated pest management approach. Sugar Tech, 1, 48-53.

Wada AC (2003) Control of sugar cane smut disease (Ustilago scitaminea Syd.) in Nigeria with Fungicides. Crop Protection 22 (2003): 45 - 49.

Wada AC and Dangana S (2016). Management of whip smut of sugar cane (Sporisorium scitamineum Sydow and H.Sydow} with some plant extracts with fungicidal actions. Natural Products: An Indian Journal: 12 (1) 2016 (031-037).

Wada AC, Abo-Atif Elwafa A, Salaudeen MT, Bello LY, and Kwon Ndung, EH (2017). Sugar Cane Production Problems in Nigeria and Some Northern African Countries. Direct. Res. J. Agric. Food Sci. Vol. 5 (3): 141-160.

Wada AC. (2018) Ratooning Ability of Two sugar cane varieties affected by Whip Smut (Sporisorium scitamineum Sydow) at Badeggi, Nigeria. International Journal of Bioresciences, Agriculture and Technology, 9 (5): 32-42. DOI: http://doi.org/10.528/zenodo.1486289.

Wenjie L, Wenfeng, L, Yingkun H (2008) Research progress in the occurrence and control of Sugar cane smut. Chinese Sugar (3): 64-66.

Yadav D (2006) Botanicals for sustainable pest management: a review. Journal of Sustainable Agriculture, 28(2), 49-71.